TECHNOLOGICAL GAPS AND STRUCTURAL ADJUSTMENTS

The Case of the European Human Capital Policy after the Second World War

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ABSTRACT

Two events greatly increased the technological gap between Western Europe and the United States in the second half of the twentieth century. First, the Second World War greatly enhanced the "Atlantic Divide". Later, the introduction of a new general purpose technology, the information and communication technologies (ICT), fostered the European technological lag. The aim of the dissertation is to study the impact of technological gaps on growth by looking at the role of human capital. This is because the gaps generated a great need for adjusting the existing educational, training and research settings. The research question addressed in the thesis is: what have been the structural adjustments undertaken by European countries in the human capital policy since the end of the Second World War? Have these changes been sustained by the technological development? To address the research question, three aspects of the human capital policy that have received little attention in the existing literature but that appear to be fundamental in order to fully understand the European response are identified. The first chapter provides the theoretical and conceptual framework for the analysis whereas chapter two gives an overview of the historical background of post-war Europe. In chapter three, the first human capital policy change is examined by analysing the expansion of compulsory schooling and trying to understand what have been its determinants. Chapter four studies the policies undertaken with respect to the curricula of education by looking at the evolution of vocational education and training with respect to general education. The introduction of the ICT programmes in vocational education is examined for three European countries. Chapter five is devoted to the estimation of the returns to education across European countries by carrying out a cohort analysis over 1985-2000. The last section provides a discussion and concluding comments on the findings of the research.

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London, March 2007

To my grandmother Rosina

London, March 2007

I declare that the work presented in the thesis is my own,

Martina Viarengo

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Chapter One

INTRODUCTION

1.1) Introduction

> *"In the simple catch-up hypothesis, the [social] capability is viewed either as exogenously determined or else as adjusting steadily to the requirements of technological opportunity. The educational and institutional commitments induced by past development may, however, stand as an obstacle. This is a question that calls for study"*
>
> Moses Abramovitz (1986, p.402)

The above quotation illustrates well the situation experienced by governments of many Western European countries (hereafter Europe) in the context of the human capital policy since the end of the Second World War. In fact there were two moments when the widening of the existing technological gap with the United States created a loss of "social capability". First, after the war itself the technological gap between the technological leadership of the United States and European countries was greatly enhanced. Later, as a result of the introduction of the information and communication technologies (hereafter ICT) a gap between the European level of implementation of the new technologies and the American one was created. These technological gaps had a major impact on the growth of European countries. As a result of the technological shift what happened to most European countries was that many institutional settings that allowed the effective use of the previous technologies were no longer adequate. In fact, different as these situations may appear, they share the common feature of having induced an institutional response as countries tried to adjust to the new technological environment. In this context education policy, among other factors, appeared to be a key tool to reduce the technological gap and foster growth. This explains why governments have undertaken structural adjustments to modify the skills of the labour force in order to meet the requirements of the new technologies. As a matter of fact, education and training have appeared in the past decades as issues of great public and political concern in many European countries. Therefore the research question I address in my dissertation is: what have been the structural adjustments undertaken by European countries in human capital policy after the Second World War? Have these changes been sustained by the

technological development? In general, European institutions have addressed these issues with, among other things, an expansion of formal education, the choice among different types of curricula and a policy change in higher education.

The notion that human capital plays a central role in the process of technological diffusion has a long history, stretching back to classical economists like Adam Smith (1776) and William Petty (1699). More recently, economic historians and economists like Nelson and Phelps (1966) and Bartel and Lichtenberg (1987) have acknowledged the importance of skilled workers in accelerating the "rate of diffusion of new industrial technologies by lowering the costs of adjustment and implementation".[1] In 1981, Easterlin in his Presidential Address to the Economic History Association argued that the great differences in the growth rates of the countries around the world were mainly due to disparities in human capital. In this regard, he considers the "transfer of technology as a person-to-person process"[2] and he identifies a skilled and well-educated labour force as the key factor that allows the technological transfer and makes countries experience economic growth.

An example of institutional commitment to this idea is the recent human capital policy of the European Union. New strategic objectives were set during the Lisbon Summit in the year 2000 in order to make the European Union gain competitiveness with respect to the other knowledge-based world economies. The plan was broad and the goals related to every field of human capital policy including "turning schools into open learning centres" as well as "making lifelong learning generally available" and "adopting an R&D policy by creating European networks for research".[3] Apart from the European framework,[4] it seems important to look at the country-level policy by taking an historical perspective to understand the process of adjustment. It would be interesting to examine historically what has been the role of national institutions in shaping the human capital policy that has determined the adoption of more advanced technologies and later the diffusion of information and communication technologies. In this regard, it is important to notice that since 1945

[1] Bartel and Lichtenberg (1987, p.10).
[2] Easterlin (1981, p.4).
[3] Rodrigues (2004, p.17).
[4] Formally, the European Community has been partly appointed to shape the education and training policy
of Member States since 1957 when the Treaty of Rome set common principles for the educational and vocational training policy. However, an active policy of the European authorities started in mid-1980s with the adoption of legally binding agreements.

the institutional response has varied across European countries and this heterogeneity calls for a detailed analysis.

Before studying the changes in education policy undertaken by European countries this chapter lays out the conceptual framework of the thesis whereas the next chapter will provide an overview of the historical background of post-war Europe concerning growth, technology and human capital.

In this introductory chapter I will proceed as follows. First, I will briefly describe the historical background and explain the interest of the research question addressed in the dissertation. Second, I will provide a definition and a description of the role of human capital in the theoretical and empirical framework. After, I will focus on the role that human capital plays for the adoption of new technologies with specific reference to the situation that characterized the post-war period and later the introduction of ICT. Then, I will highlight the limitations of the theory by emphasising the different kinds of human capital required by dissimilar technological regimes. Finally, I will address my research question and discuss my methodology. In trying to understand how European countries have tried to provide an effective response to the widening of the existing technological gap with the United States that has characterized the post-war era I will analyse and motivate the choice of three aspects of the human capital policy that have received little attention in the literature but that are of great importance.

1.2) Historical background

The aim of table 1.1 is to provide an overview of the evolution of Gross Domestic Product per capita (GDP_{pc}), technology and GDP per hour worked (GDP_{ph}) in Europe with respect to the United States and to show the heterogeneity that existed among European countries; the three benchmark years cover the interwar period, the Golden Age and the post-Golden Age.[5] The growth rates of these variables as well as the detailed historical background in terms of growth, technology and productivity will be examined in the next chapter.

Table 1.1. Indicators of GDP per capita, technology, GDP per hour worked, various years

	GDP_{pc}			Technology			GDP_{ph}		
	1935	**1960**	**1985**	**1935**	**1960**	**1985**	**1950**	**1970**	**1995**
France	4086	7546	15901	18000	35000	37530	5.45	14.83	31.39
Germany	4120	7705	15140	17011	...	33377	4.36	13.88	25.97
Italy	3148	5916	14096	9890	13356	47924	5.10	14.01	27.42
Portugal	1669	2956	8306	353	979	960	2.16	7.25	14.31
Switzerland	5907	12457	19584	7448	7269	14540	8.70	17.26	23.33
UK	5799	8645	14165	17675	26775	34480	7.44	12.52	23.95
US	5467	11328	20717	40663	47170	71661	12.00	19.66	28.07

Note: ... data not available
GDP_{pc} is real per capita GDP (1990 international Geary-Khamis dollars)
$Technology_{pc}$ is the total number of patents granted in the country
GDP_{ph} is the real per capita GDP per hour worked (1990 international Geary-Khamis dollars)
Source: Maddison (2003), WIPO (2005) and Groningen Growth and Development Centre (2006)

What can be observed is the clear productivity leadership of the United States in 1950, in fact the American GDP per hour worked is much greater than that for Europe. According to Crafts (2004a) and Smolny (2000), after the Second World War, the United States had world technological leadership and was the productivity leader in virtually every industry. This can be considered as the first great technological gap characterizing the second half of the twentieth century. European countries rapidly recovered from the destruction of the war and the technological development could start again as a result of the transitory factors and the institutional setting that shaped the Golden Age (Eichengreen, 1996; Temin, 2002). The levels of

[5] The only exception is for GDP per hour worked for which data for the interwar period were not available.

GDP per hour of 1970 show the rapid growth of labour productivity experienced by many European countries during the *Trente Glorieuses*, and indeed by 1995, France, had reached labour productivity levels greater than the United States. However, what is important to notice is that in the 1980s the introduction of ICT created another technological gap between Europe and the United States. This European lag in ICT adoption was particularly evident in the ICT-producing and service sectors and later in the whole economy. The contribution of the different type of industries to labour productivity is shown in table 1.2.

Table 1.2. Contributions to labour productivity growth differences between the European Union and the United States (EU-US, % per year)

	1979-1990	1990-1995	1995-2001
Whole Economy	0.99	1.19	-0.62
ICT-Producing Industries	-0.13	-0.25	-0.45
ICT-Using Services	0.19	0.26	-0.75
Non-ICT Industries	0.73	0.99	0.44

Source: Inklaar et al. (2003) and Crafts (2004a)

According to Crafts (2004a; 2006), the growth revival experienced by the United States since the mid-1990s is a consequence of the end of the Solow Productivity Paradox. Solow's (1987) aphorism referred to the lack of growth revival in spite of the large American investment in ICT in the 1980s.[6] While examining the effect of capital deepening and total factor productivity on output between 1974 and 2000 Crafts (2002) shows that ICT already had an impact on growth in the United States in the early 1990s while Europe is still lagging behind[7] but it takes time to adjust the economy to meet the requirements of the new technologies. In this regard, chapter four will look at a policy change in vocational and higher education undertaken by European countries to create complementarities between skills and ICT.

Following Nelson and Wright's (1992) reasoning, the American productivity lead has relied mainly on two factors. First, on the long-term primacy in mass production as a result of the large supply of natural resources and the dominant market size. Second, more recently, on high investments in research and development and

[6] Triplett (1999) reviewed eight common explanations for this paradox.
[7] Crafts (2004, p.131).

scientific knowledge that have guaranteed the initial American superiority in the adoption of the new technologies.[8] Interestingly, the core of the American technological leadership has not been human capital driven. In fact, the standards of the US mass secondary education as well as the quality of schooling have been lower than the Western European average.[9] Rather, it has been the result of factor endowments that perfectly suited the system of production and "the effectiveness with which [the] training [was] integrated into the process of improving the technology of operating firms".[10] According to Nelson and Wright, the American supremacy has for a long-time been the result of employing low skilled workers from everywhere in the world and making them the most productive in the world. Thus, American comparative advantage relied on the choice of a technique that was based on the use of physical capital and land, the abundant factors, more than skilled labour, the scarce factor; conversely European countries could rely on a large supply of more educated workers (with respect to the US). That is, given the initial endowment, the resulting relative factor prices determined the choice of different techniques of production that once chosen could not be readily changed as countries found themselves "locked-in" the technical choice they have previously made.

In is important to understand how European countries tried to close the technological gap with the United States by following their own pattern to modernity. This is because, as Broadberry (1997, p.89) suggested, "slavish copying is unlikely to be a viable response, given different local circumstances". Rather, European countries needed to gain access to the same technology but by adapting it to their own factor endowment and technique of production. The unsuccessful British attempt of imitating the American mass production system in the post-war period clearly illustrates this.[11]

In this historical context I would like to examine what European countries did in terms of human capital policy in order to create the conditions necessary to close the gap with the United States since the end of the Second World War. My reasoning

[8] Nelson and Wright (1992) also show how the internationalisation of science and technology have progressively eroded the American leadership.
[9] This fact is described by Nelson and Wright (1992, pp.1946-50), and will be explained in greater detail later in the analysis also with the support of the statistics of the Programme for International Student Assessment (PISA).
[10] Nelson and Wright (1992, p.1949).
[11] Broadberry and O'Mahony (2004, p.73).

has been particularly influenced by Abramovitz's understanding of the determinants of long run growth. He introduced the concept of "technological congruence" and "social capability",[12] although without providing any formal model. His contribution was very powerful and greatly influenced subsequent research.[13] He developed his theory in order to explain why some countries were maintaining economic leadership over a long time whereas others were not catching up in spite of some effort to adopt more advanced technologies. He argued that the adoption of new technologies is not an automatic process: for technological transfer to be effective, it is necessary for the country to have certain characteristics and to provide specific conditions. He described these conditions as the "elements of catch-up potential".[14] Among these factors, central is "social capability".[15] It consists of the institutional, political, legal structures that can determine the adoption of new technologies and create the conditions for its effective use. But also the level of knowledge, skills and the social values of the population are part of this concept, they can be shaped by policy-makers in such a way that they make countries better prepared for the exploitation of new technologies.

The other factor, the "technological congruence", consists of all the technical components functional to the exploitation of technology such as "resources availabilities, the scale of markets, the consumer demand, the technical capabilities and the organizational structure of production".[16] Abramovitz's reasoning seems to imply that governments can play a limited role in determining the right "technological congruence". This is because factors such as "resources availabilities" and "the scale of markets" are country specific and cannot be readily changed.[17] However, institutions can play a key role in creating adequate "social capability". That is to say, they can create among other things a labour force endowed with the skills necessary for the efficient use of new technologies. Since human capital is a fundamental element of social capability it seems important to develop a clear understanding of the role that European institutions have played in

[12] This concept is explained in two articles: Abramovitz (1986, p.387) and Abramovitz and David (1996, p.25).
[13] Abramovitz's (1986) paper: "Catching-up, Forging Ahead and Falling Behind" still remains the second most cited article of the Journal of Economic History.
[14] Abramovitz and David (1996, p.31).
[15] Abramovitz quotes those who first used this term in 1973, Ohkawa and Rosovsky (1973, chapter 9).
[16] Abramovitz and David (1996, p.32).
[17] In fact, the creation of the European Union that has greatly increased the scale of the market of the participating European countries, since the end of the war, seems to be quite a unique experience.

shaping human capital. More precisely what have been the policy changes undertaken since the end of the Second World War in order to create the "social capability" necessary to adapt to the new technological environment and to foster growth. Abramovitz emphasised the need for institutional adjustments by showing the potentially negative consequences of following policy guidelines that have proved to be successful for certain countries under specific conditions but that might not be the most appropriate in other technological environments.

1.3) Definition of human capital

A natural question that arises from the previous discussion appears to be: what exactly is "human capital"? What does it mean and what does it represent? According to Becker (1964; 1993), human capital is "what is embodied in one person in terms of knowledge, skills and health". This concept of human capital is broad: it includes healthcare, formal education, vocational training, on-the-job learning, adult learning, general knowledge and also experience. I will adopt a narrower definition, one used by the Organisation for Economic Co-operation and Development (OECD, 1998, p.9): "human capital is the knowledge, skills, competences and other attributes embodied in individuals that are relevant to the economic activity". This restricts the concept to what directly contributes to productive activity and provides a return to the individual and indirectly to the society as a whole. What enhances the individual's human capital but is more closely related to consumption is not considered.[18] For the purpose of the study, the definition will be further narrowed to a focus on formal education and vocational training. This can be justified by the following reasoning. First of all, even if each element that enters in the definition of human capital appears to be an essential component, it seems reasonable to assume that schooling and training are the most important because they provide the individual with the skills and the knowledge necessary to work and therefore to contribute to the well being of the society for a central part of his life. Second, data related to formal education (such as enrolment

[18] Following the OECD (1998) definition.

rates, years of schooling, levels of education...) and training (years of apprenticeship, qualifications...) are available and allow comparative studies over time and across countries. Third, they respond to policy choices. This is because governments decide the expenditure on education and training, the number of years of compulsory schooling and determine the kind of general and specific knowledge that has to be taught. Also, with respect to higher education, governments can affect the supply (by creating certain institutions that provide a certain kind of training and by creating jobs in the related sectors) and the demand (through income taxes, financial subsidies).

Thus, the aim of the thesis is to analyze the structural adjustments undertaken by European countries in education and training since the end of the Second World War as policy response to technological change.

1.4) Human capital in the theory of economic growth

The purpose of this section is to examine the role of human capital in economic theory by highlighting how different theories consider the institutional response in the sphere of human capital policy. In the following chapters of the thesis specific aspects of the European policy response in education and training during the second half of the twentieth century will be examined. Although none of the models reviewed here will be used but it seems important to understand the role of human capital in the literature and acknowledge its importance in affecting productivity and growth.

In the theoretical literature human capital is considered in two ways: as a factor of production and as a factor that facilitates the accumulation of productive capabilities. This difference is very important because it has both theoretical and empirical implications that I will briefly discuss in the following paragraphs which consider neoclassical growth theory and endogenous growth theory, and provide an overview of relevant empirical findings.

1.4.1) Neoclassical growth theory

From the 1950s until the 1980s neoclassical growth theory was the most influential theoretical framework. Its basis was the Solow (1956) model, which features a neoclassical production function that explains the level of output in terms of two factors of production: capital and labour. The two inputs exhibit decreasing returns and technological progress is considered to be exogenous.

The growth accounting technique tries to measure the impact of the inputs that enter into the production function on economic growth. A factor of production contributes to the growth of the aggregate production function if there is an increase of productivity or if there is an increase of its share (or if both changes happen). Moreover, total factor productivity (TFP) measures the change in the level of aggregate production function that is not captured by the input variation. One of the prominent scholars in this area is Denison (1962; 1967).[19] He understood that "educational background is a crucial determinant of the quality of labour"[20] and adjusted the labour input by constructing quality indexes that reflect the educational background of the population. This represented an improvement with respect to the previous exercises of growth accounting as by separating the impact of skilled and raw labour it reduced the portion of growth not explained by changes in the share and productivity of inputs. However, the result was probably less successful due to the limitations of the technique he used and the lack of data. According to Demeulemeester and Diebolt (2005, p.3), "this approach contributed to the belief that investing in education was one of the key precondition for rapid economic growth".

In an important extension of the neoclassical model, Mankiw, Romer and Weil (1992) offered a way of operationalizing empirically the Solow model adjusted to include human capital as well as physical capital and labour. They made a distinction between the contribution of unskilled and skilled labour to the growth process and human capital is not something that adjusts the labour input, as in Denison (1967), but is a factor that enters in the production function in all its autonomy. The

[19] Other influential contributions in this area, Abramovitz (1956), Kendrick (1961) and Jorgenson and Griliches (1967).
[20] Denison (1967, p.78).

implication for growth arising from this model is that an increase in the stock of human capital, considered in this framework as the share of the population with secondary education, would have an impact on the level of output.[21] This model presents many shortcomings widely acknowledged in the existing literature.[22]

In spite of the methodological differences between the existing studies, the common shortcomings come from the empirical tool used that is derived from the neoclassical theory, that is "growth accounting" and from the assumptions of the theoretical framework itself. In this empirical tool, the contribution of each input in determining the growth of the production function is measured. That is to say that growth of the aggregate production function is calculated in terms of inputs accumulation. This is likely to reduce the actual role of human capital as TFP does not only represent technological progress but also intangible elements such as quality of inputs and interaction between factors of production. These components cannot be measured in terms of the model alone but they can generate positive externalities on growth. Another limitation relies on the methodological approach: the imposition of a specific functional form and the failure of considering the interaction between the factors of production.

The Solow model predicts convergence of growth across countries, mainly because capital exhibits decreasing returns, technological progress is considered to be exogenous and consequently cannot be generated or increased through investment and institutional changes. Only inputs, in terms of a greater quantity or a more efficient use and the exogenous technological progress can affect the growth level of the aggregate production function. These assumptions have also important consequences for policy making. In fact, any policy intervention can have only "once-and-for-all effect"[23] on the level of production. This is because what determines the long run growth is the exogenous technological progress and all the other policies only have a transitory effect. In this regard, the model does not really provide a complete explanation to understand the determinants of the growth process. Moreover, the predictions of the neoclassical models have not become true

[21] Mankiw, Romer and Weil (1992, p.408).
[22] Among these critiques: Benhabib and Spiegel (1994), Olson (1996a), Hall and Jones (1999).
[23] As it is acknowledged by Sianesi and Van Reenen (2003).

as they predict that countries would converge, but this has not occurred so far (Lucas, 2000).

The convergence hypothesis is interesting in the context of my thesis because post-1945 Western Europe has been characterized by growth and convergence until the end of the Golden Age (Crafts and Mills, 2000; Temin, 2002) and by polarization thereafter (Epstein, Howlett and Schulze, 2007). Although the hypothesis of convergence will not be tested in the next chapters, it seems important to develop an understanding of it through human capital, social capability and technology. That is, similarities in terms of human capital endowment and institutional setting may lead countries to adopt similar technologies and to converge. Conversely, the impact of common economic and political factors on a schooling reform, the expansion of compulsory schooling, will be examined in chapter 3.

Economic convergence has attracted the attention of generations of economic historians starting with the pioneering analysis of Hume (1758), Mill (1848) and later Gerschenkron (1952) who considered that, among other factors, technological transfer would allow poor countries to grow faster than the rich ones. In the 1980s it regained a central position in economic debate mainly because the predictions of convergence derived from neoclassical theory were not becoming reality and the development of new techniques had allowed economists and economic historians to test the hypothesis in different ways. However, the question is still controversial, despite a few results broadly recognized in the literature. See Lucas (2000) for an optimistic defence of convergence.

Barro and Sala-i-Martin (1991) is the classic paper in this area whilst Quah (1996) argues against convergence as a worldwide phenomenon. Economic historians, such as Crafts and Mills (2000) and Epstein, Howlett and Schulze (2007), have argued that even for OECD countries institutional and structural differences have created major barriers to economic convergence after 1973.

Most recent studies have focused on the notion of conditional "club" convergence, firstly introduced by Baumol and Wolff (1988). According to this hypothesis what matters for growth are the initial conditions, the institutional setting and the structural adjustments undertaken by countries. That is, the development of the right

social capability, through, among other things, education policy and the creation of an effective legal system for the protection of property rights, is conducive to growth and determines convergence.

The importance of human capital makes one think about the role of institutions in the neoclassical framework. A critique is provided by Hall and Jones (1999) who argue that this theory only focuses on the proximate sources[24] of growth such as capital accumulation and productivity whereas it would be necessary to develop a clear understanding of the sources that determine the long run growth. This deterministic approach, in terms of the impact of institutions on growth, is central to the endogenous growth theory, designed to address some of the unsolved issues left by the neoclassical theory. Moreover, this theory is preferred as gives a greater role to human capital. A complete survey is provided by Jones (2002) and at a more technical level by Aghion and Howitt (1998). In the following paragraphs the focus will be limited to the different roles of human capital in the most representative models of the endogenous growth theory.

1.4.2) Endogenous growth theory

Starting in the 1980s new ideas challenged the underlying hypotheses of the neoclassical growth theory. In particular, researchers found that the basic assumption of a steady state of the Solow model, according to which an increase in savings does not correspond to a long run growth, was no longer adequate to represent what was happening in reality. Moreover, scholars became more interested in the ultimate sources of growth. Among these, the role of institutions appeared to be central in order to understand the process of growth.

In the AK models,[25] the growth process is considered to be endogenous as there is no exogenous technological change. In one of the first specifications of the model discussed by King and Rebelo (1990) only physical capital is considered as a factor

[24] An explanation of the difference between proximate and ultimate sources of growth is presented by Crafts (2003).

[25] These are the endogenous growth models with constant returns to capital. In this case, aggregate output is equal to the stock of capital (K) multiplied by a constant (A). This is why they are called "AK" models.

of production. The initial model was extended to include human capital. In this setting human and physical capital exhibit constant returns to scale. Thus, policies can affect long run growth. However, in order to maintain the assumption of perfect competition and therefore to exclude increasing returns to scale, the accumulation of knowledge is considered to take place in an exogenous manner. This is to say that it may happen because of "an externality".[26] This appears to be a strong and limiting assumption of what really represents the essence of the endogenous growth theory. Belonging to this category, the model developed by Lucas (1988) for instance, shows that human capital has a double effect on growth. It has a direct impact in terms of skills that increase workers' productivity but also an "external effect" that contributes to a greater level of firms' output. In Lucas' model human capital enters the production function as an input multiplied by the time individuals spend in production. The steady-state equilibrium depends on the productivity of schooling multiplied by the optimal allocation of time spent in education. The practical implications for growth are that higher rates of accumulation of skills provided by schooling and learning-by-doing have a positive and permanent impact on the growth rate. Therefore, what matters for long term growth is the accumulation of human capital through investment in schooling at any level. The role of government is limited to the provision of formal education and training. This is because the interaction between people is the fundamental source that generates the knowledge that can allow the economy to grow indefinitely.

In the subsequent developments of the new growth theory,[27] human capital is considered as a factor that facilitates the accumulation of productive capabilities. In fact, growth is endogenously determined and is a consequence of specific policies and deterministic factors rather than exogenous technological change. In these models, human capital is the key determinant of long run growth; technological advance is generated by "the accumulation of knowledge", "ideas" and "skills" (Romer 1986; 1990). Furthermore, long run growth can be affected by governments through their incentive policy and by firms through their decision related to investment in research activity. Moreover, guidelines in terms of educational and vocational training policies can affect workers' decision on how to invest in

[26] Jones (2002, p.162).
[27] Among the first who developed this theory, we can find Romer (1986), Lucas (1988) and Rebelo (1991).

education and training and consequently may have an impact on the accumulation of human capital at aggregate level. In addition to this, an indirect effect of human capital accumulation is generated by the positive externalities that foster growth. Accordingly, in these models, the interaction between the factors of production can generate positive spillover and government policies can have a permanent effect by affecting the rate of growth of production (Romer, 1986). However, it is also important to notice that in this initial new growth model the stock of knowledge is endogenous in the economy but is taken as given by firms. This is because markets are perfectly competitive, consequently firms cannot appropriate the entire returns from investments in R&D.

In models such as Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992),[28] the kind of knowledge that sustains the growth process is more directly related to the productive activity and therefore the role of institutions in determining human capital policy is more clearly defined. The focus of these models is on the industrial innovation that determines the technological progress and consequently long run growth. Also, the assumption that firms act as price-taker in a perfect competitive environment is removed; firms are assumed to respond to incentives to innovate and innovation generates monopoly power and profits. This implies that technology is no longer universally available but depends on investment in R&D. In this framework, a wider variety of policies do matter. The role of institutions in fostering growth is based on the protection of property rights and on the regulation of competition policy. It is also based on the creation of the incentives that make agents invest more resources in terms of funds and number of people involved in innovative activity. In particular, the fundamental argument is based on the "scale effect". This is to say that an increase in the level of expenditure in R&D or an increase in the number of researchers in the innovative sectors of the economy would have a proportional increase in the per capita income growth rate. This is one of the reasons why Jones (1995) strongly criticizes this class of models. That is, "the number of scientists engaged in R&D in advanced economies has grown dramatically over the last 40 years [...] and growth rates have exhibited a constant mean or have even declined".[29] Jones develops a "semi-endogenous growth model" and finds that R&D can have only a transitory effect on growth, whereas among the

[28] They are defined as "Schumpeterian models" in Jones (2002, p.89).
[29] Jones (1995, p.760).

ultimate sources one can find population growth. Despite the limitations of these models, they cannot be entirely dismissed as Crafts and Mills (2000) acknowledge. They provide a very important contribution to the economic literature by trying to explain what are the policies most likely to have an impact on growth. They focus on a very specific kind of human capital, the one that is needed for the production of knowledge, and they show how important for growth these specific sort of skills are with respect to more general knowledge.

A further role attributed to human capital in the endogenous growth theory is to allow the adoption of new technologies. In the model presented by Nelson and Phelps (1966) human capital has a double effect: it increases individual's capacity to innovate and to adapt to new technologies (Aghion and Howitt, 1998, p.338). What matters for growth in this model is the level of education. That is, an increase in the labour force with higher levels of education would have a positive impact on growth as it would lead to a faster adoption of new technologies. Following on from this literature, Benhabib and Spiegel (1994) adopt an alternative specification to the neoclassical approach and provide empirical evidence on how high human capital levels determine the innovation process and the adoption of new technologies. However, a shortcoming of their study is that if the regression analysis is restricted to the OECD countries, education is not significant. This may be a consequence of measurement problems that will be described in the next section.[30] Policy recommendations arising from these models concern investments at higher levels of education and in R&D as in Nelson and Phelps' specification human capital is probably referring to the highly skilled (Aghion and Howitt, 1998, p.356). This is because this is the share of the labour force that makes use of more advanced technologies.

Even if there is no conclusive evidence in support of these models (Jones, 1995), they are very important as by endogenising economic growth give a greater role to institutions. That is, endogenous growth theory really considers the importance of social capability for growth. Institutional and educational policies are considered as key determinants of long run growth. On the other hand, the Solow model and its subsequent specifications only consider policies related to savings to be important

[30] More recent developments in this tradition are provided by Greenwood and Jovanovic (2001) and Scarpetta and Tressel (2004).

for growth but these policies can have no more than a transitory effect. I am therefore more favourable to the endogenous growth theory. In the next chapters, I will examine specific policy changes undertaken by European institutions in the sphere of education and training with the aim of increasing human capital stock and fostering growth.

1.4.3) Empirical framework

From a theoretical point of view, the fundamental role that human capital plays in the process of economic growth has been widely recognized in the economic literature. However, from an empirical perspective in spite of some recent contributions that demonstrate the positive impact of human capital on growth it is still not possible to draw definitive conclusions.[31] This is not only because, as Sianesi and Van Reenen (2003, p.163) acknowledge, "the evidence of the neoclassical versus endogenous growth models is still inconclusive" mainly because empirical work "does not allow in general to distinguish between theories" but more importantly because technical difficulties associated with the approximation of human capital and problems with data have generated questionable results. In fact, contrary to what has been found in the micro literature,[32] one of the results of the macro studies is that what matters for growth is the initial level of schooling and not its change and also that primary education has a lower effect on growth than secondary and higher education.

For instance, Benhabib and Spiegel (1994), in the estimation of the augmented-Solow model for 42 countries including European, African and Latin American nations over the period 1974-77, find that human capital has an insignificant impact on growth per capita. Barro (1997) finds that only male secondary and higher levels of education have a positive and significant impact on growth whereas male primary schooling and female education are not significant. This analysis of 114 countries

[31] These studies will be examined later in the section and they include the analyses by Krueger and Lindahal (2001); Acemoglu, Aghion and Zilibotti (2003); Aghion and Howitt (2005); Vandenbussche, Aghion and Meghir (2006).

[32] In the microeconomic literature the existence of positive returns to education is widely accepted. A good review of the latest findings of this literature is provided by Psacharopoulos and Patrinos (2004).

over the period 1960-90 finds that an extra year of male upper-level schooling is estimated to raise the growth rate by 1.2 percentage points per year. The empirical tool that was used in these studies and that is usually applied in the literature to estimate the impact of human capital on growth is provided by regression analysis: the logarithm of the Gross Domestic Product is usually taken as the dependent variable and among the explanatory variables one can find proxies of human capital, initial level of GDP, physical investment variables, government variables, geographical dummies and other economic indicators.

A recent paper by Krueger and Lindahal (2001) is recognized as an important contribution to the literature because by considering the measurement errors and by removing the assumptions of linearity between human capital and schooling, the authors find empirical evidence of the positive impact of human capital on growth that confirms the results obtained at microeconomic level for a panel of 110 countries. Their panel includes European countries and developing countries, as well as the United States. They find that both the initial level and schooling growth have a positive impact on growth. They estimate that an extra year of schooling raise the growth rate by 10 percent, although they acknowledge the existence of differences across countries.[33] What they do in practice is an empirical exercise, they try to correct some misleading assumptions of the existing literature and after they try to fit their analysis in some theoretical model. The "Macro-Mincer" wage equation as specified in this work is obtained by aggregating the function across the individuals of a country by taking the mean of the variables of the model. The "experience" variable is omitted from most of the analyses for simplicity. In spite of some criticism,[34] the Mincerian wage equation is now considered to be one of the fundamental tools of labour economics and it has been extensively used in order to estimate the returns to education for a various set of countries over different time periods. A complete review of the latest results can be found in Psacharopoulos and Patrinos (2004). The results clearly show that there are positive returns to investments in education. The highest returns to education are estimated for low-income and middle-income countries. The importance of the contribution of Krueger and Lindahal (2001) relies on the fact that their findings confirm the positive returns

[33] Krueger and Lindahal (2001, p.1101).

[34] In particular, many scholars have found unsatisfactory the underlying assumption of no connection between the number of years of schooling and the length and profitability of on-the-job training. See for example Psacharopoulos and Layard (1979) for an alternative specification of the model.

to education found at microeconomic level and therefore they remove what Psacharopoulos and Patrinos (2004) define as "a major research gap".[35]

In spite of this important finding, when Krueger and Lindahal (2001) divide their sample in three sub-samples according to the initial level of education of the countries (low, medium and high), they find that this positive relation holds only for those countries that start at the lowest levels. According to their results, the relation does not hold for the OECD countries. Therefore, these results represent an improvement with respect to the previous literature as they remove the uncertainty on the positive impact of human capital on growth, however this analysis does not allow drawing definitive conclusions as it cannot explain the connection between these two variables in the more advanced countries.

In this regard, an innovative contribution is provided by Vandebussche, Aghion and Meghir (2006). In this paper, the authors argue that what needs to be considered is "the distance of a country with respect to the technological frontier and the composition of its human capital".[36] They argue that when the distance from the technological frontier is great, a country is likely to be an adopter of technology and consequently primary and secondary education could have a positive impact on growth. On the other hand, when a country reaches a more advanced stage of development and becomes an innovator of technology then higher education will have a positive impact on growth whereas primary and secondary education will no longer foster growth. Their theoretical specification draws heavily on the notion of "appropriate institutions" introduced by Acemoglu, Aghion and Zilibotti (2003) that refers to Gerschenkron's emphasis on the fact that for countries that industrialize at later stage policies different from those adopted by the early industrializing countries may be more adequate. Vandebussche, Aghion and Meghir (2006) test their hypothesis empirically and find that higher education has a growth enhancing effect in a panel of 19 OECD countries over the period 1960-2000. The dataset they have constructed is composed by the 15 Western European countries, Australia, Canada, New Zealand and the United States. These results show how by adopting the right specification of the type of technology and educational composition, the puzzles previously found in the literature can be solved.

[35] Psacharopoulos and Patrinos (2004, p.118).
[36] Vandenbussche, Aghion and Meghir (2006, p.98).

In spite of these results that confirm the positive impact of education on economic growth, there are still issues about the kind of production function used that seems to characterize the results obtained. Moreover, issues related to the quality of education have been raised and animate the current debate. In particular, policy-makers and scholars are concerned with the fact that in most OECD countries the expenditure in the educational sector has increased over the last 30 years without a related improvement in the quality of education. This issue among others will be analysed in greater detail later.

1.5) Methodological issues

In this section methodological issues related to the measurement of human capital will be discussed. This is because later in the thesis, human capital indicators and international datasets will be used for the analysis. It appears therefore necessary to provide a critical overview to understand both advantages and disadvantages in the use of these tools and to acknowledge the state-of-the-art methodology.

Since the 1980s with the creation of the first datasets of educational attainment such as those by Summers and Heston (1988; 1991), Barro and Lee (1993) and Kyriacou (1991), there has been a great expansion of macroeconomic analyses studying the impact of schooling on the growth of countries. In fact, as a result of the introduction of these large human capital databases, it became possible to do cross-country empirical analyses. The main methodological difficulty of these empirical exercises comes from the intrinsic nature of human capital. In fact, this concept groups together elements that can be measured as formal education, others that are more difficult to quantify such as vocational training, on-the-job learning and others that are very difficult to estimate such as general knowledge and experience. I will describe in the following pages the proxies that are commonly used in the literature and the datasets that have been constructed by scholars.

1.5.1) Proxies

Due to the difficulties in the measurement of human capital that have been mentioned above, the proxies that are more commonly used in the empirical analysis are related to formal education. These are: "literacy rates", "enrolment rates", "years of schooling" as well as "levels of education".[37] These proxies are imperfect for many reasons such as lack of consideration for quality and failure to provide a measure for the skills acquired by individuals at different stages of education. I will try to describe some of the proxies that are commonly used and their shortcomings in the following paragraphs.

First, literacy rates (i.e., the number of literates as percentage of the population in the corresponding age group) could be a good proxy for the human capital of countries at the early stages of development. In this case often a large portion of the population is illiterate and it seems reasonable to measure the impact on growth of primary education, which provides the basic literacy tools. This proxy has been used by Cipolla (1969) to study premodern Europe, Romer (1990) and Benhabib and Spiegel (1994) to examine a group of 42 countries that include developing countries of Africa and Latin America. However, as Woessman (2003a) acknowledges, using literacy rates as a proxy means "missing out most of the investments made in human capital because it only reflects the first part of the investment".[38] For this and other reasons, literacy rates do not seem an appropriate proxy of human capital for developed countries. Moreover, the use of adult literacy (i.e., adult literates older than 15 as a percentage of the population in the corresponding age group) as a proxy, used in some studies such as Azariadis and Drazen (1990) would provide valuable information about the level of skills provided by the education system in the past, but it would limit the study to a fraction of the labour force.

Also the enrolment rates (i.e., the number of students enrolled at a certain grade as a percentage of the corresponding age group) used by Mankiw, Romer and Weil (1992), suffer from some limitations. In fact, among other things they might reflect demographic changes as observed by Hanushek and Kimko (2000). Furthermore,

[37] Woessman (2003a) and Sianesi and Van Reenen (2003) present a detailed analysis of the variables that are used in the literature to proxy human capital.
[38] Woessman (2003a, p.243).

they do not really describe the current human capital stock of the country but rather what is expected. This is to say that the enrolment rate would be a meaningful proxy of human capital if all the students enrolled could complete their studies and enter in the labour force. As a result of this uncertainty, it seems an inaccurate proxy of human capital. Moreover, in developed countries high enrolment rates in primary and secondary education might not really provide complete information of what is the endowment of human capital of a country. This is because these levels of education are often compulsory in most developed countries. In fact, high enrolment rates might be consistent with either "stagnant higher education investment or a rapid expansion"[39] as Judson (2002) acknowledges. In order to have better description it would be necessary to have information related to higher levels of education.

The average years of schooling solves many problems of the proxies previously described. In fact, it is now a very common and widely used measure to proxy human capital. The estimates of average years of schooling can be obtained with three methods: the perpetual inventory method, the projection method and the attainment census method (these methodologies have been extensively described by Woessman (2003a)). The main shortcomings of this proxy are explained by the fact that average years of schooling do not reflect the dissimilar productivity level at different stages of education. It does not seem reasonable and moreover it contradicts the theoretical assumption of decreasing returns to human capital. In addition to this, quality is not considered. This is because by using this proxy it is assumed that the quality is the same overtime and across countries. This does not seem realistic; therefore many economists have tried to correct it by adding a variable that could highlight qualitative differences across educational systems (such as student/teacher ratio, class size or even institutional differences such as private/public school, centralized examination systems and other variables examined by Woessman (2003b) and Barro and Lee (1996)).

Vocational training has not been commonly used to proxy human capital, even though it appears to be a key factor (CEDEFOP, 1998). This is mainly due to the difficulties in trying to measure it and the great differences that exist across countries

[39] Judson (2002, p.211).

and that reflect the different methods of production, as outlined by Broadberry and O'Mahony (2004). However, comparative studies exist for a small set of countries (as a result of Steedman's work)[40] and some historical data are available at the European Centre for the Development of Vocational Training (CEDEFOP) to proxy human capital.

An attempt to measure experience to proxy human capital has been provided by Wasmer (2001) for eight OECD countries: Finland, France, Germany, the Netherlands, Spain, Sweden, the United Kingdom and the United States over 1960-95. The author provides a methodology where the experience in the labour market is recorded in a similar manner as the accumulation of stocks of capital by using the perpetual inventory method. Thus experience is recorded as "a stock of past history of labour market participation". He finds that a reduction in experience during the 1970s was more than compensated by a rise in the level of education of the active population.

Most of these variables will be used in the next chapters. Illiteracy rates will be used in chapter three in order to understand whether they had an impact on the expansion of compulsory schooling after 1945. This is because, even if the fifteen countries examined are "developed", illiteracy was still widespread in Southern Europe after the Second World War. The evolution of the enrolment rates at the different levels of education will be presented in chapter two whereas average years of schooling will be used in both chapters two and three to show how the human capital flow and stock have changed over time. Vocational training will be covered in chapter four by studying three countries but without attempting to construct a variable as the approach used will be more analytical. On the other hand, the variable experience, measured in its basic form (i.e., age squared), will be used in the regression of the returns to education in chapter five.

[40] Among the most significant comparative studies, Steedman (2001) and Steedman et al. (2003).

1.5.2) Datasets

In addition to the methodological difficulties in the measurement of human capital, errors in the first datasets of educational attainment such as Barro and Lee (1993; 1996) and Kyriacou (1991) have generated misleading results in the regressions. More reliable datasets, with a greater focus on national information and classification procedures, have been developed by De la Fuente and Doménech (2000) and Bassanini and Scarpetta (2001) as well as by Cohen and Soto (2001). A brief overview of these datasets follows.

The Summers and Heston (1988) dataset that can be found in the Penn World Table has been very influential and has led to a large development of empirical work. In fact, it provides consistent data of GDP and national expenditures by using a common set of prices in a common currency for 130 countries over 1950-85. The latest version of this dataset, Heston et al. (2006), covers 188 countries between 1950 and 2004. Real education measures were introduced in the Barro and Lee dataset.[41] In the second version of the Barro and Lee (1996) dataset, educational attainment at primary, secondary and tertiary levels for the male and female population were recorded. The population chosen was over age 15 and over age 25 for 126 countries in the world over 1960-90. Schooling inputs were collected at 5-year intervals from 1960 to 1990. The main gap of this dataset is due to the fact that when surveys were not available, education attainment was used to fill the gap without using age specific estimates. Moreover, some results, in particular concerning developing countries, were found by researchers "to be implausible".[42] This was due to errors in the primary data sources. The third version of the Barro and Lee (2000; 2001a) dataset was extended to cover 142 countries over the period 1960-95 and projections for 2000 were provided. The authors filled the missing data of survey and census by using gross enrolment rates adjusted for repeaters. Moreover, they considered the different duration of the education levels across countries in constructing the average years of schooling.

Recent developments of the literature have focused on providing a methodology to correct the measurement errors. Among these contributions, the work by Portela,

[41] Barro and Lee (1993, p.363).
[42] De La Fuente (2002, p.1).

Alessie and Teulings (2004) provides an analysis of the shortcomings of using the perpetual inventory method to construct the education data of countries and presents a technique to correct for this mismeasurement based on the use of the regression results.

De La Fuente and Doménech (2000) revised the Barro and Lee (1996) dataset. They added a larger amount of national information and corrected the changes in classification criteria. In fact, they used primary data of national sources for countries for which the series seemed to be consistent, in particular for developed countries. On the other hand, when primary sources and national data seemed unreliable and this was in particular related to less developed countries they reinterpreted some of the data. They estimated a production function exhibiting constant returns to scale. The dataset was limited to 21 OECD countries (16 Western European countries, Australia, Canada, Japan, New Zealand and the United States) because of the greater quality of data as they argue that "the educational statistics for this set of advanced industrial nations are presumably of decent quality".[43]

A further improvement in this direction is provided by Bassanini and Scarpetta (2001). They constructed an improved dataset on human capital for the same set of countries as in De La Fuente and Doménech (2000) over 1971-98. They derived it from the Barro and Lee (1996) dataset by taking into account the changes introduced by De La Fuente and Doménech (2000) and by improving it subsequently. In fact, up to 1990 they derived the data on educational attainment from this dataset and collected the data related to the subsequent time period from the OECD Education at a Glance. Moreover, they used a different econometric technique, the Pooled Mean Group (PMG) to assess the long run relationships between factor inputs and output for the eight OECD countries. They found a positive relationship between human capital and growth. In fact, they estimated the impact of an additional year of education on long run growth to be 6 percent. However, their findings do not provide empirical evidence in favour of the augmented-Solow model. Their results support the AK model as specified by Lucas (1988).

A dataset for a larger group of countries and a longer time series was provided by Cohen and De Soto (2001). They extended De La Fuente and Doménech (2000)

[43] De La Fuente and Doménech (2000, p.5).

dataset for 95 countries over 1960-2000 and a projection for 2010. Their new dataset was corrected with data obtained from the OECD, UNESCO and National State Agencies. In order to adjust when data from the census were missing, they used the extrapolation method. Moreover, they dealt with other issues that could affect the dataset: they assumed mortality rate to be homogenous and immigrants to have the same educational level as the population of the host country. Their contribution to the improvement of the dataset on human capital with respect to the Barro and Lee (2000; 2001a) depends on the methodology they used to extrapolate missing data from census. In fact, they used different classifications to group the education levels and they relied more on census and national information. They also improved the De La Fuente and Doménech (2000) dataset by adopting different and more systematic classification criteria. By taking the elasticity of the variables and by using the Mincerian specification, they show how their empirical findings support the results of the existing literature that attribute the private return to human capital to be about 8 percent and also they confirm the estimated parameters of the Mankiw, Romer and Weil (1992) model.

Later in the analysis different sources will be used in order to construct the variables related to education. Data related to the enrolments at the different levels of education that will be used in chapter two to show the evolution of the participation rates since 1950 will be extracted from the UNESCO Statistical Yearbook. On the other hand, in chapter three data related to the average years of schooling and the share of the population who has completed primary, secondary and higher education will be extracted from the Cohen and Soto (2001) dataset. This is because, as suggested above, this is one of the best datasets currently available. In chapter four data related to the number of first year students and graduates in computer science in Germany and the Netherlands will be extracted from national sources whereas for Portugal what is available in terms of broader categories of fields of study will be extracted from the UNESCO Statistical Yearbook. This source will also be used to examine the composition of the enrolments in vocational training and general education between 1970 and 2005 in the three countries under study.[44] In chapter five the variable years of education of the population of the seven countries in the sample will be extracted from the International Social Survey Programme (ISSP) dataset in order to estimate the returns to education.

[44] In addition to this, for Germany data of the Federal Institute for Vocational Training will be used.

1.6) Human capital and technology

In this section the main features of the technological environment characterizing the post-war European experience will be described. The focus will be on the review of the literature that has provided information on the type of human capital necessary for the effective use of these technologies. In chapter two, a detailed analysis of the nature of these technologies and the factors that create the favourable conditions for their adoption will be carried out. In the subsequent chapters specific aspects of education and training policies undertaken by European institutions to shape the human capital stock to meet the technological requirements will be investigated.

After the Second World War the technological gap with the United States was greatly magnified as Broadberry (2006) has shown. This was not merely a result of the massive destruction of the capital plant and the dislocation of production experienced by almost all belligerent countries. The extent of the transatlantic gap was much greater and it was the result of an "exogenous interruption of the normal process of the technological diffusion".[45] It was during these years of conflict that the United States continued to develop new knowledge and techniques that led to major innovations in the electronic industry as well as in the chemical manufacture and the iron and steel technology. According to Landes (1969) this technological development was not the result of a major breakthrough but it was the product of a steady improvement in the application of scientific knowledge and institutional arrangements that had already started in the interwar period. Important features characterized this evolution as new development in technology started relying more and more heavily on science and knowledge. This technological gap was reflected in the productivity lag of the European countries with respect to the United States, as shown in table 1.1. The gap was evident in both manufacturing and service sectors. The productivity in the service sector was particularly revealing of the European lag (Broadberry, 2006). This is because services in general and market services in particular could not be substituted by imports like manufactured goods. Apart from factor endowments such as large scale markets, natural resources, organization, management and overall "low-margin methods to produce industrialised or mass market services"[46] it is reasonable to ask what skills were necessary to adopt the new

[45] Landes (1969, p.504).
[46] Broadberry (2006, p.1 and p.22).

technologies, this is to say what was the role of human capital in this technological environment? How could it foster the adoption of new technologies?

The system of mass production developed in the United States relied on the application of technological innovations to the Taylorist system of production. That is, "Fordism"[47] relied on the "standardisation of output using assembly lines and the routinization of work, breaking it into small de-skilled tasks".[48] Therefore, the division of tasks and work processes had important consequences on the demand for skills as it required a large supply of low skilled workers and a smaller supply of highly educated workers (Clarke, 1992, p.17). On one hand the rigid division of tasks and fragmentation of production led to the "deskilling of jobs". That is, workers did not need formal education as they could learn how to perform their task on the job or through basic apprenticeship. On the other hand, this system of production created the need for highly educated wokers for the management of production and the constant development of new tools and machines. The success of the Chandlerian corporation relied on these strategic factors, the investment in production, management and marketing that allowed the achievement of economies of scale and scope (Broadberry, 1997, p.81).

This mode of production well suited the American endowment characterized by large availability of land and capital and scarce supply of labour. As suggested earlier, countries need to make their choice among the different existing techniques along the "available process frontier",[49] that is determined by their factor endowment. This implies that the adoption of the same technologies can be undertaken by using a different composition of factors of production. This explains why the same mode of production could not be adopted in Europe which relied on a greater supply of semi-skilled workers. This is why the "flexible system of production"[50] was better suited for Europe.

This form of specialisation relies on a form of skilled craft production which provides customized goods and can supply an increasingly fragmented and volatile market (Burrows et al., 1992, p.3). In this system of production workers have greater

[47] This label describes the system of production developed by Henry Ford.
[48] Definition of the Business Dictionary (2007) and Raff (2003).
[49] As defined by Broadberry (1997, p.86).
[50] This concept was introduced by Piore and Sabel (1984).

responsabilities as they may work in self-regulating groups (Burrows et al., 1992, p.4). In contrast to Fordism, the labour force needs to be more educated as it can be redeployed to perform different jobs. This type of labour endowment, workers with shopfloor skills, was precisely the advantage of the German model of production that was characterized by a large supply of workers that received training through apprenticeship (Broadberry and Wagner, 1996). This was also the mode of production better suited for the other Western European countries as they were endowed with an abundant supply of shopfloor skills.

The major technological change of the last decades has been characterised by the introduction of ICT. These new technologies heavily rely on science: personal computer technology, digital information appliances, microprocessor technology, and scientific instruments. ICT is a general purpose technology (GPT)[51] and this aspect is important for my research. This is because, as it will be explained in the following paragraphs, this type of technology is likely to have a greater impact on the economy than other technologies but at the same time requires a greater adjustment for the realisation of its potential. It took hundred years for steam to have its height impact on growth (Crafts, 2004) and several decades for electricity (David, 1991). Moreover, in contrast with these GPTs, ICT by creating a demand for different skills is more directly related to changes in education and training policy. Jovanovic and Rousseau (2005)[52] recognise three features that define a general purpose technology. The first is "pervasiveness" by means of the adoption of the technology in many sectors of the economy. In this regard, the introduction of ICT has initially occurred in specific sectors of the economy such as information and communication, manufacturing, financial services and is progressively spreading to different branches of the economy. David and Wright (2003) consider this pattern of development similar to what happened for electrification in the United States during the 1920s. The second is "improvement". That is, the new general purpose technology should make progress and lower the cost of its use over time. Also, GPT should be the tool that allows the creation of other innovations in terms of new "products or processes".[53] However, among others, there are two aspects that make ICT different from the previous technologies. The first is related to the productivity

[51] See David and Wright (2003) and Crafts (2004b).
[52] This terminology is derived from Bresnahan and Trajtenberg (1995).
[53] Jovanovic and Rousseau (2005, p.1183).

slowdown that occurred before ICT's arrival which has been stronger than during the electrification era. In addition to this, ICT has induced an important acceleration of the inventive activity and subsequently of innovation in many sectors (Jovanovic and Rousseau, 2005). Consequently, technological change was intensified and quickly spread across the sectors of the economy making the introduction of this general purpose technology more "revolutionary" than the previous technologies.[54]

The state of ICT diffusion and its evolution since the 1980s varied widely across European countries. Indicators such as the share of ICT investment[55] show that in the 1980s countries like the United States, the Netherlands, Germany, Italy and Ireland had the highest investment levels, amounting to 10-15 percent of total gross fixed capital formation. In 2001 other countries became important investors in ICT: the United Kingdom and Sweden invested more than 20 percent whereas Denmark and Finland had an investment rate around 15-20 percent.
In this context, economists have started examining the role that human capital played for the adoption of ICT and in the remainder of this section I will review the main findings in the existing literature.

The positive impact of human capital on ICT adoption, proxied by "the fraction of the labour force that has better than primary education", is supported by empirical evidence. According to Caselli and Coleman (2001) a one percentage increase of human capital increases computer imports by one percent. This study is the first to analyse the determinants of the adoption of computers for 155 countries over the period 1970-90. In a more recent work, Caselli and Coleman (2004) by using the growth accounting technique provide insight on how the endowment of skills of the labour force determines the choice over what technologies to adopt in such a way that they are complementary to the country specific stock of human capital. Bassanini and Scarpetta (2002) also recognize the positive role of human capital on the productivity performance of the OECD countries they include in their sample. However, they draw a distinction: they claim that a "skill upgrading"[56] occurred in those countries, such as United States and Canada that experienced an increase in labour utilization whereas in most European countries that experienced a decrease in

[54] Jovanovic and Rousseau (2005, p.1181).
[55] This indicator is measured as as a percentage of non-residential gross fixed capital formation of the total economy. These data have been obtained from OECD (2003, p.21).
[56] Bassanini and Scarpetta (2002, p.328).

working hours, what happened was a decrease in the employment of low skilled-workers. The studies that have been examined clearly show how the expansion of education or an upgrading in terms of skills of the labour force has positively affected the rate of adoption of the new technologies. These studies have focused on the quantitative aspect by looking at the fraction of the labour force holding a certain qualification and by focusing on primary and secondary levels of education. However, they do not address the question: what kind of human capital fosters the adoption of the ICT technologies? What are the challenges that policy-makers face in trying to determine what are the skills that help workers in dealing with these new technologies? These are the questions that will be addressed in the next chapters. That is, the interest of the analysis lies in examining how European institutions have adjusted the human capital of their labour force in order to recreate the "adaptive efficiency" specific to their own technical pattern.

Berman, Bound and Machin (1998) by testing for the hypothesis of technological change in the manufacturing sector, observed that the shift from unskilled labour to the high-skilled workers occurred in all developed countries during the 1980s. In addition to this evidence, they find that this change happened in the same industries across different countries. Their argument becomes even more convincing when they discover a similar pattern even if in smaller scale in the less developed countries. Following Abramovitz' s reasoning,[57] the fact that highly educated workers have not seen their wages decrease in spite of the increased supply of skilled workers, supports the hypothesis of technological change, that in this case has been named "skill-biased technological change". This refers to the increased demand for high-skilled workers and a greater quality of human capital as a result of the technological change. This aspect will be further explored in chapter 5 when returns to education across European countries for the different cohorts of the period 1985-2000 will be examined. More specifically, this change has also led to a substantial modification of the composition of the workforce. In fact, by looking at the statistics related to enrolment in higher education and the first employment of graduate students, for instance for Britain, it is possible to observe the shift from traditional subjects toward degrees that have been more recently introduced in communication science, business administration, social sciences and the creation of communication based

[57] This is explained with a detailed analysis in "Reinterpreting Economic Growth: Parables and Realities", (joint with Paul David in 1973).

degree programmes (Elias and Purcell, 2003). The analysis of the ICT-related degrees in vocational education and training as well as in higher education will be the topic of the analysis of chapter four.

The widening of the existing technological gaps with the United States generated an initial loss of "social capability": organizational settings that had allowed countries to successfully exploit the previous technologies were no longer adequate. This happened because the new technological environments required a different kind of "social capability" and "technological congruence". Cheap and low skilled labour progressively lost their position as fundamental factors to gain competitiveness and a more educated labour force became a necessity. As a result of the technological gaps, the institutional response varied across European countries. Therefore it seems important to examine what the different institutions did in order to create the "social capability" essential to deal with the technological change.

1.7) Limitations of the theory

By looking at this evidence, it seems reasonable to question how economic theory based on human capital and growth can explain the interaction between the adoption of more advanced technologies, as well as technological change, and the demand for a new kind of human capital. This issue is particularly sensitive because it is especially during the transition from the former to the new type of technologies that effective policy guidelines to shape human capital are needed.

In spite of the problems related to the specific models and the empirical frameworks, economic theory presents more serious limitations when trying to estimate the impact of human capital on growth. First of all, the proxies that are used and that have been described in an earlier section are very basic measures. In most of the existing studies the estimation relies on data of primary and secondary school without considering higher education that seems to be the educational sector that is potentially capable of making important contributions to growth, especially in developed countries. Moreover, the theory does not allow for the examination of the

composition of human capital. This is to say that it is not possible to test the impact of different kinds of education such as vocational training with respect to formal education. In models such as Hopenhayn and Chari (1991), defined as a "vintage human capital model", human capital cannot adapt to new technologies as the skills embodied in the labour force are specific and cannot be transferred. This implies that firms would face huge costs for the adoption of new technologies. This might be true in some context but it is difficult to accept as a general rule. Acemoglu and Pischke (1999) emphasize the need for the analysis of optimal skills by arguing that an adequate provision of training plays a key role when firms need to make a decision over the adoption of new technologies. Also, existing theory cannot provide policy guidelines to measure the impact on growth of different fields of education, Murphy, Shleifer and Vishny (1991), suggest that differences in the composition of human capital might have an impact on growth. A further shortcoming of the theory is represented by the fact that it does not consider the interaction of dissimilar kinds of human capital with different technological regimes. As Goldin and Katz (1998) have suggested, the introduction of new technologies may substitute workers' skills. According to their explanation, this was what happened during the transition from the artisan shop to the factory. On the other hand, the demand for more educated workers may increase when their skills are complementary to the use of the new technologies. This is a very sensitive issue for policy-makers because an expansion of education is likely to have different consequences depending on the technological environment. However, theory does not allow to test for different educational policies and for the interaction between the different composition of skills and technology. In fact, this kind of framework considers the adaptation of human capital to new technology as an automatic process and only suggests possible effects of different quantitative policies on growth. The interesting aspect is how the institutions react to this major change and what are the policies they adopt to successfully experience the transition to the new technological regime. In this context, the experience of European countries since the end of the Second World War may be insightful. However, in the existing literature there is no historical or empirical study that tries to undertake a comprehensive analysis of the interaction of these major changes and the human capital policies implemented. This is where I would like to make a contribution to the literature.

The focus on institutions can be justified as follows. First, as North (1990) suggests, the study of institutions, which "set the rules of the game",[58] is "what economic history is all about".[59] This is because the study of how different initial conditions in terms of endowments and political choices had an impact on growth and development is central to economic history. In fact, agents can make decisions concerning their investments in education, health and saving by taking the economic, political and social framework as given. That is to say that apart from the creation of economic incentives, institutions can also create an environment that is more or less favourable to acquire a certain type of knowledge. The example of the choice between acquiring skills to become a successful pirate or a productive chemical engineer well describes this.[60] In this regard, human capital policy can be considered as government intervention in the market place. According to public economics theory, "market failures" can arise in the provision of education when, without any institutional intervention, the provision of education would be different from the optimal level.[61] These market failures can be caused by different factors. Among the ones described in the literature one can find "externalities", "imperfect information" and "imperfect competition" (Barr, 1998; Stevens, 1999). The first is related to the external benefit of education that can make social returns to be greater than private returns. In this case the society as a whole could benefit from an increase in the level of education of the population. For instance a more educated population may lead to a decrease in crime, (Lochner and Moretti, 2004), an improvement in health (Lleras-Muney, 2002) and to an improved citizenship in terms of voting behaviour, (Moretti, Milligan and Oreopoulos, 2004). Imperfect information may prevent people from collecting information concerning the merits of education but also about the different educational opportunities therefore leading individuals to underinvest in education. The third market failure refers to the imperfect competition in capital markets which may make it difficult for less advantaged people raising money to face the cost of education due to the uncertainty concerning future returns. Moreover, "equity arguments" can lead governments to intervene in education policy.

[58] North (1990, p.3).
[59] North (1990, p.132).
[60] North (1990, p.77). The author argues that it is the nature of the institutions that creates the incentive for people to acquire different kind of skills. According to North's reasoning, a society that implements a greater "redistribution" would create incentives for people to become "pirates" whereas a society that rewards the productive activity would create greater incentives for people to acquire skills more oriented towards productive activities.
[61] Please refer to Bator (1958) and Mankiw et al. (2002) for a detailed explanation.

In the cases outlined market forces alone would not maximise economic efficiency and social welfare as education would be under-provided. This creates the need for governments to intervene in education policy. In this regard, the increase in school-leaving age, which will be examined in chapters three and five, provides a good example of institutional intervention implemented to raise the education level of the population. In fact, the market failures previously described may cause education to be under-supplied, therefore calling for a change in legislation. That is, governments can increase compulsory schooling if the marginal benefit is greater than its marginal cost.[62] Changes in the labour market can make these conditions vary and determine the optimal level of compulsory schooling which may differ over time and across countries.

On the other hand, it is worth observing that the need for state policy does not necessarily imply the existence of market failures. However, it may be the case that after the Second World War governments perceived the gap and implemented education and training reforms because the market response would have taken longer to become effective. This "speed of adjustment" argument has been suggested by Howlett (1994) for the increase in the role of the state that took place in Britain between 1939 and 1945. In this regard, the driving force behind the institutional response can be considered the strategic motivation (Broadberry and Howlett, 1998). Moreover, an institutional intervention in education and training can be justified by the fact that the majority of European workers are educated in public institutions therefore a public intervention is necessary in order to make major educational changes to occur.

The action of institutions can be examined through policies. In this specific case it would be interesting to examine what countries did, in education and training policy, in order to foster "adaptive efficiency".[63] This concept implies that depending on the economic context and the technological regime, countries need to adjust in order to meet the requirements of the new technology. But the adjustments necessary to

[62] For example, Psacharopoulos (1978, p.75) provides an analysis of the economic efficiency of the increase in school-leaving age law that was implemented in Greece in 1976 in terms of "social costs" (i.e., building expenses, teacher salaries, overall cost of keeping students additional time in school) and "social benefits" (i.e., higher productivity and earnings of children with respect to what they would have earned without additional schooling).

[63] North (1990, p.80), quoting Pelikan (1987).

successfully adapt to the new technologies vary overtime as different contexts require the appropriate institutional response. Also the cross-country dimension is important. In fact, the adequacy of education policies varies according to the level of development. As Gerschenkron (1962) has pointed out in his work, the great complexity of the process of catch-up in backward countries differs with respect to the one of the more advanced. He argues that what is important is to consider "the basic peculiarities of economic backwardness"[64] of these countries and the different policies they require in order to successfully adopt the more advanced technologies. This would explain how, depending on the initial conditions after the war, countries may have adopted different human capital policies. The advantage of using educational policies as a tool for the analysis relies on the fact that both descriptive analysis and empirical work can be carried out. This explains why I have decided to study some of the most important changes in education and training policy since the end of the war. What can be observed as a general evolution of education policy that will be explored in depth in the next chapters is the progressive shift from "quantity", that was a serious issue at the end of the conflict when many European countries exhibited high illiteracy rates to the "quality" of education (Hanushek, 2005). The latter aspect has animated the policy debate at European level more recently. In the next section I will address my research question and I will discuss the methodology I will use for the analysis.

1.8) Research question and plan of the analysis

The question I would like to address in my research is how European countries adjusted their human capital policy to the widening of the existing technological gaps that have occurred since the end of the Second World War and whether these changes have been sustained by the technological development. This is the big question. It can be split in order to study historical aspects of the education and training policies that have been less developed in the literature.

[64] Gerschenkron (1962, p.30).

In chapter two, I will provide an historical analysis of the state of technology, growth and human capital over 1950-2000. The topics I would like to consider in the following chapters are: the expansion of compulsory schooling, the curricula of education and the policy change in higher education as well as the returns to schooling. This is because in the recent empirical literature there are some studies that focus on the determinants of the adoption of more advanced and ICT technologies, but what is needed is a more general outlook of how human capital influences the technological diffusion. In particular, what has been the role of human capital with respect to the adoption of more advanced technologies after the war and later, of the ICT technologies and what did European countries do to adopt these new technologies. It is now possible to take an historical perspective by examining the education and training policy and their consequences since the end of the Second World War. This will show how different technological regimes require different kinds of human capital across historical times. It is also possible that some of the disappointing results with respect to the effect of human capital on growth are due to the short run perspective and to the fact that most of the existing studies have only considered how education and training have raised workers' productivity. This is in a way a limited view of the role of human capital that fails to provide a clear vision of the fundamental role that human capital has played in post-war Europe and what institutions have done in order to shape it. It would be interesting to examine what has been the evolution of the general design of the European education systems, what reforms have taken place and what strategy has been designed by European countries in order to close the gap with the United States. This is the reason why in the first part of the research I would like to focus the attention on the driving forces that have led the majority of European countries to raise compulsory schooling after the end of the Second World War. A further issue that historically has appeared of great interest in this general context is the one related to what kind of education, institutions should provide. The discussion over the choice between vocational training and general education has long animated economic debate. Moreover, the issue related to what kind of human capital policy has been more adequate in facilitating the introduction of ICT-related degrees needs to be studied in detail. In fact, few studies have focused the attention on this issue and none of the existing studies has presented a comprehensive analysis of the European experience.

Another aspect that might help in evaluating human capital policy is the estimation of the returns to education over time. That is, the analysis would provide a clear picture of the evolution of the wage premium across the different cohorts within Europe. That is new degree programmes have been introduced and participation rates have varied across countries. Both the institutional response and the market response have varied across countries and this interaction needs to be investigated.

Moreover, the choice of these topics is motivated by the following reasoning: they cover aspects of each educational sector that have become increasingly important as a result of technological change. In fact, the three topics briefly described in the previous paragraph are among the key issues that have animated the policy debate of the last fifty years. The expansion of compulsory schooling, a topic that has always been central to the policy debate since the introduction of formal education, became very sensitive in the aftermath of the Second World War. Moreover, the issue of what kind of education to provide: very specific by means of vocational training or general education has raised great policy concern since the early introduction of ICT. Furthermore, the expansion of higher education and the introduction of new degrees such as the ICT degree programmes is a clear institutional response to what was perceived as one of the necessities for upgrading the labour force in the information age. In addition to this, returns to education are central to policy concern across Europe. The topics selected cover the whole education system: the first topic concerns the expansion of compulsory schooling at the primary and the lower secondary levels of education; the second topic focuses on the upper-secondary and higher sector of the education system; the third topic covers the overall educational system. Therefore the rationale behind the sequence of the topics that will be analysed relies on the investigation of aspects of the different levels of the education and training system. The choice of the topics also reflects the shift of institutional strategy from issues strictly related to the "quantity" of education (i.e., number of years of compulsory schooling, number of students enrolled...) to a more "qualitative" conceptualization of the education policy (i.e., curricula of education, composition of higher education...).

It is important to observe that institutions change very slowly and the outcome of adjustments of the educational system can be perceived only when the students who received the formal education enter in the labour force. Moreover, these students

would only represent a portion of the workforce. In addition to this, the schooling system changes very slowly because of its specific nature. The main factor of production is represented by teachers, the turnover is for this reason generally slow and the level of technology embodied in teacher's knowledge can be updated but entirely replaced after quite a long time. It seems therefore appropriate to use a long run approach for the analysis and to set the beginning of the study in the aftermath of the Second World War. The time period chosen for the empirical analysis is 1950-2000 because the quantitative information is not available for the immediate aftermath of the Second World War. However, I will provide a descriptive analysis of the period 1945 to 1950.

In each substantive chapter a different number of Western European countries will be examined. The choice has mainly been dictated by data availability, the requirements of the technique used and the attempt of capturing the European heterogeneity in terms of education and training systems.

A further clarification seems to be necessary at this stage. The education policy of the United States will be studied only in chapter two in terms of general background. This is because American technological leadership has not been primarily human capital driven. Therefore, no claim is made that European countries should have adopted the American education and training policy in order to successfully close the technological gap. The USA is also not studied in depth for a practical reason. The three core chapters will examine original aspects of education policy that have not been previously studied. Data have been collected from a variety of national and international sources. This has required a great amount of work and in some parts of the thesis, in chapter four for instance, the analysis has been limited to three countries due to the great difficulty in collecting the data necessary to carry out the analysis for a larger number of countries. Collecting the same kind of data for the United States has not been viable. In particular, in chapter 3 the United States have not been studied as compulsory schooling laws have been implemented at different points in time across the states. In chapter 4, it has not been possible to collect data related to the introduction of the ICT-related degrees as a result of the lack of a central authority and the dissimilar introduction of these degrees across states. In chapter 5, the changes in compulsory schooling laws are used as instrumental variables and due to data constraint it is not possible to have information related to the state where each person interviewed did her studies. As a result of the

great mobility of the American labour force it does not seem plausible to assume that workers have studied in the state of current residence. Therefore, the analysis of the American educational policy with respect to the topics considered in the following chapters is beyond the scope of this project but represents a promising area for future research. In the following paragraphs I will provide a brief overview of the themes that will be studied in the next chapters in order to show the importance of the issues and the need for the analysis.

1.8.1) The expansion of compulsory schooling

The expansion of compulsory schooling is a very significant education policy change that has been undertaken by many European countries since the end of the Second World War. In fact, fifteen Western European countries increased the school-leaving age over the period 1945-2000. It is important to notice that this policy change has been highly concentrated in the twenty-five years following the end of the war, a period during which eleven countries implemented the school-leaving age laws.

Historically, the issue of the expansion of compulsory schooling has been dictated by different technological and socio-economic priorities that have generated dissimilar policy guidelines. Nevertheless, since the end of the Second World War most European countries have adopted a similar policy in expanding compulsory schooling. A report compiled in 1983 by the OECD recognized that in modern societies this has become necessary in order to "achieve the greatest good for individual and community to organize and control the education of the young...and to ensure that all have equal access to it".[65] This statement illustrates what is missing from the existing historical and economic literatures: an investigation of the driving forces behind this policy change at European level after the Second World War. In this context, the key issue is to develop an understanding of the technological, socio-economic and historical forces that have driven the expansion of compulsory schooling in Europe.

[65] OECD (1983, p.10).

Although, studies have been carried out for many individual European countries, what is missing from the existing literature is a comparative analysis on the determinants of the expansion of compulsory schooling and this is the gap I would like to fill with my work. The research question I will address in this part of the dissertation is: what are the driving forces behind the increase in compulsory schooling that took place in Europe after the Second World War? That is to say, how is it possible to explain the timing of the changes in school-leaving age laws that occurred in most European countries after the war? In order to address these issues I will proceed by taking an historical overview of the institution of compulsory schooling in Western European countries. I will use both primary and secondary sources. After, I will describe the post-war situation and the timing of the passage of the school-leaving age laws that has characterized the experience of European countries by highlighting the importance of the topic. The empirical investigation makes use of a new technique based on survival analysis, which has been traditionally used in medical analysis. I will conclude the section by analyzing the results and by repositioning the findings in the historical background of post-war Europe.

1.8.2) Institutional response to the technological gap in vocational education and higher education

Chapter four will start with a critical review of how the existing literature has addressed the need of increasing the level of human capital of the population as a result of the introduction of the ICT technologies. The shortcomings of the model that is closest to the topic of the dissertation will be emphasised. An important aspect of the argument will be the heterogeneity within Europe in terms of educational curricula and rates of ICT adoption.

The research question that will be addressed in this chapter of the thesis is: how have institutions of different countries adjusted their education and training system in order to support the ongoing technological transformation since the beginning of the 1980s? Namely, what strategy was undertaken with respect to vocational and higher education in order to facilitate the adoption of ICT technologies. The choice between general education and vocational training is an issue that has created great

divergence among policy-makers and an analysis is necessary to fully understand the debate and the different policies undertaken in the European context. In this regard, the ICT-related vocational training programmes as well as the degrees introduced in three European countries will be examined. Moreover, a critical evaluation of the European policy and its impact on the convergence of the education and training systems towards a European model will be carried out. Finally, a tentative conclusion will be drawn on the adequacy of the EU policy to close the gap with the United States. The analysis will focus on three European countries: Germany, the Netherlands and Portugal, each representing a different aspect of European heterogeneity.

1.8.3) Returns to education across European countries

Following the analysis undertaken in the previous chapters concerning policy changes at primary and lower secondary level in chapter three and at secondary and higher education level in chapter four, the focus of this section will be on an aspect related to the interaction between education and technology, that is the estimation of the returns to education. This is because having examined technological change and the extraordinary expansion of education that has taken place in Western Europe since 1945, it seems important to try to develop an understanding of what is the market reward and how it has changed over time. According to Nelson and Phelps (1966) as well as Krusell et al. (2000), the spread of more advanced technologies should lead to an increase in wages of skilled workers. Therefore, it seems important to examine how demand and supply for skills have interacted.

The research question that will be addressed in this chapter is: what are the returns to education across European countries? How have they changed over time? The estimation will be carried out for seven Western European countries by using a cohort analysis over 1985-2000. An internationally comparable dataset will be used as well as an innovative technique that allows reducing the problem of endogeneity that arises from the estimation of returns to schooling. The results will be compared with those found in previous studies in order to check for consistency. Having examined in chapter two the expansion of education in terms of participation rates

and in the following chapters by means of institutional changes, this chapter will provide an insight on how the wage premium has changed across countries according to the different levels of education.

1.9) Conclusion

Two major events have created an initial loss of "social capability" in Europe in the second half of the twentieth century. First, the Second World War contributed to an increase in the technological gap between the United States and European countries. Second, a major technological change has occurred during the last decades as a result of the introduction of the information and communication technologies, generating great transformations in the socio-economic environment of most European countries. In this context, countries have found it necessary to undertake major adjustments in order to benefit from the technological opportunity. This is because the lack of adaptability would have prevented European nations from taking advantage of the new technological opportunities. Many studies have analysed specific aspects of the adjustments that have taken place in the different knowledge-based societies. However, none of these studies has examined the institutional response by taking both a comparative approach and a long run perspective. The purpose of my research is to try to fill this gap in the existing literature by taking an historical perspective for the analysis of the institutional response in key educational sectors that have not been adequately studied until now. In fact, during the last decades, European countries have experienced a big adjustment challenge. It is possible to take a comparative approach and add much value to the existing literature in answering the historical question by looking at aspects of human capital policy that have not been previously studied. This is because issues such as the expansion of compulsory schooling, the choice of the curricula in terms of vocational training and general education as well as policy changes in higher education have animated the policy debate of most European countries during the last decades. Nonetheless, institutional intervention has varied across countries and this heterogeneity needs to be analysed. In fact, it may well be true that the production of human capital and "the distribution of earnings" are "a race between technology and education"[66] as the events of the twentieth century have shown. However, institutions seem to have a key role to play in this race, especially since the end of the Second World War.

[66] The phrase "the distribution of earnings is a race between technology and institutions" comes from Goldin and Katz (1999, p.1), quoting Tinbergen (1975).

Chapter Two

POST-WAR EUROPEAN GROWTH, TECHNOLOGICAL GAPS AND THE ROLE OF HUMAN CAPITAL

2.1) Introduction

The interest of my thesis is to look at the impact of technological gaps on growth by analysing the role that human capital plays in this process. The purpose is to examine the structural adjustments undertaken by European countries to adapt the skill endowment of the labour force to the necessities of the new technologies in order to foster growth. At this stage, it appears essential to provide an overview of the historical context that is relevant to the topics that will be explored in the next chapters. This chapter will provide an overview of the historical background of growth, technology and human capital over the period 1950-2000.

The post-war history of Europe has been characterized by major socio-economic transformations. The early post-war experience was shaped by a rapid reconstruction and an extraordinary growth that for its exceptional character was called the Golden Age.[67] In Western Europe a phase of political consolidation of democracy followed the war, a new European order was established and new agreements were reached at international level creating the bases for subsequent cooperation and integration during the 1950s to the 1970s. Moreover, most European countries started absorbing the "backlog of existing technologies"[68] in the aftermath of the war and later new technological developments enhanced the globalisation process. Furthermore, a great social change was caused by the demographic expansion that occurred after the war. This was due to a decline of mortality and a transitory rise in fertility that occurred in all Western countries but did not last for long.[69] In addition to this, the greater economic prosperity created the demand for new types of social services and the role of the state in the provision of these services was greatly intensified in many European countries as Johnson (1999) has shown. Whilst acknowledging the importance of some of these major transformations in creating the need to adjust the existing educational institutions, the focus of the analysis in this chapter will be limited to the aspects that are more relevant to my dissertation. Therefore, I will provide the analysis of the historical background in terms of growth, technology and human capital that have shaped the European scenario in the post-war era.

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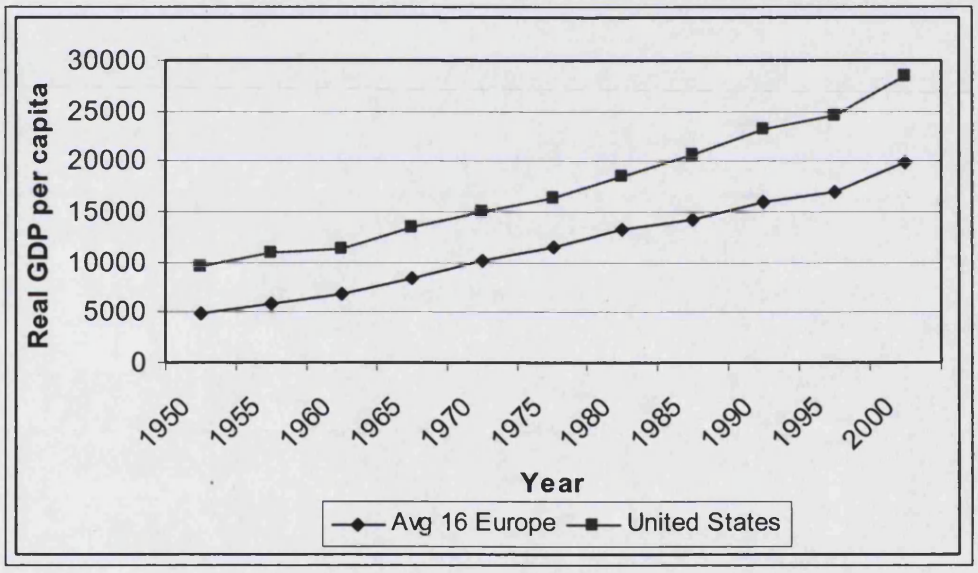
[67] This is how the European growth over the period 1950-73 is conventionally called. Among the authors who have made use of this expression: Crafts and Toniolo (1996) and Temin (2002).
[68] Eichengreen and Vazquez (2000, p.92).
[69] Baines (1999, p.163). The author describes how in 1950 the fertility rate was above the replacement level in many European countries whereas in 1970 it remained at this level only in Ireland, Spain and Portugal.

I will describe the pattern of growth by highlighting the acceleration and the post-Golden Age slowdown that has been illustrated by authors like Maddison (1991) and Crafts (2004a). Then, I will examine the progress of technology since 1945 by focusing on the early technologies and the later introduction of the information and communication technologies. In this context, I will take a comparative approach in order to look at the impact of these technologies on productivity in both European countries and the United States. After, I will provide an overview of the main changes that have occurred in terms of schooling participation and I will highlight some of the issues that have gained a central role in the debates concerning the educational system of the European countries. Finally, I will illustrate the main features of the European vocational training systems and I will describe the pattern of participation.

2.2) Growth

In this section the evolution of GDP per capita will be considered both in terms of levels and growth rates since the end of the Second World War. Moreover, the contributions that in the existing literature provide an explanation for the pattern of growth will be reviewed. GDP per capita has progressively increased in Europe since the end of the war, this long period of growth and peace has allowed Western Europe to become prosperous, and citizens to benefit from increased living standards. The graph below shows the evolution of the average real GDP per capita of sixteen European countries over 1950-2000.

Figure 2.1 Evolution of real GDP per capita, average of 16 European countries (1990 Gheary-Khamis dollars), 1950-2000*



Note: * The European countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.
** For Germany, the Federal Republic is considered until 1989, thereafter the entire country.
Source: Groningen Growth and Development Centre (2006)

According to Crafts and Toniolo (1996), European countries have experienced two "epochs of growth"[70] since the end of the Second World War. The first epoch covers the period 1950-73. During this period the European experience was characterized by a rapid reconstruction and an extraordinary growth that for its exceptional

[70] Crafts and Toniolo (1996, p.32).

character was called the Golden Age. In fact, most European countries experienced exceptional rates of growth, fast increases in investment rates and major institutional transformations at both national and international level. The second phase, which goes from 1973 onwards, is characterized by a general growth slowdown and by a negative economic performance in most European countries. The average growth for the Golden Age and the subsequent period has been calculated and from table 2.1 it is possible to examine the pattern of GDP per capita in levels and growth rates for sixteen European countries and the United States.

Table 2.1. Levels and Growth Rates of GDP per capita in 16 European countries and the United States, 1950-2000

	Levels (1990 Gheary-Khamis dollars)			Growth per year (%)	
	1950	1973	2000	1950-1973	1974-2000
Austria	3706	11235	20656	4.94	2.28
Belgium	5462	12170	20649	3.54	1.98
Denmark	6943	13945	22969	3.08	1.87
Finland	4253	11085	19528	4.25	2.12
France	5271	13114	21277	4.04	1.81
Germany*	4281	13153	18981	5.00	1.37
Greece	1915	7655	12070	6.21	2.00
Ireland	3453	6867	21741	3.03	4.36
Italy	3502	10634	18786	4.95	2.13
Netherlands	5971	13081	21601	3.47	1.88
Norway	5463	11247	25133	3.19	3.02
Portugal	2086	7063	14105	5.45	2.59
Spain	2189	7661	15622	5.60	2.67
Sweden	6739	13494	20759	3.06	1.61
Switzerland	9064	18204	22381	3.08	0.77
United Kingdom	6939	12025	20159	2.42	1.93
Average 16 EU countries**	4827	11415	19776	3.81	2.06
United States	9561	16689	28403	2.45	1.99

Note: * For Germany, the Federal Republic is considered until 1989, thereafter the entire country
** The average has been calculated for the 16 Western European countries presented in the table
Source: Groningen Growth and Development Centre (2006) and Crafts and Toniolo (1996)

What can be observed from the table is that GDP per capita growth has been more important in Southern European countries that were the countries that in 1950 exhibited the lowest levels of GDP per capita. Greece, Italy, Portugal and Spain

grew on average at levels higher than 5 percent per year. On the other hand, countries like Denmark, Norway and Sweden, that had relatively minor opportunities to catch-up, grew at a sustained rate of around 3 percent. During the Golden Age, the lowest growth among these European countries was experienced by the United Kingdom, 2.42 percent per annum. The European growth performance was even more surprising if one thinks about the damages and the dislocations of the factors of production caused by the war. Obviously, as Cameron (2004) has shown part of this growth, especially during the first years following the war, was due to reconstruction and the redeployment of capital and labour from wartime to civilian economic activities. Following the author's estimation, by using a Cobb-Douglas production function with a labour share of 0.7, a loss of a quarter of capital stock reduces output by 8 percent.[71] In this regard, West Germany lost 12 percent of its capital stock, France 8 percent, Italy 7 percent whereas the United Kingdom lost 2 percent of its capital stock.[72] In table 2.2 it is possible to observe the timing of post-war reconstruction for twelve Western European countries.

Table 2.2. Post-war reconstruction, 12 European countries, 1945-1951

	Setback Year*	**Recovery Year****	**Reconstruction Growth Rate*****
Austria	1886	1951	15.2
Belgium	1924	1948	6.0
Denmark	1936	1946	13.5
Finland	1938	1945	...
France	1891	1949	19.0
Germany	1908	1951	13.5
Italy	1909	1950	11.2
Netherlands	1912	1947	39.8
Norway	1937	1946	9.7
Sweden	never		
Switzerland	never		
UK	never		

Note: * Setback Year: pre-war year when GDP was the same as in 1945
** Recovery Year: year when GDP recovered its highest pre-war level
*** Reconstruction Growth Rate: annual growth rate of GDP during the period 1945 and the recovery year
... Data unavailable
Source: Crafts and Toniolo (1996) and Cameron (2004)

[71] Cameron (2004, p.9).
[72] Cameron (2004, p.9). On the other hand, Broadberry and Howlett (1998, p.69) offer a different figure for the United Kingdom as they have estimated the loss of physical capital to be equal to 18.6 percent of the prewar stock of national wealth.

In the aftermath of the Second World War, reconstruction was very rapid in countries like Denmark, Finland and Norway where the damages caused by the war were more limited with respect to the Continental countries as the setback year indicates. However, it is possible to notice that also in countries like France, Germany and Italy that suffered from major war destruction, restoration was fast and by 1951 these countries had reached their highest GDP pre-war levels. In this regard, Smolny (2000) acknowledges the existence of a high positive correlation between reconstruction growth and the extent of war-time damages.[73] But the high growth rates were not simply a deviation from the long-run pattern of growth resulting from the recovery of the war as Janossy (1969) suggested. Crafts and Mills (1996) provide econometric evidence of the unexpected growth rates that characterized the post-war period. In fact, the authors recognize the importance of reconstruction in fostering growth especially in the immediate aftermath of the war. However, they reject the hypothesis of a temporary deviation from a long-run growth. According to the authors, who provide empirical evidence for ten European countries, the growth rates experienced at the end of the war were much higher than the process of reconstruction would have implied. Many explanations have been provided by economic historians and economists in order to account for the astonishing European growth performance until 1973. Eichengreen (1996) and Olson (1996b) focus on the institutional aspects. According to the former it was the creation of institutions at both domestic and international level that allowed the implementation of wage moderation and high investment rates that finally led to growth. Olson's (1996b) analysis relies more on the removal of social barriers represented by pressure groups that lost a great amount of power during the war and that were no longer able of retarding growth after the war. More generally, Abramovitz (1986) highlights the importance of the appropriate conditions conducive to growth. These were both institutional, economic and social factors that created the right "social capability" that allowed countries to increase investments and to import more advanced technologies. Maddison (1991) considers all these explanatory factors to be important and he adds to these the "governmental promotion of buoyant domestic demand".[74] On the other hand, Temin (2002) gives attention to the contingent factors that created the scope for catch-up. According to his argument, these were three major disequilibria: the war-time destruction, the high portion of labour force in the

[73] Smolny (2000, p.593); this is shown in a graph.
[74] Maddison (1991, p.168).

agricultural sector and the income level below the equilibrium level. According to the author, these major disequilibria created the conditions for countries to grow at very high rates after 1945.

The Golden Age came to an end in the 1970s when the pattern of sustained growth slowed down. From table 2.1 it is possible to observe that on average Western European countries grew at 2.06 percent per annum between 1974 and 2000 (whereas during the *Trente Glorieuses* they were growing on average at a rate of 3.81 percent). From table 2.1 it is also possible to observe that Southern European countries continued to grow at a rate above the average whereas Germany, Sweden, Switzerland and the United Kingdom experienced the lowest rates of growth. The only exception to this sluggish performance is represented by Ireland, a country which experienced a modest rate of growth during the Golden Age but much higher growth, 4.36 percent per year, after 1973 when the massive investments in ICT accounted for the growth revival. ÓGráda and O'Rourke (1996) as well as Barry and Crafts (1999) have provided an exhaustive analysis of the historical experience of this "Celtic Tiger". According to Crafts and Toniolo (1996), the European slowdown was a normal return to the long-run pattern of growth. Among the tentative explanations that can be found in the literature, Temin (2002) highlights the importance of the structural adjustments, which have been outlined above, that eliminated the disequilibria and reduced the scope for catch-up.[75] Eichengreen (1996) focuses both on the transitory factors and the circumstances that ended the wage moderation at domestic level and undermined cooperation in the international scenario such as the oil shocks, the breakdown of Bretton Woods and rising capital mobility.

In order to summarize the content of this section: a period of extraordinary growth has characterized the post-war experience of most Western European countries. Starting in 1973 this unprecedented pattern of growth came to an end and was followed by a lower growth performance. Many scholars have studied these trends of European growth and have provided tentative answers to understand the driving forces behind the beginning and the end of the Golden Age. Interestingly, towards

[75] According to Temin once the reconstruction was achieved, the transfer of the labour force from the agricultural sector to the more advanced sectors of the economy was completed and income had reached its equilibrium level, the transitory determinants of the high growth rates disappeared.

the end of the seventies a new general purpose technology, ICT, was introduced in Western countries. This technological change created the potential for a growth revival. However, the new technological opportunity also required a different "social capability" in order for countries to take full advantage from it. A large body of literature shows how European countries lagged behind the United States in creating these new conditions.[76] The historical background of the technological environment that has characterized the European experience will be explored in the next section.

2.3) The state of technology

2.3.1) Technology after the Second World War

As acknowledged in the previous chapter, the end of the Second World War saw an increasing technological gap between Europe and the United States that induced governments of European countries to undertake reforms in many sectors of the economy (Eichengreen and Iversen, 1999). In this section I will start by describing the main features of technology in the aftermath of the war, after I will provide some measures of productivity in order to quantify the gap with respect to the United States. Finally, I will review the more satisfactory explanations that can be found in the existing literature.

I should start by acknowledging the difficulty of finding accurate analysis of the state of technology in the aftermath of the Second World War. In fact, studies of international organizations start later, normally in the late 1960s, whereas national sources are often not available. In this paucity of information, Broadberry's (1997) collection of case studies, represents a valuable source of information. This insightful study shows the technological differences between Europe and the United States in the early post-war period in a number of industries. It covers the period 1950-90 and the main focus is on the United Kingdom. Nevertheless, detailed information related to the state of technology in other European countries can be

[76] See for example Gust and Marquez (2002) and Kneller et al. (1999).

extracted from the book. The author shows how in sectors such as the chemical, the oil refining as well as the iron and steel industry, the United States benefited from an undisputed technological leadership with respect to European countries. Also, in the engineering industry the United States maintained their leading position. In 1950, in producing motor vehicles, the productivity of American firms was more than four times greater than British firms; also in the production of consumer goods such as radios and household appliances American productivity was four times greater than on the other side of the Atlantic.[77] According to Broadberry, "technology was the fundamental factor underlying these dramatic trends".[78] This is because the technologies of mass production were perfectly suited for the American economy. The size of the market, the great availability of natural resources and the stock of human capital sustained the American technological leadership as Nelson and Wright (1992) have argued. On the other hand, the same technologies could not be immediately adapted to the European system of production as it took some time before European countries could create the appropriate "technological congruence". Broadberry's (1997) analysis draws on both national sources and the reports of the Anglo-American Council on Productivity that was established in order to increase cooperation between American and British firms and to support the Anglo-Saxon firms in the adoption of more advanced technologies. Another important document that provides data on the technological development in the aftermath of the war is the international study carried out by the National Institute of Economic and Social Research (NIESR) from 1967 until 1972. This report is particularly important as it is the first joint project at which a number of research institutes of other European countries such as Austria, France, Italy, Germany and Sweden participated. In order to study the advance of technology and to measure the spread of the related innovations in the economy of different countries, the authors of this report, Nasbeth and Ray (1974) selected ten new processes introduced in the immediate aftermath of the war and they carried out an investigation at the micro level. They examined the speed of diffusion of the new processes and the level achieved by 1968.[79] The ten processes were chosen in order not to create a bias in the analysis: they covered consumer goods as well as producer goods and small and large capital investment; in addition to this, processes more or less directed to the export sector were selected for

[77] These data have been extracted from Broadberry (1997, p.317).
[78] Broadberry (1997, p.318).
[79] Nasbeth and Ray (1974, p.11).

the analysis. A questionnaire was constructed and submitted to individual firms in order to understand what were the most important factors that affected the diffusion of technology. The United States was the leader in the diffusion of numerically controlled machines.[80] Nasbeth and Ray discussed that this was probably the result of the development of the electronic fire-control developed in the United States during the Second World War.[81] Also in the adoption of the tunnel kilns in brick-making[82] and the diffusion of the basic oxygen steel process[83] the United States was the earlier adopter. The diffusion of shuttleless looms was achieved first by the United States and Germany. On the other hand, Sweden was the first to diffuse the process of continuous casting of steel and the process of special presses. Therefore, according to the results of the NIESR inquiry there was no unique leader in the diffusion of the new technological processes. However, the United States showed its primacy in most of the selected innovations. As the Anglo-American Council on Productivity had shown, the United States was the technological leader and in the 1960s could still develop and adopt technologies faster than European countries on average.

At the macro level a measure for the technological gap has been provided in the economic literature by using the growth accounting approach. This approach relies on the decomposition of growth according to the contribution of the different factors of production. In this context, an indicator that is used in the literature to compare the performance of different countries in the various sectors of the economy is labour productivity. This is because, in spite of some difficulties, this measure is quite easily compared across countries.[84] In table 2.3 the labour productivity of eight European countries in the manufacturing sector is estimated with respect to the United States for three benchmark years 1950, 1973 and 2000.

[80] Among these numerically controlled machines, pumps, turning machines, turbines and printing machines were selected (Nasbeth and Ray, 1974, p.29).
[81] Nasbeth and Ray (1974, p.27).
[82] This was an improved process for shaping the raw material and it was the application of a Danish invention of 1840 (Nasbeth and Ray, 1974, p.105).
[83] This was an improved technique adopted in the process of steelmaking (Nasbeth and Ray, 1974, p.146).
[84] Difficulties arise when one wants to compare the "quality" of labour. This is because differences in vocational qualifications can make the task difficult.

Table 2.3. Real GDP per hour worked in manufacturing, 1950-2000 (US=100)

	1950	1973	2000
Belgium	...	71.6	104.3
Finland	38.0	58.7	106.6
France	37.7	76.2	92.6
Germany	33.6	83.1	87.6
Netherlands	35.4	80.5	95.3
Spain	...	38.0	38.2
Sweden	48.6	90.1	95.1
United Kingdom	36.4	54.9	55.2

Note: data for Germany refer to West Germany until 1989
... data not available
Source: Groningen Growth and Development Centre (2004)

What can be observed from the table is the greater American labour productivity with respect to the European countries analyzed. It is also possible to notice that this leadership decreases over time; however only Belgium and Finland reach labour productivity levels greater than the United States in 2000.

A better measure to capture the transatlantic technological gap of course would be the total factor productivity. However, this measurement involves the estimation of capital productivity, being the technological progress estimated as the residual growth once the impact of the other factors of production has been taken into account. Data on capital productivity are not always accurate especially for the earlier periods as estimations have been included in the national accounts of many European countries only since the 1970s and "direct observation of capital stock is a complicated and resource demanding process".[85] This is one of the reasons why scholars have moved into this area of research very slowly. For a limited number of countries it is possible to have estimation for the total factor productivity since 1950. Labour and capital productivity measures have been extracted from van Ark (1993). Other accurate estimates of capital productivity and hence total factor productivity have also been provided by Jorgenson et al. (1981).

[85] van Ark (1993, p.33).

Table 2.4. Total factor productivity in manufacturing, 1950-1989 (US=100)

	1950	**1973**	**1989**
France	40.1	65.8	72.9
Germany	51.3	77.6	78.6
Netherlands	46.5	70.2	70.6
United Kingdom	50.0	59.0	65.5

Source: van Ark (1993)

What can be observed from the table above is the large gap between the American total factor productivity and the European one. Total factor productivity in the United States in 1950 was nearly twice as great as that in the European countries analysed. It is also possible to discern the progressive catch-up that has been particularly important for France, Germany and the Netherlands.

The analysis so far has been limited to the manufacturing sector but estimates for the whole market economy have been provided by Broadberry (2006). According to the author, the service sector is the sector of the economy that more clearly reveals the technological differential between countries as there is less scope for imports in this sector of the economy. A measure of total factor productivity that shows the increased technological gap of the two major European economies with respect to the United States since the end of the Second World War is presented in table 2.5.

Table 2.5. Total factor productivity of US and Germany relative to the UK, 1935-1990

US/UK (UK=100)	**Agriculture**	**Industry**	**Services***	**Aggregate economy**
1937	119.2	161.2	89.1	105.9
1950	132.6	217.6	110.2	138.1
1973	125.9	202.2	120.6	137.4
1990	138.8	157.3	119.8	125.3
Germany/UK (UK=100)	**Agriculture**	**Industry**	**Services***	**Aggregate economy**
1935	59.6	97.1	88.8	78.2
1950	44.7	89.4	89.3	76.2
1973	48.1	105.7	127.6	108.6
1990	65.4	98.5	139.0	116.5

Note: * both market and non-market services are included
Source: Broadberry (2006)

What is worth noticing is the increased gap in total factor productivity that characterizes the British experience with respect to the United States in the immediate aftermath of the war, especially in the industrial sector where the gap increased by more than fifty percentage points. The above table also shows the relative productivity performance of Germany with respect to the United Kingdom. In spite of the war-time destruction, Germany recovered quickly and since 1973 has achieved greater total factor productivity than the United Kingdom at aggregate level but not in the agricultural sector. Unfortunately, data for other European countries are not available. However, Germany and the United Kingdom can be considered among the most advanced European economies as early as in the 1950s and therefore they should provide a plausible measure of the transatlantic gap.

Among the causes of the productivity differential, Broadberry (1997) emphasizes the importance of factor endowment and market size as affecting the possibility of adopting US-style mass production technology. Apart from this descriptive analysis, empirical estimations have been undertaken by scholars in order to explain the technological gap with the United States. In the estimation carried out by Broadberry and Crafts (1996), human capital appears to be the single most important factor in explaining the productivity differential between the United States and the United

Kingdom. This result is supported by O'Mahony's (1992) findings who also draws a distinction of the labour force according to the level of skills and finds that human capital was an important determinant of the productivity differential between Germany and the United Kingdom in 1987. This was evident in many industries such as the chemical industry where, as Broadberry (1997) reports, the Anglo-American Council on Productivity found that in 1953 in the United States there was "a technically qualified man for every six workers" whereas "in Britain the ratio was one to sixteen".[86] There is no similar information available for the other European countries. Other factors identified by Broadberry and Crafts as affecting the relative productivity performance appear to be the restrictive practices to bargain and expenditure on R&D.

The technological gap between the United States and European countries had greatly intensified by the end of the war. However, soon after the reconstruction was completed great opportunities for catch-up became available to European countries as Eichengreen (1996) emphasised. This was a result of many policies undertaken at domestic and international level such as the Marshall Plan, the creation of productivity agencies, the greater cooperation between countries and the beginning of the European integration process as well as the expansion of trade and many others factors. European countries undertook different policies in order to narrow the technological gap with the United States and to become more competitive.

In the next chapter I will examine a human capital policy, the expansion of compulsory schooling that was perceived by European institutions as an instrument to increase competitiveness at international level (Marlow-Ferguson, 2002). Table 2.6 shows the increased effort of European countries in terms of R&D expenditure. Data for earlier periods and other European countries are not available.

[86] Broadberry (1997, p.295).

Table 2.6. Expenditure on R&D per person employed, 1960-1987 ($ in 1985 US relative prices)

	1960	**1973**	**1987**
France	207	448	761
Germany	179	475	848
Netherlands	291	514	687
United Kingdom	343	480	650
United States	809	814	1074

Source: Maddison (1991)

In this section the technological gap of European countries with respect to the United States at the end of the Second World War has been described. This was done by showing how Europe lagged behind in terms of labour and total factor productivity in specific sectors as well as in the whole economy. Also, key results in the existing literature showing the importance of human capital in explaining the "Atlantic Divide" have been acknowledged. In this regard, it seems of great interest to develop an understanding of what has been the policy response in education in the post-war period. That is to say, what European governments did in order to shape the human capital stock to close the technological gap with the United States. These issues will be investigated in the following chapters.

2.3.2) Information and communication technology

The major technological change of the second half of the twentieth century is represented by the introduction of the information and communication technology. The broad ranges of these new technologies share the feature of allowing more efficient ways of gathering, storing and transmitting information.[87] In doing so, they foster the introduction of innovations in products, processes and organizational structures. Some of the innovations involved by these technologies consist of advances in microelectronics, computing (hardware and software), telecommunications and opto-electronics as well as micro-processors,

[87] UNESCO (2002a, p.13).

semiconductors and fibre optics according to the definition provided by the UNESCO (2002b). As a result of its great impact on the whole economy, this general purpose technology has been considered by Jovanovic and Rousseau (2005) as one of the two most important and revolutionary technological advances to date, the other being electricity at the beginning of the twentieth century. In fact, it should be acknowledged that the importance of these technologies is increasing as they provide "the support of the central nervous system of complex societies by transmitting and processing information and commands among the various parts of such societies".[88]

In order to examine the spread of ICT in the European economies, in table 2.7, a measure of the share of investment in ICT as a percentage of GDP is provided. The measure of ICT investment includes computer and communication equipment as well as expenditure on software. These data are extracted from the dataset assembled by Timmer et al. (2003) in the context of a research project of the Groningen Growth and Development Centre. It has been constructed for fourteen European countries and the United States over 1980-2001 and in June 2005 has been updated and extended until 2004. Data for earlier periods are very difficult to obtain. This is because statistics on ICT investment and capital stock are not easily available for every country and differences in classifications make the comparison even more difficult. However, this short time-series is a good source of information, the best available so far, also because as Timmer et al. (2003) recognize: even if ICT has been available since the 1970s, "only recently has become a dominant factor in economic growth".[89]

[88] Radicella (2002, p.3).
[89] Timmer et al. (2003, p.17).

Table 2.7. Investment in ICT as a share of GDP, 1980-2004 (current prices)[90]

	1980	1990	2001	2004
Austria	1.3	1.9	2.4	2.3
Belgium	1.7	3.1	3.6	2.8
Denmark	1.5	2.9	3.6	3.2
Finland	1.1	1.9	4.3	3.7
France	1.0	1.5	2.1	1.7
Germany	1.3	2.4	2.5	1.9
Greece	0.7	1.3	3.3	2.3
Ireland	0.9	1.2	1.9	1.1
Italy	1.5	2.3	2.5	2.2
Netherlands	1.6	2.4	2.9	2.4
Portugal	1.2	1.8	2.1	1.9
Spain	0.9	2.5	2.1	2.0
Sweden	1.6	2.7	4.7	3.1
United Kingdom	0.8	2.3	3.0	2.4
Average 14 EU countries*	1.2	2.2	2.6	2.4
United States	2.5	3.3	4.2	4.1

Note: * The average has been calculated for the 14 Western European countries presented in the table
Data for 1980-2001 have been extracted from Timmer et al. (2003, table 3)
Data for 2004 have been extracted from Timmer et al. (2003), appendix tables updated in June 2005
Source: Timmer et al. (2003), table 3 and appendix tables updated June 2005

What can be immediately observed is the disparity in investment between the European Union and the United States. In spite of the increase in investment until 2001, on average Europe has lagged behind the United States since the early 1980s,[91] at this time the investment in ICT as a share of GDP was less than half of the American one. From a decomposition of the share in gross fixed capital formation that is drawn from the dataset constructed by Timmer et al. (2003), it is possible to observe that the "Atlantic Divide" in terms of GDP expenditure has been reduced as a result of the increased European investment in office and computer equipment and to a lesser extent thanks to the communication equipment that goes from 2.9 percent in 1980 to 4.4 percent in 2001.[92] In spite of some improvement, the gap in the

[90] These data are lower than Daveri's (2002, p.351) estimations for the period 1992-2001. However, the evolution of the expenditure is nearly the same.
[91] This is true if the European average is considered. In fact, as it will be explained further below, there are exceptions. In the year 2001, countries like Finland and Sweden have invested in ICT a share of GDP that is greater than the American one.
[92] Data related to ICT presented in this section have been extracted from the dataset constructed by Timmer et al. (2003) and the appendix tables updated in June 2005. Different sources will be acknowledged.

software industry remains high where the share in non-residential gross fixed capital formation reaches 13.9 percent in the United States in 2001 against an European rate of 7.1 percent. It is also important to notice the great heterogeneity that exists at European level. Countries like Belgium, Denmark and Sweden had investment rates well above the European average over the entire period considered and in 2001 ICT investment as a share of GDP in Finland and Sweden was greater than the American one. On the other hand, countries like Greece and the United Kingdom started from low rates, 0.7 and 0.8 respectively, but they could catch-up and reached levels above the European average in 2001. Ireland has experienced increasing inward investment and a great development of ICT manufacturing especially in the last decade of the twentieth century.[93] The Irish republic has been so successful in adopting ICT technologies that its experience has been defined the "Irish miracle". Among other things, an indicator of the successful performance of this "Celtic Tiger" is the increase by 40.6 percent of the communication equipment measured as a share of gross fixed capital formation over the period 1995-2000.

Another indicator that has been introduced in the literature in order to capture the phenomenon of ICT spread since its early stages is the import of computing equipment. According to Caselli and Coleman (2004), who first constructed a dataset for a large number of countries around the world, computer imports can be considered as an adequate proxy for computer investment because many countries in the 1970s did not have a computer industry and therefore computer imports really reflect the embodied technology. Obviously these data have to be considered with caution as over time many countries have developed a domestic computer industry and therefore computer imports cannot longer be considered an adequate proxy to measure computer investment. Nevertheless this indicator is important as computers represent the ICT appliance that has been the most pervasive in society. Moreover, as a result of data availability, this indicator allows extending the analysis to several European countries. It is important to notice that obviously this indicator cannot be used to make a consistent comparison between the diffusion of ICT in Europe with respect to the United States. This is because, in the 1980s and 1990s the United States was the world leader in computer manufacturing. Therefore, the measure of computer imports would not reflect the American high rate of investment in

[93] This has been explained by Barry and Crafts (1999).

computers. In table 2.8, data related to computer imports per workers for fifteen European countries are shown.

Table 2.8. Computer imports per worker, 1970-1990

	1970	1980	1990
Austria	...	63.14	236.46
Belgium	7.71	100.67	363.33
Denmark	6.62	78.28	261.03
Finland	2.08	56.62	209.96
France	4.60	59.53	198.79
Greece	0.60	6.08	42.62
Ireland	1.38	95.82	451.44
Italy	2.26	38.27	150.83
Netherlands	8.29	117.22	689.84
Norway	1.70	79.89	263.80
Portugal	0.95	8.99	82.05
Spain	1.89	25.33	134.91
Sweden	3.14	85.81	290.21
Switzerland	5.37	126.22	563.57
United Kingdom	2.28	60.20	257.67
Average EU countries*	3.49	66.80	279.77
United States	1.12	8.33	126.56

Note: * The average has been calculated for the Western European countries presented in the table
... Data are not available
Source: Caselli and Coleman (2004)

In spite of the fact that for a later period this indicator may not be revealing of the effective rate of investment in ICT technology as previously mentioned, what is striking is the increase in computer imports in Europe from 1970 to 1980. This computer per worker indicator takes a value of 3.49 in 1970 and reaches 66.80 in 1980. Differences across European countries are consistent with the dissimilarities previously analyzed in the ICT investment as a share of GDP. The leading countries over the period 1970-80 are Belgium, the Netherlands and Sweden whereas the laggard countries appear to be Greece and Portugal. In addition to disparities in gross fixed capital, the greater investment of the United States in ICT has contributed to acceleration in the growth of the capital service input with respect to the European one. As shown in table 2.8, between 1980 and 1990 Southern European countries experienced an important increase in computer imports. In 1990 they were nine

times greater in Portugal, seven times in Greece and around five times in Spain and four in Italy than the levels attained ten years earlier. On the other hand, the Netherlands, Switzerland and Ireland exhibited in 1990 the greatest levels of computer imports per worker.

Indexes on ICT diffusion have been constructed by international organizations such as the OECD and the UNESCO. However, they provide only recent information. Other indicators provide insight not only on expenditure but also on the effective use of the ICT technologies. Among these, the size of the sector appears to be a very interesting indicator. According to the OECD (2003) findings, this is quite small in most European countries and there are enormous differences in the "distribution of ICT across the economy"[94] especially between the United States and European countries as a whole, even though there exists important heterogeneity among these countries as van Ark et al. (2003) suggest. What appears to be a common trend is that a greater diffusion of ICT technologies has occurred in sectors such as financial, legal and business services, health, education, retail, some manufacturing industries and as a general pattern it seems that larger firms have a greater rate of adoption. In addition to this, in a report on ICT investments and growth accounting prepared for the European Union, van Ark et al. (2003) show how different was the contribution of the ICT technologies to the labour productivity especially between the United States and the European countries. Helpman and Trajtenberg (1998) show how barriers such as high stock of previous technologies and closed dependence from other sectors prevented some industries such as the automobile and the telecommunication from being "the early adopters"[95] of the transistor. On the other hand, the early adoption in the computer industry reflected a clear need and an unprecedented opportunity for improvement.

As noted in the previous section, the catch-up of many Western European countries has been remarkable at the end of the Second World War but the average productivity performance of European countries has been less satisfactory than that of America. It seems important to examine what has been the contribution of ICT to economic growth in order to understand whether ICT can be part of the explanation

[94] OECD (2003, p.21).
[95] Helpman and Trajtenberg (1998, p.87).

for the recent American economic performance and the surge of American productivity growth since the mid-1990s that has been highlighted by Crafts (2004a).

According to Timmer et al.'s (2003) estimation, the average annual GDP growth over the period 1995-2001 was 3.52 percent in the United States against the European rate of 2.42. In fact, ICT can potentially increase output and output growth in three ways: by "increasing productivity growth in the ICT-producing sectors" or through "capital deepening driven by high levels of ICT".[96] The third way described by Scarpetta et al. (2004) would consist of an increased efficiency in the ICT-using sectors that have adopted the ICT technologies. In order to examine the impact of ICT on GDP and productivity growth, growth accounting analyses have been carried out at the Groningen Growth and Development Centre in order to examine the impact of ICT at both aggregate and industry level.

By looking at the decomposition of GDP growth according to the factor inputs and the residual total factor productivity, it is possible to observe that the major growth divergence between the European Union and the United States can be explained by labour productivity differential and IT capital services over the period 1980-2000 as shown in table 2.9.

Table 2.9. Sources of growth differences between the United States and the European Union (US-EU, % per year)

	1980-1990	1990-1995	1995-2001
Gross Domestic Product	0.81	0.84	1.10
Contribution of labour	1.18	1.45	0.46
Contribution of capital services	0.00	-0.08	0.30
IT capital services	0.25	0.20	0.36
Non-IT capital services	-0.24	-0.27	-0.06
Contribution of TFP	-0.37	-0.53	0.34

Source: Timmer et al. (2003)

[96] Scarpetta et al. (2004, p.16).

By decomposing the sources of average labour productivity growth, it is possible to observe that information technology is clearly an important determinant of the European lag over the period 1980-2000. See table 2.10.

Table 2.10. Sources of labour productivity growth differences between the United States and the European Union (US-EU, % per year)

	1980-1990	1990-1995	1995-2001
Average Labour Productivity	-0.82	-1.24	0.48
Contribution of capital deepening	-0.45	-0.71	0.14
Information Technology	0.18	0.11	0.30
Noninformation Technology	-0.63	-0.82	-0.16
TFP	-0.37	-0.53	0.34

Source: Timmer et al. (2003)

It is also important to observe the great differences that exist between European countries. Ireland, Finland and Sweden exhibit labour productivity growth higher than the United States and this is determined in the case of Ireland mainly by TFP from IT-production whereas for Finland and Sweden the labour productivity performance is equally divided between increases in IT-capital per hour and TFP from IT-production. On the other hand, in countries like Austria and Greece the fact that labour productivity growth remains higher than the European average over the period 1995-2001 is a result of improvements in the non-ICT sector.[97]

At sectoral level, in an analysis carried out by van Ark et al. (2002) that covers fifty-two industries in sixteen OECD countries[98] over the period 1990-2000, supporting evidence was found in favour of the more rapid productivity growth in the United States as opposed to the slower European performance. This phenomenon has been concentrated in the American ICT-using industries and the ICT-producing manufacturing industries, especially the "whole sale trade and securities".[99] On the

[97] Timmer et al. (2003, pp.51-5).
[98] The countries included in the analysis are: Austria, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Sweden, Spain, Switzerland, the United Kingdom, Canada, Japan and the United States.
[99] van Ark et al. (2002, p.1).

other hand, Europe has experienced a better performance in non-ICT industries and has lagged behind in both ICT-producing and ICT-using industries. The evolution of these indicators of productivity for the European Union and the United States is presented in table 2.11.

Table 2.11. Productivity growth of ICT and non-ICT industries, EU and US, 1990-2000

	1990-1995		1995-2000	
	EU	US	EU	US
Total Economy	1.9	1.1	1.4	2.5
ICT-Producing Industries	**6.7**	**8.1**	**8.7**	**10.1**
ICT-Producing Manufacturing	11.1	15.1	13.8	23.7
ICT-Producing Services	4.4	3.1	6.5	1.8
ICT-Using Industries	**1.7**	**1.5**	**1.6**	**4.7**
ICT-Using Manufacturing	3.1	-0.3	2.1	1.2
ICT-Using Services	1.1	1.9	1.4	5.4
Non-ICT Industries	**1.6**	**0.2**	**0.7**	**0.5**
Non-ICT Manufacturing	3.8	3.0	1.5	1.4
Non-ICT Services	0.6	-0.4	0.2	0.4
Non-ICT Other	2.7	0.7	1.9	0.6

Source: van Ark et al. (2002)

Among the explanations for this "Atlantic Divide" in terms of ICT diffusion and growth differential, the most optimistic explanation provided by economists is that there is a lag between the United States and European countries for the diffusion of ICT. Van Ark et al. (2002) show the high correlation between European labour productivity growth over 1995-2000 and the same indicator for the United States between 1990 and 1995. They find positive correlations by using both Spearman rank and Pearson correlations at industry level. This lag could be revealing of the adjustment necessary to create "social capability" in order to efficiently use the new technologies in the economic activity. In this regard, David (1990) highlighted the need for a structural adjustment before the general purpose technology can have a positive impact on productivity growth. The author compares the pattern of diffusion of ICT technologies to the one that characterized the Dynamo. In this context, I will describe in the following paragraphs some of the factors that have been taken into

consideration by scholars who have tried to explain the rate of adoption of the ICT technologies. These are also the factors that have created the need for a structural adjustment in many European countries in order to take advantage from the new technological opportunity.

The crucial role that human capital plays for the adoption of ICT and the need for an institutional adjustment have been acknowledged in the previous chapter. The important role played by human capital has found empirical support in a number of studies that have been reviewed earlier and will constitute the underlying framework of the analysis in a later section of the dissertation. In what follows I will focus on other factors for which an adjustment of European institutions has appeared to be critical to fully exploit the new technological opportunities.

Gust and Marquez (2002) and Bassanini and Scarpetta (2002) recognize the fundamental role of regulation. Their reasoning implies that rigidities in the labour and product markets are more costly when opportunities for the adoption of new technologies occur. This is because the rigidities existing in most European countries are what prevented them from experiencing the American acceleration in productivity growth. The two studies employ quite different methodologies: the former a panel analysis and the latter a growth accounting exercise. However, the main findings are similar: the diffusion of ICT technologies, considered in terms of expenditure and production, has a positive impact on productivity growth. Moreover, the experience of European countries shows that a lack of competition in the product market and rigidities in the labour market have delayed the adoption of ICT technologies and the related productivity speed up as they have prevented firms from adapting without costs their labour force to meet the requirements of the new technological regime. In this regard, Faini (2006) has shown that differences in employment rates and hours worked per person are important factors in explaining the income gap between Europe and the United States over the last thirty years. However, the explanation for this is not readily available. This is because it is not possible to draw definitive conclusions on whether the fall in employment and hours worked in Europe[100] are due to a preference for leisure (Blanchard, 2006a) or to a

[100] Faini (2006). The author estimates that in Europe employment rate was reduced from 62.9 to 58.8 percent between 1970 and 1995 (p.86) whereas hours worked declined from 1745 to 1521 over 1979-2001 (p.78) against a rise in the American employment rate (from 63.3 to 74.4 percent) and a very small reduction in hours worked (from 1849 to 1821).

highly regulated labour market, union imposed regulations, social norms, pension laws (Alesina, Glaeser and Sacerdote, 2005) and heavy taxes (Prescott, 2004). This would also prove how the institutions that characterize most European welfare states, based on the principle of social justice, equity and wage bargaining probably have not created the appropriate "social capability" for the diffusion of the ICT technologies. Blanchard and Wolfers (2000) hold a more optimistic view by arguing that much has been done to reduce the rigidities in the European labour and product markets. According to Caselli and Coleman's (2001) another factor that has prevented the adoption of computer-technology "in virtually all countries of the world"[101] over 1970-90 is a large share of government in GDP. Among the factors that had a positive impact on the adoption of ICT technologies, the authors acknowledge openness to trade in the manufacturing sector, effective property rights protection.

The recent growth revival experienced by the United States shows that the Solow Productivity Paradox has been removed (Crafts, 2006) and the spread of ICT across the different sectors of the economy is having a positive impact on the American productivity. On the other hand, Europe is not experiencing the same growth revival. It would be interesting to examine what has been the European policy response in sectors like education and training that appear to be crucial for the adoption of ICT technologies. That is to say, given the fact that some adjustments are necessary to provide workers with the skills necessary to use the new technologies, what was the European human capital policy for the adoption of ICT? When did European countries start addressing this issue in human capital policy? Was the response adequate and was it different from the American one? These are issues that will be examined in the following chapters.

In order to summarize, in this section the state of technology at the end of the Second World War and the gap with respect to the United States have been discussed. After, the features of ICT have been briefly described. Then, the rate of diffusion of the new technologies and their impact on the economic performance of European countries has been discussed. The recent US growth revival with respect to the disappointing average European performance has been acknowledged. Finally, a tentative analysis of the factors that can affect the rate of diffusion of ICT has been

[101] Caselli and Coleman (2001, p.1).

provided. Among many determinants, human capital has been recognized by scholars as a key factor for the adoption of technology since the end of the Second World War. In this historical context, the human capital policy changes undertaken by European countries in order to adopt more advanced technologies after the Second World War and later the ICT technologies will be the focus of the analysis of the following chapters. The analysis will cover different levels of education such as compulsory schooling, vocational education and higher education whereas the next section will provide an historical overview of the state of human capital in the second half of the twentieth century.

2.4) Human capital

In this section both the evolution of education and vocational training will be examined across Europe and America. In spite of the fact that European education systems are unique as they "are a reflection of the social, political and historical contexts in which they were developed"[102], it is important to observe the existence of common sets of characteristics that make it possible to identify different models of education systems. Green et al. (1999) have found clusters according to the cultural traditions, the structure of the different levels of education as well as the type of regulation and governance. Namely, they have identified four groups: Southern European countries, Nordic states, German-speaking countries and the Anglo-Saxon systems.[103] According to the authors, these clusters exhibit similarities with respect to the level of centralization, the involvement of the public and private sector as well as in the structure of the secondary and post-secondary systems. Later in the analysis a specific reference will be made to these models of education systems in order to understand how the institutional response has varied across the different systems and to see whether there has been convergence with respect to the policy changes examined.

[102] Sung et al. (2005, p.8).
[103] Green et al. (1999, p.26).

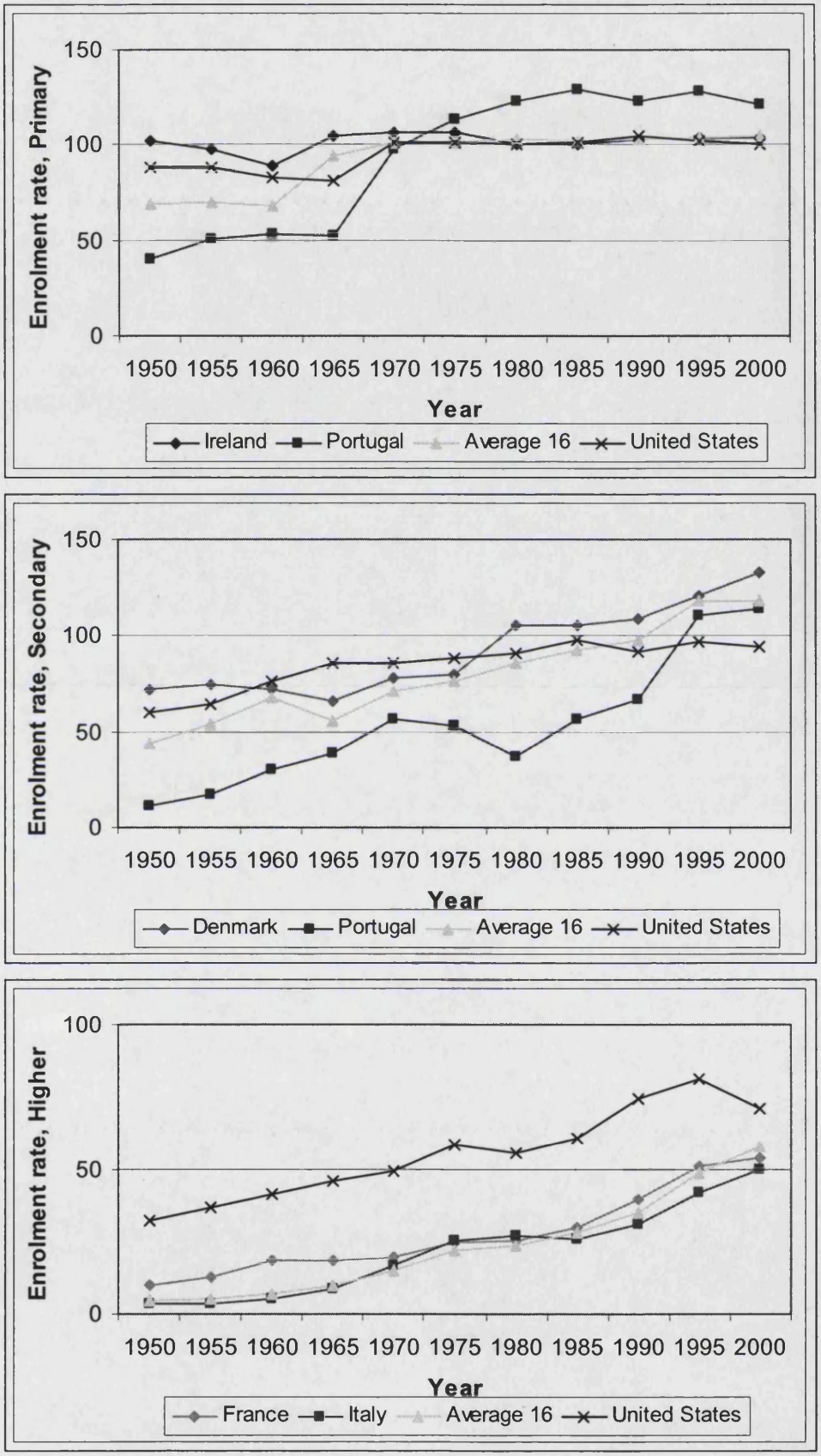
2.4.1) Education

2.4.1.A) Expansion of education

What can be observed since the end of the Second World War is a great expansion of education in every European country. This increase in participation rates at primary and secondary levels had already occurred in the United States before the end of the war.[104] The analysis of this chapter will focus on the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. Concerning Europe, the increased schooling participation can be observed at primary, secondary and higher education levels. However, the pattern of participation has proved to be different depending on the educational level and the country. In a chapter of a report prepared for the OECD, Kotwal (1975) provides an insightful analysis over the distribution of education in Europe since the end of the war and shows the great increase in participation rates. In the next page I present three graphs showing the evolution of enrolments in primary, secondary and higher education over the period 1950-2000. As it would have been difficult to show the pattern of enrolments for the sixteen countries in a single graph, what is displayed is the pattern of the country that in 1950 had the highest rate of enrolments, the pattern of the country that in 1950 had the lowest rate of enrolments and the average of the sixteen countries. Also, the evolution of the enrolments for the United States is illustrated. The complete dataset showing the evolution of enrolments for these countries at each level of education is presented in the appendix (table 2.A).

[104] In this regard, Goldin (2000) talks about the "three transformations of American education". That is, the author illustrates how the United States have led in the expansion of the participation rates with respect to their European counterparts since the nineteenth century. She also acknowledges how the phenomenon of "mass higher education" has occurred in the United States after the Second World War.

Figure 2.2 Enrolment rates in primary, secondary and higher education, 1950-2000



Source: UNESCO Statistical Yearbook (*various years*)

With reference to primary education, in the aftermath of the Second World War, European countries already had very high enrolment rates, averaging 69 percent. These rates varied from 40 percent for Portugal to 102 percent for Ireland. They are calculated as the ratio of pupils enrolled in primary school to the population aged between 5 and 14.[105] It can also be observed that starting in 1970, on average, the sixteen European countries in the sample reached universal attendance, also those countries that started at the lower levels. The United States started at a higher level of participation with respect to the European average and reached universal attendance in 1970.

Enrolments in secondary school have followed a steady increase since the end of the war in Europe but with a slower pace with respect to primary education. According to the statistics of the UNESCO, in 1950, on average the enrolment rate in secondary education was 44 percent of the cohort of reference in the European countries I consider in the sample.[106] The average hides important differences, as for instance in Spain the enrolment in secondary education was very low, 17 percent, whereas in countries like Denmark the enrolment rate had already reached 72 percent as it is shown in the graph. By 1995 all the European countries had reached 100 percent enrolment rate in secondary education apart from Greece and Italy that nevertheless were closely to universal attendance (95 and 94 percent respectively). These Southern European countries are among those that started with very low enrolment rates in the post-war period but experienced a remarkable expansion of enrolments especially since the end of the 1960s. The universal attendance reached at secondary level implies that people at least complete the lower secondary education level until the compulsory school-leaving age. The United States have led the expansion in enrolments until the early 1980s when Denmark took over.

[105] The data related to the gross enrolment rates of the European countries in the sample are provided in the appendix (table 2.A). These ratios are calculated as the number of pupils enrolled in primary education divided by the population aged between 5 and 14. However, data for enrolment rates adjusted according to the number of students of the age cohort used in the denominator are not available in detail. This is to say that enrolment rates in this case also vary according to the length of the education level of each country. Therefore in some cases enrolment rates greater than 100 can be reached depending on the length of pre-primary education and the starting age of primary education. (For instance, the length of pre-primary education is 4 years in Finland whereas only 2 years in Ireland and the United Kingdom, 1 year in Sweden and Denmark). However, here the interest is to show the great expansion of the schooling participation since the aftermath of the Second World War. Therefore I will not analyse in detail the age cohort with respect to the duration of primary schooling in the European countries. This applies also to gross enrolment rates at secondary and higher education levels.

[106] Participation in secondary education as defined by the UNESCO Statistical Yearbooks: "number of students in secondary education as percentage of 15-19 age group".

The expansion of higher education has been more restricted with respect to the other levels of education. In fact, in the aftermath of the Second World War in Europe only a very limited proportion of the population aged between 20 and 24 was enrolled in tertiary education, the average for the sixteen European countries was 4.4 percent. The proportion of the population varies from 9.8 percent in France to 3.5 percent in Italy[107] and it widely reflects the institutional setting and the forms of subsidies that regulate the participation to higher education in each European country. What can be observed is that some countries, including the Nordic nations already mentioned, had quite high enrolment rates after the war (i.e., Denmark at 4.7 percent, Finland at 4.2 percent and Sweden at 3.2 percent) whereas countries like the United Kingdom and Ireland had a much lower participation level (i.e., United Kingdom 1.4 percent and Ireland 2.9 percent). Starting towards the end of the 1960s, European countries have experienced a rapid expansion of higher education. The European average for the sixteen countries in the sample goes from 9.6 percent in 1965 to 21.5 in 1975. Many factors can explain this phenomenon and will be examined in the next chapters. For example, the institutional intervention in terms of progressive reduction of fees that took place in many European countries, and other factors such as the technological change that created the demand for a more educated labour force.[108] In fact, this is likely to be an important part of the explanation given the wage premium that educated workers have received with respect to unskilled workers. In 1995, on average 48.3 percent of the age group of reference was enrolled in higher education in Europe. Countries like France, Belgium and the United Kingdom exhibited enrolment rates equal or greater than 50 percent in 1995.[109] One of the explanations for this expansion at higher education level refers to the nature of the technological change that has occurred since the end of the 1970s, as a result of the introduction of ICT. Berman, Bound and Machin (1998) argue that the increased demand for skilled workers and the reduction in the demand for less skilled workers

[107] Early data for countries like Greece, Portugal and Spain are not available and these are also the countries that exhibit the lower levels of enrolments in both primary and secondary school in 1950. Therefore the choice of Italy as the country that exhibits the lowest rate of enrolments in higher education in 1950 is dictated by data availability.

[108] See for example Lindert's (2004) discussion on the increase of public spending in the post-war period and Berman, Bound and Machin's (1998) industry-level analysis on the skill-based technological change.

[109] As has already been argued in an earlier note, data for enrolment rates adjusted according to the number of students of the age cohort used in the denominator are not available in detail from 1950. However, this cross-section is the only one available for a large number of countries starting in 1950. This is the reason why it has been used here in spite of this shortcoming. The interest of this section is to provide an overview of the expansion of the participation rates in education across Europe and the United States since 1950.

in the OECD countries is a consequence of the introduction of more advanced technologies that create a complementarity with more educated workers. The authors find evidence for this in the same manufacturing industries across different countries. Another stream of the economic literature has focused on the change in the composition of the labour force by using a more qualitative approach. That is to say by looking at the changes according to the different fields of study. Among these analyses, the one provided by Elias and Purcell (2003), which covers the United Kingdom over the period 1975-2000, is particularly insightful. The authors show the changes in the composition of skills acquired in higher education and the composition of skills necessary to work in the old and new sectors of the economy. An extension of this type of study by including many European countries will be the focus of the analysis of the fourth chapter. In the context of higher education, the United States have been the uncontested leader. As it is possible to observe from the graph, the United States already in 1950 had enrolment rates much higher than any European country. The expansion has continued over the fifty years examined and in the year 2000 the American supremacy in terms of higher education is still unambiguous. However, as it will be shown later the quality of American education has appeared to be lower than European education, as indicated by the results of the international test scores.

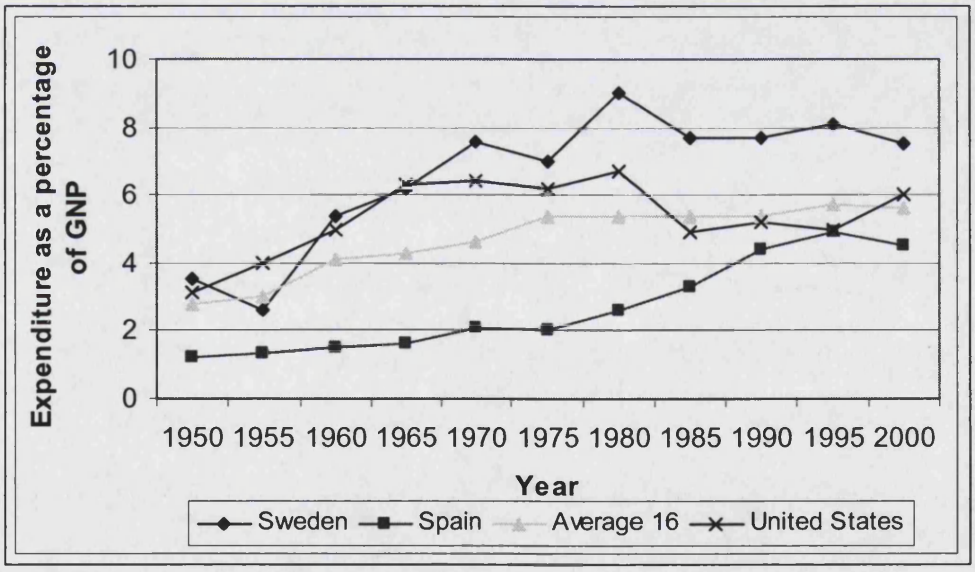
2.4.1.B) Expenditure on Education

The expenditure on education is an important indicator that shows what share of resources each country devotes to the educational sector. It depends on many factors: the distribution of the school-age population, the demographic structure of the population, the volume of the public expenditure as a whole and many others (OECD, 1990, p.56). It is also a useful indicator that allows international comparisons and inter-temporal analyses. It is important to notice that similar percentage can hide great differences in terms of money spent for education. It seems important to look at this aspect because many reforms undertaken by countries in the educational sector are likely to increase the commitment of governments in terms of expenditure. Policy changes in human capital such as the expansion of compulsory schooling, the introduction of ICT programmes in apprenticeship and of new degrees in higher education will be examined in the

following chapters. Therefore, in this section a brief overview related to the evolution of the expenditure on education at aggregate level and according to the level of education will be provided.

The graph below shows expenditure on education as a share of Gross National Product (GNP) for Spain and Sweden as they were the countries with the lowest and highest expenditure as a share of GNP respectively in 1950, as well as the average of the sixteen countries and the United State since 1950. Data for the other European countries are shown in the appendix (table 2.C). International comparisons usually make use of Gross Domestic Product (GDP). However, it is not possible to have accurate data for the proportion of GDP spent on education for the past. Therefore, GNP has been chosen to observe the long-run evolution of the expenditure on education for a sample of European countries and the United States.

Figure 2.3 Expenditure on education as a share of GNP, 1950-2000



Source: UNESCO Statistical Yearbook (*various years*)

What can be observed is that even if the expenditure on education has followed a dissimilar evolution in the different European countries, a common trend can be identified. On average, for the sixteen European countries expenditure has increased until 1975 and after it has remained at a constant level. For countries like Belgium, Finland, the Netherlands and the United Kingdom there has been an important

increase in the expenditure on education from 1950 until 1975. The expenditure more than doubled in Finland, the Netherlands and the United Kingdom whereas in Belgium it reached 6.2 percent in 1975, more than three times the value of 1950. After 1975, the expenditure on education has progressively been reduced and after maintained at a steady level in these countries as a result of the welfare state crisis. This is a phenomenon experienced by many developed countries as Estes (1992) points out: in the 24 richest democracies, public spending on education dropped by more than 16 percent over the period 1972-89. In other countries like Norway and Sweden public spending on education exhibits an increasing trend until 1980, but then was reduced as well. In France and Ireland the reduction in the expenditure on education started after 1985. The case of Ireland is interesting because the rise of the expenditure on education has been lower than the other countries in the immediate aftermath of the war. The pattern of the expenditure is similar to the one followed by the other countries but with a lag. The educational policy of Ireland can be considered as an interesting case of catch-up of more advanced countries. The United States have spent more in formal education than the European average until the mid-1980s but less than one of the leaders in popular education, that is Sweden. The greater investment in human capital undertaken by the United States has been considered by Broadberry and Ghosal (2002) as one of the factors responsible for the faster development of the American market service sector. The data related to GDP that are available for 1975 and 1993 confirm this evolution and are presented in table 2.12.

Table 2.12. Public expenditure on education as a percentage of GDP,[110] 1970-2000

	1970	1980	1990	2000
Austria	4.6	5.7	5.4	6.0
Denmark	...	7.4	6.3	8.0
Finland	...	5.8	6.0	5.6
France	...	5.1	5.1	6.0
Germany*	3.7	4.8	4.1	5.6
Greece	2.8	3.2	...	4.0
Ireland	6.2	6.4	5.0	4.0
Italy	...	4.5	5.2	4.6
Netherlands	7.5	7.1	5.7	5.2
Portugal	...	3.7	4.3	5.7
Spain	...	...	4.4	5.6
Sweden	7.9	8.5	5.6	6.7
United Kingdom	6.2	5.7	4.9	5.2
United States	6.4	6.7	5.2	6.0

Note: * Data for Germany refer to the Federal Republic until 1989
... Data are not available
Source: OECD (1996), Education at a Glance Indicators and UNESCO Statistical Yearbook (*various years*)

Before focusing on the analysis of the expenditure at different levels of education, it is necessary to point out that among the factors that determine changes in the resources devoted to education, demographic change and the increase in schooling attendance play a key role. Population growth and a longer time spent in school generated a greater public spending on education in Europe in the post-war period as Lindert (2004) has shown.

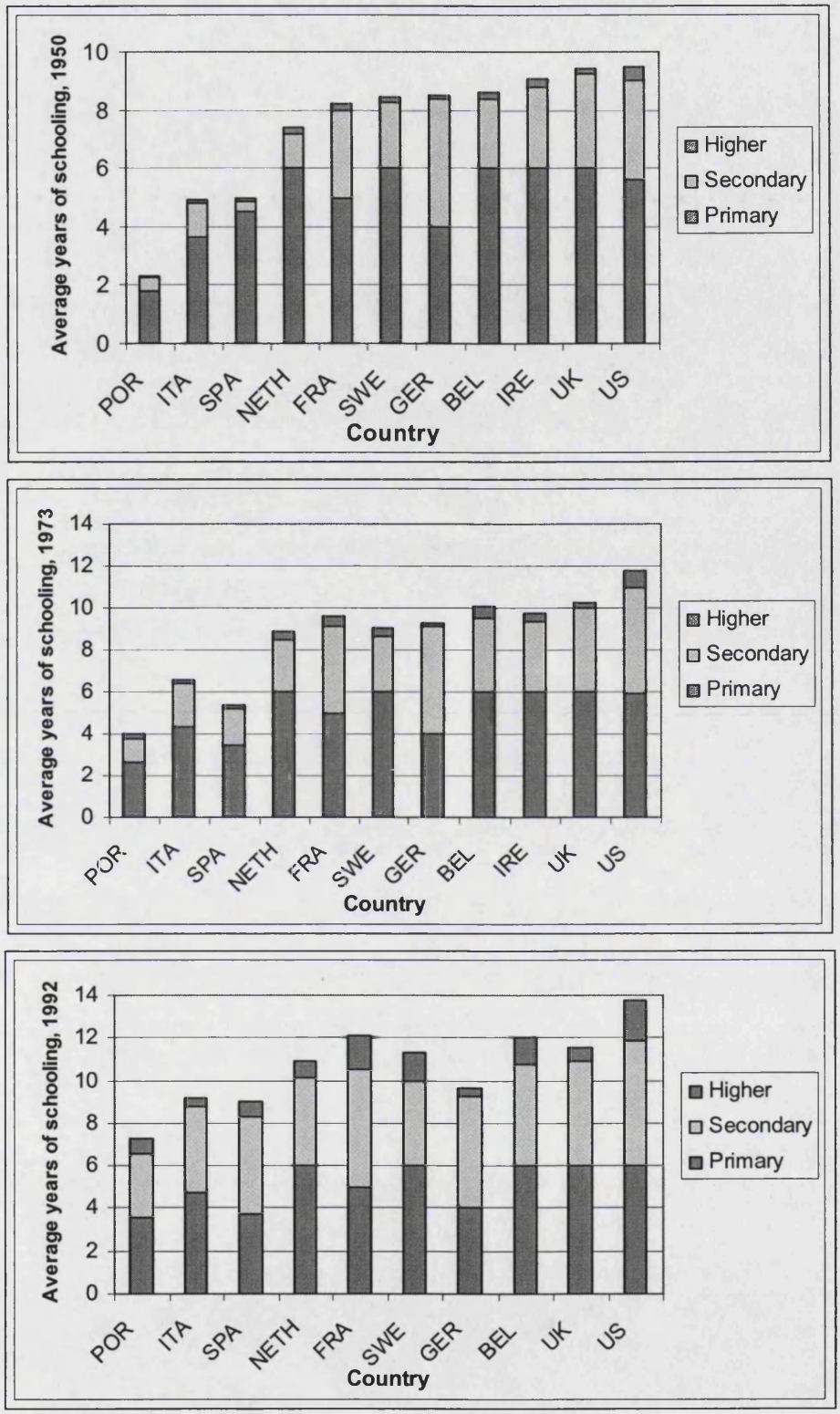
An analysis carried out by the OECD (1996) shows that the greatest determinants of the expenditure on education are participation rates and spending per student. The latter will be examined in detail later. The participation rate is determined both by the demographic pattern and the time that people spend in education. The increase in population across Europe that started after the war progressively decelerated in the 1970s.[111] In the United States the "Baby Boom" phenomenon lasted from 1946 to 1964 and led to a peak in terms of participation rates in primary and secondary school in 1971.[112] This demographic transition towards an older society consequently decreased the number of pupils. However, evidence related to a drop in fertility rates and a consequent reduction in the number of children going to school is mixed. Poterba (1997) by examining the experience of the United States over the

[110] Public subsidies to households are included in this measure.
[111] Baines (1999, p.163).
[112] Marlow-Ferguson (2002, p.1501).

period 1960-90 suggests that spending is not adjusted according to lower schooling attendance. In contrast with this result, Kempkes (2005) finds that East German institutions adjusted educational expenditure to the smaller cohort of students after 1990. In fact, this event has been in a way more than balanced by the fact that people spend, on average, more time in full-time education. According to the OECD (1996) estimates, "upper secondary education has been completed by half of the people who left school during the 1960s and by around 80 percent of today's young people".[113] This fact has been examined in detail in the previous section of the chapter but in figure 2.4 I present a summary of the average years of schooling completed by the population according to the education level at three points in time: 1950, 1973 and 1992. The evolution of the average years of schooling is characterized by a steady increase since the end of the Second World War. What can be observed by looking at the graphs is that the greatest increase of average years of schooling has occurred at secondary level. The data from which these graphs have been derived has been extracted from Maddison (1996) and can be found in the appendix (table 2.D).

[113] OECD (1996, p.13). This is quite different from the number shown in figure 2.2. This is because, as previously explained, the early UNESCO data only take into account the age group of reference as numerator. Therefore, the participation rate can either be understated or overstated depending on the actual length of the primary, secondary and higher education. However, these data have been used here because they are the best source available that allows making an international comparison starting from 1950. Moreover, the interest is to provide an overview of the increase in schooling participation rates since the end of the Second World War.

Figure 2.4 Average years of schooling in 1950, 1973 and 1992[114]



Source: Maddison (1996)

[114] Data for Ireland are not available for 1992.

What appears clear from the graphs is that the United States has exhibited the greater number of average years of schooling. In Europe the situation is quite heterogenous. In countries like the United Kingdom, Sweden, Germany and France the population is endowed with high levels of formal education, only slightly below the American levels. On the other hand, Southern European countries like Italy, Portugal and Spain have lagged behind in terms of educational participation but as the picture for the year 1992 shows, the catch-up has been remarkable after the mid-1970s. A specific reference to these countries will be made later when the institutional changes in compulsory schooling levels will be examined.

I will examine now the expenditure according to the level of education. Data have been collected by the UNESCO and published in the Statistical Yearbook. There is a lack of documentation that does not allow making a detailed comparison across the European countries I have selected for the analysis. However, it is possible to observe that from 1970 until 1990 the greatest public expenditure on education has been devoted to the secondary sector. This is true for Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Norway, Switzerland and the United Kingdom.[115] Sweden represents an exception as, over the period 1970-90 the greatest share of public spending has been devoted to the primary sector. The complete dataset can be found in the appendix (table 2.E) whereas table 2.14 shows the repartition of the expenditure according to the level of education for Italy, Sweden, the United Kingdom and the United States.

[115] There are missing data for Portugal and Spain; therefore the series of expenditure is not complete.

Table 2.13. Share of public expenditure on education by level of education, 1970-2000

Country	Year	Pre-primary	Primary	Secondary	Tertiary	Other*
Italy**	1970	2.7	28.4	38.1	8.8	22.0
	1975	4.8	30.0	42.4	13.3	9.4
	1980	6.0	29.2	41.0	9.1	14.8
	1985	7.0	23.0	35.5	10.2	24.2
	1990	...	...	...	...	...
	1995	8.4	23.6	49.2	15.0	...
	2000	10.0	23.1	45.4	17.8	2.8
Sweden	1970	...	...	17.7	14.5	24.7
	1975	...	...	13.3	12.3	36.2
	1980	0.1	44.6	13.6	9.3	32.5
	1985	0.1	47.9	20.1	13.1	18.8
	1990	0.1	47.6	19.6	13.2	19.6
	1995	7.2	25.7	39.4	27.7	...
	2000	6.6	27.9	37.7	27.2	...
UK	1970	...	...	36.2	23.0	14.1
	1975	...	...	39.5	20.7	11.3
	1980	...	...	40.1	22.4	10.8
	1985	3.0	23.7	45.9	19.8	7.6
	1990	3.6	26.1	43.8	19.6	6.8
	1995	2.6	29.7	44.0	23.7	...
	2000	9.4	25.0	48.4	17.2	...
US	1970	...	70.5	...	29.5	...
	1975	...	67.5	...	32.5	...
	1980	...	36.5	...	...	...
	1985	...	...	30.3	25.1	...
	1990	...	...	37.0	24.1	...
	1995	7.0	31.7	36.1	25.2	...
	2000	...	...	...	...	...

Note: * Other includes "other types" and "not distributed"
** Data for 1980 are not available; the data presented refer to 1979
... Data are not available
Source: UNESCO (1999) Statistical Yearbook and UNESCO Online Education Database (2006)

It is not possible to make a consistent comparison with the United States due to the paucity and apparently not great accuracy of the data available from the UNESCO. The expenditure on tertiary education has followed a pattern that is different across European countries. From 1970 until 1990 the expenditure has steadily increased in Austria, Belgium, Finland, Ireland, the Netherlands, Norway and Portugal. It has decreased in Denmark and the United Kingdom and it has first declined and after increased again after 1985 in France and Italy. The evolution in terms of share of public expenditure in the secondary and tertiary sectors is clearly a consequence of the increased participation at higher levels of education.

In order to make the analysis accurate, it is necessary to examine the expenditure per student and to decompose it among its components. The data available do not allow examining the expenditure per student over the entire period 1950-2000.[116] This is because series constructed by the OECD and other international organizations only start after 1950. Therefore, I present in the appendix (table 2.F) the breakdown of the expenditure per student according to the education level in 1988. Data are in US dollars and the purchasing power parity has been used. Then, I will show what the components that determine the level of expenditure are. The most important components of the expenditure per student have been recognized to be: teachers' salary and pupil-teacher ratio, OECD (1992). The complete time-series of the pupil-teacher ratio has been constructed by using Mitchell's Historical Statistics for Europe. These data are presented in the appendix (table 2.J). Table 2.14 presents OECD data related to the change in teachers' salary and pupil-teacher ratio over the period 1985-93 as well as the overall percentage change in the expenditure per student. The choice for the time period is mainly dictated by data availability. In fact, earlier data are not available.

[116] In table 2.G in the appendix the public expenditure per student as percentage of GDP per capita is presented for three benchmark years 1975, 1980 and 1985.

Table 2.14. Change in expenditure per student decomposed by change in teachers' salary and pupil-teacher ratios, 1985-1993 (percentage)

	Teachers' salary	Pupil-teacher ratios	Spending per pupil
Austria	26.05	4.40	24.70
Belgium	7.63	-20.00	32.40
Denmark	1.39	-10.40	28.20
Finland	14.97	-3.70	6.20
France	21.79	3.20	36.90
Germany	11.77	-0.90	6.10
Greece	-28.79	-18.80	...
Ireland	26.73	-8.90	33.90
Italy	23.46	-32.30	66.00
Netherlands	2.26	8.20	-10.60
Portugal	12.00	-27.90	101.60
Spain	16.09	-39.50	65.20
Sweden	6.73	6.80	3.90
United Kingdom	2.55	15.40	43.30
United States	6.10	-3.1	22.2

Source: OECD (1996), Education at a Glance Analysis

Both the increase in teachers' salary and the reduction in pupil-teacher ratios have contributed to the increase in spending per pupil over the period 1985-93. The increase in the expenditure per student has been particularly important in Portugal, Spain, Italy, the United Kingdom, France and Belgium. The increase has been less important in Finland, Germany and Sweden; in Sweden it seems largely due to the small increase in teachers' salaries. According to Storesletten and Zilibotti (2000), in Sweden "teachers' wages have been independent of any measure of productivity"[117] and they have been very low during the 1980s. This may be a consequence of the egalitarian wage policies undertaken in Sweden in the aftermath of the war as Eichengreen and Iversen (1999) suggest. On the other hand, social agreements regulate teachers' wages in a slightly different way in Austria and Germany as "the bargaining was not centralized at national level".[118] The United States show levels of change that are similar to the European average.

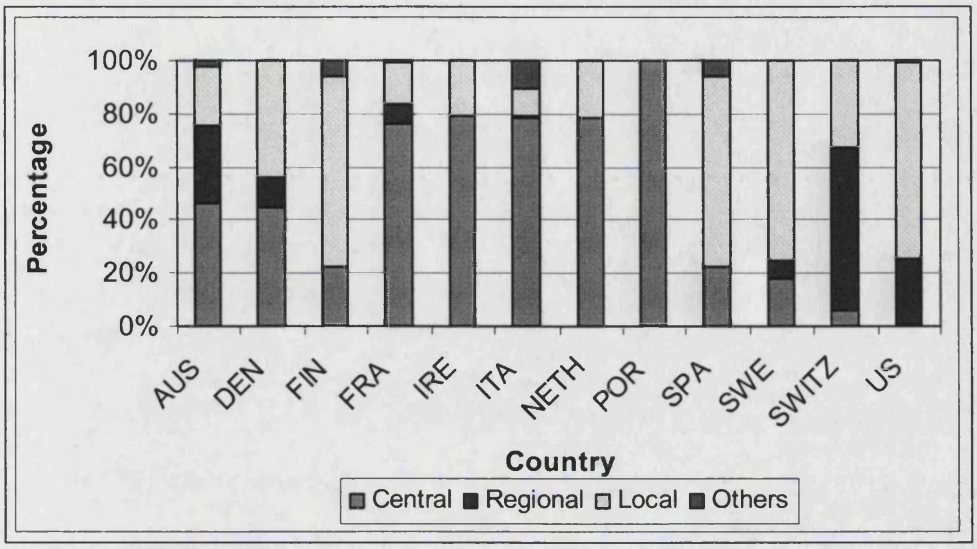
[117] Storesletten and Zilibotti (2000, p.8).
[118] Eichengreen and Iversen (1999, p.12).

Having examined the evolution of the expenditure on education and to a certain extent its components, it would be interesting to look at the sources of the expenditure. In every European country, as well as in the United States, the largest share of expenditure on education comes from public sources and the contribution from the private sector is very low. An exception is Germany that has a high share of private investment.[119] In 1995 for instance, the private investment was 1.27 percent of GDP whereas on average the private investment of the other European countries was 0.35.[120] This is mainly due to the dual system that consists of a very structured vocational training system. This involves a greater participation of the private sector for the provision of training. Data are available for 1990, 1995 and 1998 and they can be found in the appendix (table 2.H).

The level of decentralization in the expenditure on education is also an important factor that needs to be analysed. Data are available for recent time only; the graph in the next page shows the expenditure by level of government for the year 1988.[121] However, there has been some change since the end of the Second World War in terms of decentralization of the public expenditure on education.[122] Countries like France, Ireland, Italy, the Netherlands and Portugal have a highly centralized system and are still maintaining it. On the other hand, in Nordic countries like Finland and Sweden local authorities and municipalities in particular, have acquired greater autonomy in terms of spending on education since the 1970s. Also, Spain is experiencing a transition, as can be observed from the graph, local authorities are becoming an important source of funding. In Germany and Switzerland, the two federal states, also the system of funding for the educational sector is organized in a decentralized way. No change has occurred for these countries since the end of the Second World War. On the other hand, the American system has been highly decentralized and mainly funded by "small independent districts".[123] This feature of the American system, among others, has been recently central to debate on whether this type of template does not undermine the provision of schooling in the poorer areas.

[119] This can be observed from the data presented in the appendix (table 2.H).
[120] Data have been taken from OECD (2001) and are not available for Belgium, Finland, Greece and Switzerland.
[121] Data from which the graph has been derived are available in the appendix (table 2.I).
[122] A description of the pattern of decentralization experienced by some European countries can be found in the EURYDICE Database (2006) country reports and OECD (1992).
[123] Goldin (2001, p.288).

Figure 2.5 Sources of public expenditure on education by level of government after inter-level transfers, 1988



Source: OECD (1992)

This brief overview of the expenditure on education since the end of the Second World War has shown that spending on education as a share of GNP has increased from the end of the Second World War until 1975 in every country considered. This is when most European countries had to reduce social expenditure as a result of large deficits due to the very generous welfare state, negative economic situation that marked the end of the Golden Age and demographic change. Also, the sources of expenditure have been described and the progressive decentralization process that has taken place in some countries since the end of the Second World War has been examined. In this regard, the next section will focus on the main reforms that have been undertaken at different educational levels since the end of the Second World War.

2.4.1.C) Reforms of the institutional design of the educational sector at primary and secondary level

During the post-war period most European countries undertook major structural adjustments of the national educational systems. This was due to many economic, social and political motivations, but also practical reasons justified the reforms. In the following paragraphs I will try to provide a brief and coherent overview of the

main changes that have characterized the schooling system after the Second World War in Europe and the United States. The focus of the analysis will be on compulsory education which is the educational sector that has known the greatest expansion in Europe since the end of the war.

First of all, the great expansion of schooling that took place since the aftermath of the conflict required many structural innovations to face the increased demand for education. The democratization of the schooling experience was greatly determined by the fact that compulsory education was set free of charge.[124] This guaranteed the access to education to children from the working class and the poorest household. This change was important as the demand for public schooling is greatly determined by its cost.[125] Obviously also the opportunity cost to the schooling experience is likely to have a great impact on the demand for schooling. Among the factors affecting the outside opportunity of staying in school are the wage of young workers and child labour laws. However, issues related to child labour were tackled in most European countries at the time of industrialization. According to Plank (2004), "the traditional rationale for the public provision of schools was essentially political".[126] That is to say that states wanted to enable children to become part of society by providing them with the basic knowledge of literacy, numeracy, national and civic traditions. Schooling had the function of making children become citizens and allowing them to actively participate in society. Lindert (2004) shows how open access to education was generated by the increased democratization of the Western societies before the Second World War in some countries and later in others.[127] Later, the economic returns from knowledge and skills enhanced the role of the state in making citizens productive through education. This became a particularly sensitive issue at the end of the Second World War in Europe when the belief that a more skilled labour force would have made a better use of technologies became widespread. Also, the compulsory schooling laws played an important role in increasing schooling participation. Certainly, laws alone are not likely to change social behaviour. However, governments undertook many programmes to effectively

[124] Lindert (2004, vol.2, p.39).
[125] For example, Lindert (2004, vol.2, p.33) shows how the delayed expansion of mass education in England before 1914 was a consequence of "powerful elites opposed to schooling the masses at taxpayer expense".
[126] Plank (2004, p.2).
[127] Lindert (2004) also provides a discussion in order to exclude the possibility of reverse causality. This is to say, he explains why it was not the expansion of schooling that generated the spread of democracy.

implement the laws. First of all, they provided the schooling infrastructure, actively enforced the laws and eliminated the fees for compulsory education. This is the institutional reform that will be examined in the next chapter.

It is important to notice that European countries and the United States have developed different educational systems that are the result of different historical developments, legal origins and cultural legacies. However, there are common features related to compulsory schooling that make educational systems comparable across countries. Boli, Ramirez and Meyer (1985) recognize three characteristics that have been common to the educational systems during the last two centuries: the first is related to the fact that "mass education is institutionally chartered to be universal, standardized and rationalized".[128] To be more specific, in every country the principles governing education are regulated by law, education should be provided to every individual in society without imposing restrictions according to gender, ethnic group and social class differences. Another aspect considered is the homogeneity with respect to the general aims that govern the educational institutions. In spite of the great cultural differences that exist in the countries education is provided to allow individuals to acquire the knowledge and develop the skills that society values. In fact, these elements are very similar across countries. The third characteristic described by the authors refers to the centrality of the individual. In fact, education is meant to develop individual's skills and capabilities that will enable him to contribute with his activity to the economy but also will help him to become a member of modern society. These features are common to the educational systems of the European countries. Following these principles, countries have adopted different educational policies and reforms.

It seems now important to examine what institutional factors have led to the phenomenon of mass education after the Second World War. The focus in the following paragraphs will be on compulsory schooling laws and the role of the state. A remarkable similarity can be observed in the pattern of legislation of compulsory schooling laws across European countries. The first legislation was introduced towards the end of the nineteenth century in most European countries. Prussia was one of the first countries where the schooling participation was made compulsory. According to Hage et al. (1989), apart from Protestantism, the reason why Prussia

[128] Boli, Ramirez and Meyer (1985, p.147).

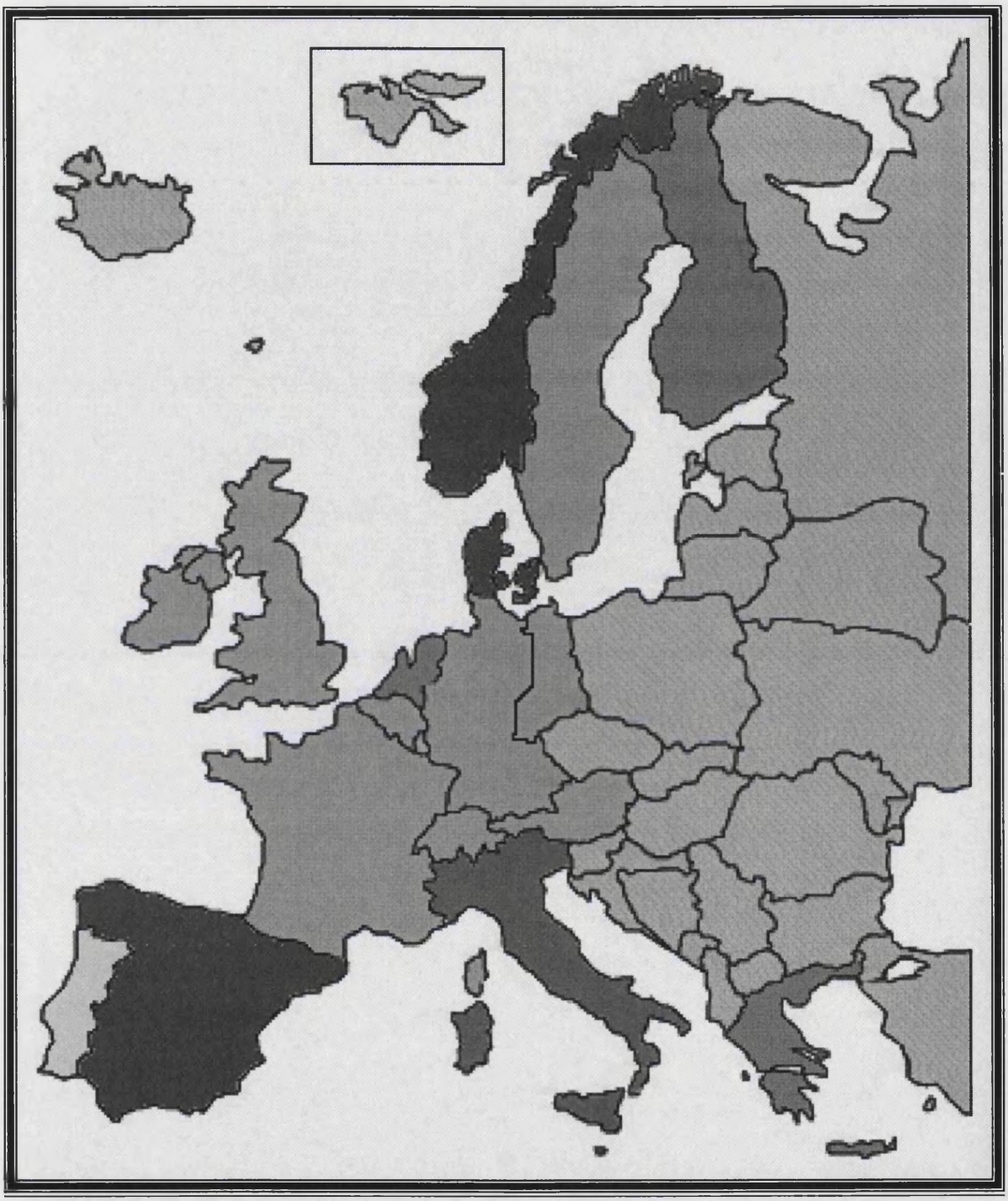
was the first state that passed the legislation was that after the defeat at Jena by Napoleon, the German State perceived education as an instrument to build a modern army. The law passed in 1763 under Joseph II, and it was followed by Austria in 1774 and Sweden in 1842. In the appendix (table 2.B) the timing of the development of the compulsory schooling legislation is shown for each country in the sample.[129] After the Second World War, again we can observe that all the European countries under study, have raised the school-leaving age, in the year 2000 compulsory schooling varies from 9 years in Portugal to 12 years in Belgium.[130] The pictures in the next pages provide an historical overview of the change in school-leaving age laws in the post-war period. What is shown is the number of years of compulsory schooling in 1950 and 2000 in fifteen Western European countries. The detailed description of the changes in compulsory schooling laws in the European countries after the Second World War can be found in table 3.1.[131]

[129] Table 2.B shows the expansion of compulsory schooling from its origins to 1938 whereas table 3.1 shows the changes in school-leaving age laws over 1938-2000.

[130] As it will be clarified in the note of table 3.1 compulsory schooling in Belgium is full-time until 15 (at 16 only if the student is 15 and has not been enrolled in the first two years of secondary school), after it is part-time until 18 (EURYDICE Database, 2006).

[131] Germany has been excluded as the country was divided until 1990 and different education systems existed in the Federal Republic of Germany and the German Democratic Republic.

Figure 2.6 Number of years of compulsory schooling in 15 European countries, 1950



Source: data have been extracted from table 3.1.

Legend

3 years

5 years

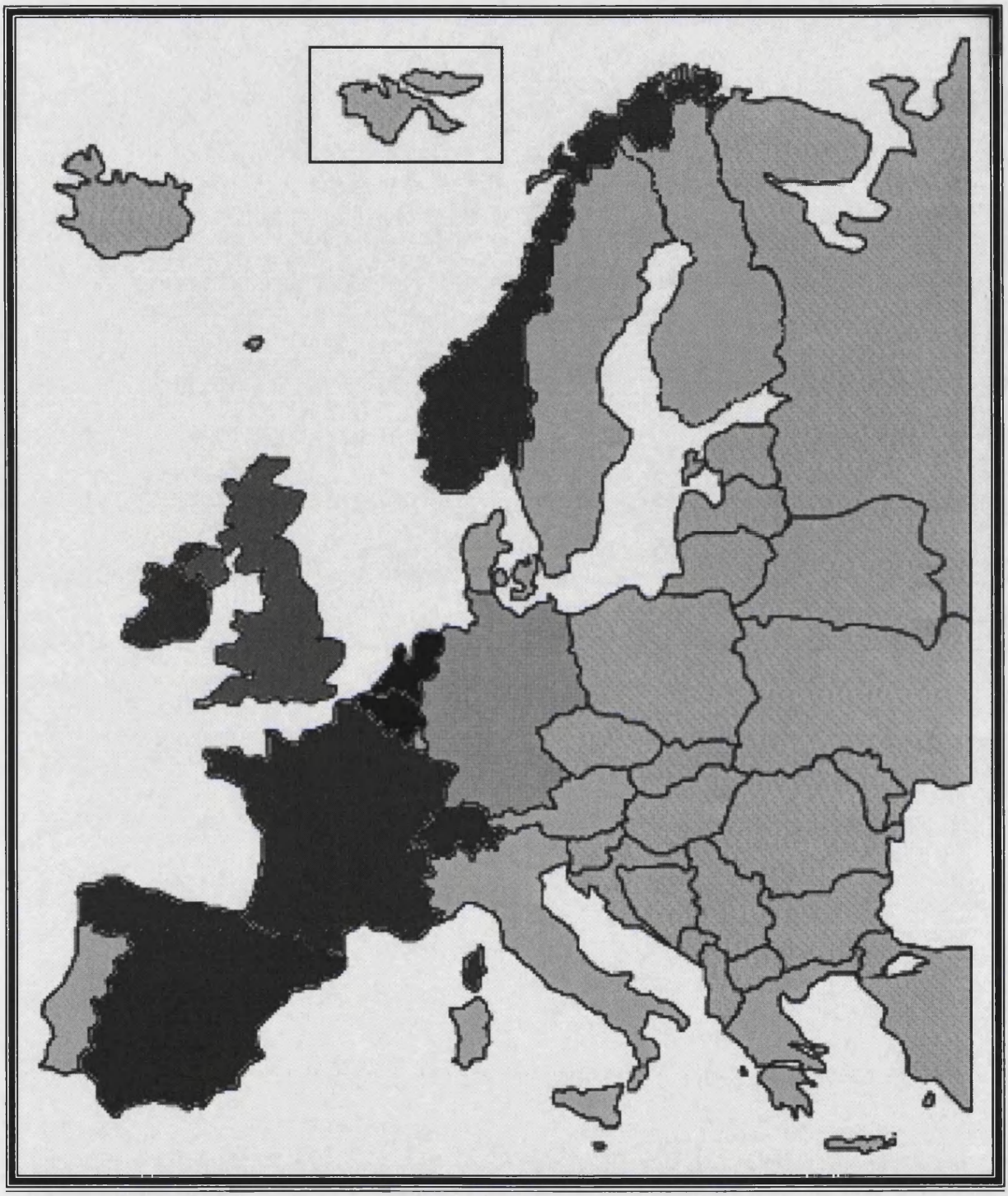
6 years

7 years

8 years

9 years

Figure 2.7 Number of years of compulsory schooling in 15 European countries, 2000



Source: data have been extracted from table 3.1.

Legend

9 years 10 years 11 years 12 years

A question that arises from this pattern is why European countries expanded education after the Second World War. Certainly the explanation related to the spread of democracy and the extension of the electoral suffrage described by Lindert (2004) seems interesting but still incomplete to explain the historical pattern. One question that arises is how did the determinants of schooling relate to the passage of the schooling laws. This is an issue that will be explored later in order to understand what is the rationale for raising the schooling attendance. In fact, it seems important to understand what can explain the development of this dramatic expansion of education that has occurred in the last two centuries with an important acceleration since the end of the Second World War. Data that show this pattern in terms of enrolments can be found in Lindert (2004),[132] they are available for twenty-one countries over 1830-1930 and for twenty-four countries over 1881-1937. More recent data referring to the post-war period can be found in the Statistical Yearbook of the UNESCO of various years and have been presented in the graphs of figure 2.2. In the Constitution of the United States the responsibility of each state to define its own educational statute is declared, however the federal government maintains the responsibility "to provide material resources to U.S. schools" and in case of violations of the rights guaranteed to citizens.[133] This explains why there is a great heterogeneity in terms of changes in compulsory schooling laws across the American states. That is, heterogeneity across the United States may be similar to the heterogeneity across Europe. Thanks to Oreopoulos's (2003) work, the timing of the changes in minimum mandatory schooling laws across the states is provided for the period 1915-75.[134] From the author's graphs, it is possible to observe the great dissimilarity in the expansion of compulsory schooling across the American states which makes the search for common causal factors more difficult to achieve.

It is important to notice that there are features of institutional design that need to be considered while examining the expansion of compulsory schooling. Among these, private versus public education, forms of assessment, selective versus non-selective education, existence of a tracking system, competition between schools, as well as existence of performance tables and national or local curricula management.[135] They

[132] These time series on school enrolments are available in Lindert (2004, Vol. 2, appendix A).
[133] Marlow-Ferguson (2002, p.1497).
[134] Oreopoulos (2003, p.30).
[135] Other aspects like "closed number versus open access for higher education places" will be examined in section 2.4.1.E.

seem to be important to study the changes in compulsory schooling laws as both changes in and differences across these features may have an impact on the timing and the intensity of the policy change. (For instance, the existence of a local management and an overall greater autonomy in education policy may lead to a gradual implementation of the increase in the school-leaving age as happened across the German *Lander* in the post-war period (Pischke and von Wachter, 2006, table 1)). However, most of these features greatly differ across countries. For example, the distributions of students according to the type of school attended (public or private), varies across Europe.[136] During the academic year 2001/02 in most Western European countries, the majority of students at ISCED 1, 2, 3 and 4 levels has attended public institutions whereas in Belgium and the Netherlands proportionally more students have attended government-dependent institutions (EURYDICE, 2005a, Figure B7). In this regard, some of the features outlined above will be described in the remaining of this chapter and to a certain extent in the next ones. However, a detailed description of these institutional variables for each country will not be presented. This is because of the difficulty in collecting data for all these institutional variables for the fifteen countries over 1950-2000. This is the reason why in chapter three, where a formal analysis of the raise in school-leaving age will be carried out, the focus will be on years of schooling only.

Other reforms consisted of reorganizing the schooling system among the different levels of education. The majority of countries including Sweden, Denmark, Finland, unified primary and lower-secondary level of education in order to have a comprehensive system for compulsory education (Grant and Bell, 1995). In Denmark, the reform was even greater as any formal examination between primary and secondary schooling was abolished. Other countries like France introduced a two-year programme between primary and secondary education in order to postpone the division between general education and vocational training.[137] In the United States a different policy change has taken place to unify primary and lower secondary schooling.

[136] It is important to notice that "this is a difficult area as across Europe private schools have different meanings" (Dr Vignoles, unpublished examiners report Viarengo PhD thesis, 2007). The definition used by EURYDICE (2005a) is the following: an institution is classified as public if it is controlled directly by the public authorities. If not, it is considered as private. Private institutions are said to be government-dependent if they receive more than 50 percent of their finance from the public sector whereas they are considered independent-private if they receive less than 50 percent of their financing from the public authorities (EURYDICE, 2005a, note figure B7).

[137] World Education Encyclopaedia (2002), country reports.

Furthermore, changes in the institutions responsible for the curriculum were important in some European countries. In countries like Austria, France, Ireland and the Netherlands the curriculum was determined at national level and this remained unchanged during the aftermath of the Second World War. In other countries like the United Kingdom, the curriculum was introduced in 1988, however "methods of teaching and textbooks were not prescribed"[138] at national level, leaving great autonomy to the Local Education Authorities. In federal countries like Switzerland and Germany the curriculum was decided by the members of the confederation and the Länder.[139]

Also the issue of the examinations attracted great attention and involved major changes. This is because some countries did not have any formal examination in order to evaluate students for the passage from one level of education to the subsequent. In Ireland, the Education Act of 1998 has confirmed that in order to be admitted to the secondary schooling level, children are not required to take any formal examination.[140] On the other hand, countries like France, England and the Netherlands have established a national system in order to assess students' performance.[141] Also, the issue related to the lack of centralized standards of education has raised great concern among policy-makers who start considering the great American freedom in terms of education as a potential drawback especially for the poorer part of the population.[142] A recent study by Woessman (2003b) has shown how important is the institutional design of the schooling system in determining students' outcome. Among the factors recognized as to have a positive effect in shaping students' performance, the existence of centralized examinations set at national level has been found to be important.

The autonomy in the funding policy adopted by European countries with respect to the different administrative levels has been different.[143] There has been a progressive movement in the direction of decentralization in countries like Sweden with a shift

[138] Hofman et al. (2004, p.82).
[139] EURYDICE Database (2006), country reports.
[140] EURYDICE Database (2006), country reports.
[141] EURYDICE Database (2006) and Hofman et al. (2004), country reports.
[142] This among other "virtues of the past" that have become "vices of the present" have been described by Goldin (2000).
[143] Hofman et al. (2004, p.9) and sections related to "governance of schools" and "freedom of school choice" in the country reports.

of responsibilities from the central government towards municipalities. Also in England local authorities have acquired greater autonomy for the administration and management of schools since the Education Reform Act of 1988. Moreover, barriers to entry in private schools have been set in some countries by means of students' allocation and fees that parents have to pay. In highly centralized countries like France and Ireland for instance, parents have to pay a substantial part of the fees if they decide that their children should study in a private school, they can choose the school in Ireland but not in France. However, even in Ireland, under certain circumstances public authorities can modify their first choice. Austria and Denmark are intermediate cases where parents cover a substantial share of the cost for the private school, students are centrally allocated but parents can choose an alternative. On the contrary, in Germany parents have to pay low fees for private schools and, depending on the Länder, they can choose the school.[144] In countries like Belgium and the Netherlands, parents can choose the school for their children and do not have to pay any fee if they choose a private school. Therefore, for these countries there is no discrimination of private with respect to public schools. On the other hand, in the United States public and privately funded schools have coexisted since the early development of the American educational system and there have not been major changes in this federal system since 1945.

Many important reforms have been undertaken at primary and secondary education level since the end of the Second World War in Europe and the United States. Some of the most important reforms have been described in the previous paragraphs and among these, the expansion of compulsory schooling appears to be central. This is because it was a major policy change undertaken by most European countries in the second half of the twentieth century. Also, it is directly related to growth and technology because it is a policy change that can have a major economic impact. In fact, it is the greater advance in technology that creates the demand for a more skilled labour force. On the other hand, a more educated labour force has an impact on the technological development and finally on growth. This, among other things, explains why this topic will represent the focus of the analysis of the next chapter.

[144] Hofman et al. (2004, p.71).

2.4.1.D) Quality of schooling

The quality of education is a very important aspect of education that only recently has received attention from scholars. This is because of the great heterogeneity that exists across countries. In fact, primary and lower secondary education levels are normally considered to be similar across countries.[145] However, great differences exist in terms of qualitative outcome, expressed by means of test scores, as well as in the organization of the programmes. Moreover, its impact seems to be great. Hanushek and Kimko (2000) by looking at the experience of many countries since the 1960s find empirical evidence in support of the fact that "labour-force quality has a consistent, stable and strong relationship with economic growth".[146] The main reason why quality has not been used in the literature is that it is very difficult to measure whereas quantitative measures of schooling are more readily available. The methodological problems first of all arise from the fact that it is not strictly defined what the concept of quality refers to. In this section, only a short overview on test scores, curriculum and instruction time will be provided. Some indicators related to quality will be used later in the analysis but they will not constitute the main focus of the study. This is because it is very difficult to provide an accurate measure for quality comparable across countries. Moreover, there is no complete and accurate dataset for the past. The only existing data are available at aggregate level. In addition to this, quality of schooling has not been the primary policy concern in the past especially until the end of the Golden Age.

Among the instruments that have been used in the literature those that allow comparisons across countries are the international test scores. There are both advantages and disadvantages in using these tools as an indicator of quality. They are designed to measure the cognitive abilities that students acquire by investing in education and they are currently used by researchers as a proxy for the quality of schooling. They have been administered since the early 1960s by the International Association for the Evaluation of Educational Achievement (IEA), an independent, international cooperative of national research institutions and governmental research agencies. It has conducted many studies by focusing separately on the achievements in basic school subjects such as mathematics, science and reading comprehension. A

[145] This is because apart from few exceptions, the school tracking in Europe and the United States takes place at upper secondary level.
[146] Hanushek and Kimko (2000, p.1203).

more recent international students' evaluation programme has been organized by the OECD, with the Programme for the International Student Assessment (PISA).

In the following pages the results of the first tests in mathematics and science administered by the IEA are presented. The data have been kindly provided by Professor Hanushek. Data of the test scores have been combined for each country and scaled in order to maintain a 50 world average. In this way a single number summarizes the country's performance in mathematics and science for a given year. One of the shortcomings of these data is that they do not exist for each country for every test. Therefore every test has a different sample size that depends on how many countries participated: 11 countries participated in 1963, 18 in 1970, 17 in 1981, 18 in 1985, 6 in 1988 and 19 in 1991. Only the United Kingdom and the United States participated in every international test. It is not possible to draw definitive conclusions about the quality of a schooling system only by looking at the results of the international tests in mathematics and science. However, they remain the best available tool to compare the quality of schooling across countries. This is also because in each test the country position is relative to the other participating countries and these vary from one test to the other. However, it is possible to observe the following patterns: Germany only participated to two tests but in each case obtained among the highest scores. Switzerland only participated once with a good performance. Ireland performed below the average in both tests whereas the Netherlands performed above the average in every test. On the other hand, the performance of the United Kingdom is not linear, but what is clear by looking at these indicators is that since 1985 the results in international test scores have been lower. Finally, Spain only participated in 1988 and 1991, performing in both cases below the average. Interestingly, the American performance in these standardized tests has been rather low; in fact the United States has ranked below the median in the six test scores. The issue of the low quality of the American education is not novel. Authors like Goldin (2001) and Hanushek and Kimko (2000) have pointed out the potentially dangerous consequences of this "forgiving" educational system, that is "without severe tracking at early age" and "without strict standards".[147] These poor educational achievements have raised a great concern among policy-makers. The acknowledgment of "A Nation at Risk" led to the proposition of many reforms in order to improve the quality of the American schooling system (Hanushek, 2003;

[147] Goldin (2001, p.289).

Hoxby, 2003). Moreover, in 1995, the American Department of Education made a priority the objective of "Raising the Educational Achievement of Secondary School Students".[148] The results of the test scores that have been undertaken at international level since the end of the Second World War are presented in the next page.

[148] Marlow-Ferguson (2002, p.1504).

Table 2.15. International Test Scores in Mathematics and Science, 1963-1991

Year	Country	Test Score
1963	Israel	66.27
	Japan	61.15
	Belgium	*60.35*
	Germany	*57.01*
	France	*53.53*
	Netherlands	*53.35*
	Finland	*50.39*
	United Kingdom	*49.98*
	Australia	38.70
	Sweden	*35.53*
	United States	28.26
1970	Japan	76.55
	New Zealand	70.61
	Hungary	65.15
	Australia	65.12
	Germany	*62.27*
	Sweden	*56.87*
	United Kingdom	*55.63*
	Finland	*55.14*
	United States	54.85
	Netherlands	*53.29*
	France	*49.89*
	Belgium	*48.59*
	Italy	*47.28*
	India	21.63
	Iran	20.79

Year	Country	Test Score
1981	Japan	68.05
	Netherlands	*60.41*
	Hong Kong	56.99
	France	*55.41*
	Finland	*54.80*
	Belgium	*51.67*
	Sweden	*51.34*
	United Kingdom	*51:07*
	New Zealand	49.77
	Canada	48.31
	Israel	47.57
	Hungary	46.13
	United States	42.89
	Luxembourg	39.45
	Thailand	38.95
	Swaziland	35.46
	Nigeria	34.15
1985	*United Kingdom*	*58.98*
	Hong Kong	56.88
	Singapore	56.51
	Netherlands	*56.12*
	Hungary	55.89
	Japan	54.84
	Korea	54.36
	Australia	47.56
	Thailand	46.77
	Sweden	*45.78*
	Finland	*45.21*
	Canada	43.22
	United States	42.5
	Italy	*36.36*
	Philippines	34.35

Source: Hanushek and Kimko (2000)

Table 2.15. International Test Scores in Mathematics and Science, 1963-1991 (cont'd)

Year	Country	Test Score
1988	*United Kingdom*	*50.23*
	Korea	54.57
	Canada	50.23
	Spain	*49.59*
	Ireland	*47.5*
	United States	46.6
1991	China	59.28
	Korea	58.31
	Switzerland	*57.17*
	Taiwan	56.28
	Hungary	53.90
	USSR	53.89
	Italy	*53.43*
	France	*52.74*
	Israel	51.42
	United Kingdom	*50.61*
	Canada	50.48
	Spain	*49.27*
	United States	48.99
	Slovenia	48.68
	Ireland	*47.67*
	Jordan	39.38
	Brazil	33.91
	Mozambique	24.26

Source: Hanushek and Kimko (2000)

A question that arises from the previous analysis is what determines the performance in the international test scores, namely what factors can explain the differences across countries. An interesting contribution to this field of research comes from Woessman (2003b) who shows that for the Third International Test in Mathematics and Science among the most important determinants of the test scores are

institutional factors. The author provides empirical evidence in support of the argument that students' background and resources devoted to education do not have a strong impact on test performance whereas the institutional setting of the educational system does.[149] Among the institutional variables considered are central examinations, division of power among the administrative levels, role of unions, competition between public and private schools. Also, many differences exist between educational systems in terms of time spent in school during the year. Table 2.16 shows the number of days and hours of schooling across countries.

Table 2.16. Total hours and days of schooling to students in primary education, 1990

Country	Days of schooling	Hours of schooling
Austria	200	960
Belgium	182	...
Denmark	200	1040
Finland	190	874
France	180	972
Germany (West)	220	760
Greece	180	900
Ireland	173	...
Italy	204	816
Netherlands	200	1000
Norway	190	...
Portugal	175	980
Spain	205	1025
Sweden	200	1200
Switzerland	207	...
United Kingdom*	190	950
United States	179	1148

Note: *Data are not available separately for England, Scotland and Wales and Northern Ireland
... Data are not available
Source: Barro and Lee (1997)

There are important dissimilarities in terms of days of schooling ranging from 173 days spent in school in Ireland to 220 days per year in Germany. Also, in terms of

[149] This is a pioneering result. In fact, single country studies have shown the importance of the family background (i.e., parents' education, social class...) in determining students' schooling achievement.

hours of schooling, Sweden ranks first with 1,200 hours whereas Germany has the lowest number of hours, 760. On the other hand, the United States exhibits a high number of hours of schooling, 1,148.

The curriculum in terms of time of instruction according to the subject shows the existing differences across countries. Unfortunately, data for the United States are not available; therefore it is not possible to provide a measure of the Atlantic divide. Nevertheless, it is interesting to look at the European scenario because by examining the curriculum in secondary school, great differences among countries can be observed. In fact, countries like Austria, France, and Germany have a greater focus on scientific subjects whereas in Italy and Switzerland more time is devoted to social studies. Austria, Greece, Italy, Norway and Spain are very centralized in terms of choice of curriculum whereas in Ireland and the Netherlands the flexible part is around 20 percent. (It is important to observe that these are also countries where the schooling system is highly privatized). Obviously, the data reported in the table in the next page are related to secondary school in a specific year, 1994. Therefore, it is not possible to draw any conclusion. However, apart from differences in terms of expenditure and institutional settings, differences in terms of curriculum also characterize the educational systems of the European countries.

Table 2.17. Instruction time for major subject areas as a percentage of total instruction time in lower-secondary education, 1994

Country	Reading and Writing	Modern foreign languages	Mathematics	Science	Social studies	Technology
Austria	13	10	16	14	13	6
Belgium	...	...	...	...	...	...
Denmark	20	10	13	12	11	...
Finland	13	15	11	13	7	...
France	17	11	14	11	13	8
Germany	14	17	13	11	11	2
Greece	13	11	12	12	12	6
Ireland	23	7	12	9	19	...
Italy	22	10	10	10	14	10
Netherlands	10	14	10	8	11	5
Norway	17	10	12	8	10	...
Portugal	13	10	13	15	17	...
Spain	20	13	13	10	10	6
Sweden	14	9	11	10	15	3
Switzerland	...	...	...	...	...	...
UK	...	...	...	...	...	...
US	...	...	...	...	...	...

Country	Arts	Physical education	Vocational skills	Other	Total compulsory part	Flexible part
Austria	6	11	...	6	100	0
Belgium	...	...	...	...	...	...
Denmark	9	7	...	3	90	10
Finland	14	10	...	6	93	7
France	14	11	...	...	92	8
Germany	8	9	2	...	94	6
Greece	8	9	...	16	100	0
Ireland	...	5	...	4	84	16
Italy	13	7	...	...	100	0
Netherlands	7	9	3	1	78	22
Norway	13	9	...	13	100	0
Portugal	10	10	...	...	90	10
Spain	12	10	...	6	100	0
Sweden	7	8	13	7	97	3
Switzerland	...	...	...	...	...	...
UK	...	...	...	...	...	...
US	...	...	...	...	...	...

Note: ... Data are not available
Source: OECD Database (1996, Table P11, p.141)

The focus of the next chapter will be on the quantitative aspect of the expansion of compulsory education that has taken place in Europe since the end of the Second World War. However, it seemed important to provide an overview of the qualitative aspect of schooling of both Europe and the United States. This is because it shows the great heterogeneity that exists across countries. The greater participation rates and the lower quality of the American system have been opposed to the more

restricted participation but greater quality of their European counterparts. Moreover, the issue of quality is important as it can have an impact on the economic outcome as Hanushek and Kimko (2000) have shown. Only recently there has been a shift of policy interest from quantity to quality because universal attendance of compulsory education has been reached in most developed countries. But for a long time, since the end of the Second World War, the attention of policy-makers has been concentrated on the expansion of compulsory schooling and this is the topic that will be examined in the next chapter.

2.4.1.E) Reforms of the institutional design of the educational sector in higher education

Policy change in higher education has been a major concern of European governments over the period 1950-70. Later again, starting from the late 1980s, after a period of stagnation, structural policies and plans for reforms became central to the policy debate as Teichler (1993) has suggested. The great expansion that has occurred in the tertiary educational sector since the end of the Second World War has been described earlier in this chapter. Both the economic and technological development created the need for a more educated labour force and the process of democratization that has occurred in most European countries has shifted participation from the "gifted few" to the "masses".[150] In this section, the institutional response in various aspects of higher education will be examined.

Among the first reforms undertaken by European countries were those adopted in order to open access to higher education. In many countries this took the form of a liberalisation of higher education. In Italy, the Law 910 of 1969 allowed holders of an upper secondary qualification to have free access to all faculties.[151] This policy was adopted also in Greece in 2000, when the general examination for the admission to university was abolished and free access to higher education was granted to all upper secondary school leavers.[152] Other countries like Germany and the Netherlands maintained a more limited access to higher education that was regulated

[150] Gellert (1993, p.9).
[151] The information concerning policy reforms in higher education have been extracted from the country reports of the EURYDICE (2000) publication. Different sources will be acknowledged.
[152] EURYDICE (2000, p.47).

by the Higher Education Framework Act of 1976 and the Law of 1978 respectively and made the access dependent on the type of secondary qualification obtained.[153] Later, some countries regulated student participation in higher education by shaping it as a function of the needs of the labour market. Consequently, countries like Italy and the Netherlands introduced the *numerus clausus* in certain courses like human and veterinary medicine.[154]

Also, changes in the structure of financial aid were important in affecting the participation to higher education. The majority of countries abolished student fees and this had a major impact on participation. In Ireland for instance, between 1965 and 1995 participation growth increased by six times.[155] One exception to this, is represented by Portugal where the tuition fees increase of 1992 was decided in order to cover half of the educational cost per student. However, the law was suspended in 1995 as a result of strong opposition.[156] Moreover, many countries increased financial support granted to students. In Spain, the Real Decreto 2298/1983 established the structure of the financial aid given to students;[157] in Italy the legislation relied on the exemption from fees and the possibility for students to do part-time jobs.[158] In the same context, in 1988, the Swedish government increased financial aid by raising the proportion of grants awarded.[159] In the United States several factors helped in increasing participation rates in higher education after the war even if the process of "mass higher education" was already in place before 1945. Among these factors, the spread of the Scholastic Aptitude Test (SAT) that standardized the process of university selection and also the creation of the "junior colleges" in the 1970s that guaranteed access to students from more disadvantaged background.[160]

Another important structural adjustment undertaken by European countries consisted of the institutional differentiation. That is to say, the creation of different types of higher education; in most of the cases this took the form of a sort of higher technical

[153] EURYDICE (2000, p.44 and p.62).
[154] This legislation was introduced in the Netherlands in 1984 and in Italy in 1997 (EURYDICE, 2000, p.63 and p.59).
[155] EURYDICE (2000, p.54).
[156] EURYDICE (2000, p.71).
[157] EURYDICE (2000, p.48).
[158] EURYDICE (2000, p.58).
[159] EURYDICE (2000, p.76).
[160] EURYDICE (2000, p.14).

training. According to Gellert (1993, p.17), "without these alternative institutional provision the rapid quantitative expansion would not have been possible". In Italy, "Law 196 on the labour market and the access to it" established a system of non-university higher education in 1997.[161] This was similar to what occurred in Portugal from 1979 onwards with the development of vocational higher education at polytechnic institutions.[162] In Finland higher technical training was initially established on an experimental basis through the establishment of "experimental polytechnics". This was so successful that in 1995 these institutions were transformed in permanent polytechnics.[163] Also, in Britain polytechnics were established after the Second World War in order to foster the expansion of vocational higher education. However, this type of higher vocational education was abolished in the early 1990s.[164] The orientation towards this type of vocational education and training systems has not occurred in the United States where formal education remains the main form of instruction.

A further major change that has characterized the post-war period has been the progressive autonomy extended to universities in most European countries that has existed since a long time in the federal educational system of the United States. In fact, the delegation of more decision power in management, funding and planning has taken place in most countries. In this regard, the Spanish Constitution of 1978 established 17 Autonomous Communities and increased autonomy of universities.[165] In Greece, the Nomos 1268 of 1982 gave more autonomy to universities.[166] Similar legislations passed in Portugal and Finland where more decision power was transferred to the institutions themselves.[167] Also in Italy, where the educational system has traditionally been highly centralized as a result of the fact that since the unification of 1860 education has been conceived as one of the most important instruments to foster national cohesion between a multi-cultural population,[168] the Bassanini-laws enhanced the institutional autonomy by setting new dispositions for the regulation of the decision-making power between the state and the individual

[161] EURYDICE (2000, p.59).
[162] EURYDICE (2000, p.70).
[163] EURYDICE (2000, p.74).
[164] Further Education Act of 1992. EURYDICE (2000, p.78).
[165] Lamo de Espinosa (1993, p.88) and EURYDICE (2000, p.48).
[166] EURYDICE (2000, p.46).
[167] This was a result of Law 108 of 1988 in Portugal and Act on Universities 645 of 1997 in Finland (EURYDICE, 2000, p.70 and p.75).
[168] Moscati (1991, p.91).

universities.[169] In fact, greater autonomy was given to universities even for the planning of curricula. Also, in Austria greater autonomy with respect to management and internal organization has been extended to universities since 1993.[170]

The report on institutional reforms on higher education prepared by Eurydice (2000), clearly shows the pattern of decision power in the various aspects of higher education such as budget spending, administration and internal regulation as well as course and development planning. It is possible to observe the progressive extension of autonomy granted first in the financial domain and after in administration and internal regulation. Concerning course and development planning, in the majority of the European countries considered, autonomy granted to universities is still limited or absent and decision power remains at state level.[171] Moreover, it is possible to notice that the only countries where universities had full autonomy in every domain before 1980 were Ireland and the United Kingdom.[172] According to Neave and van Vught (1991), there has been a reshaping of the relationship between governments and the other actors involved in higher education through a decentralization of responsibility. In this sense, they argue that there has been a greater stress placed by governments on efficiency that has led to the adoption of strategic management practices to organize higher education. In this regard, a greater flexibility has become necessary in order to increase the responsiveness to fast changing labour market conditions. In this context, the authors point out that in countries where the extension of decision power to universities has been greater, "simultaneously one observes an equal stress on developing systems of evaluation and quality control".[173]

Another form of expansion that appears important in order to understand the structural adjustment to the technological and economic changes is related to the creation of new degrees and fields of study. For instance in Austria between 1965 and 1995, according to the Eurydice (2000) report, there was a 60 percent increase in courses especially in economic and social sciences. Also, the Finnish government in 1966 promoted studies in technology and social sciences. This aspect will not be expanded upon now as it will constitute the focus of the analysis in a later chapter of

[169] EURYDICE (2000, p.59).
[170] EURYDICE (2000, p.89).
[171] An extensive analysis of the pattern of the reforms in management and control can be found in the EURYDICE (2000, pp.91-3) report.
[172] This can be noticed by looking at the table in EURYDICE (2000, p.91).
[173] Neave and van Vught (1991, p.252).

the thesis. The absence of a centralized educational authority in the United States and the great educational autonomy that characterizes the American system make it more difficult to know the content and the timing related to new degrees that have been introduced across the American states.

Even though there is no specific higher education policy defined by the Member States of the European Community, the European dimension has been important in inducing reforms especially in the recent past and mainly in two ways. First of all, there has been recognition of the degrees awarded in other Member States of the European Community and recognition of the right to receive higher education in another Member State. These rights are based on "the principle of non-discrimination on grounds of nationality".[174] This has also indirectly led to a progressive standardization of the length and the content of the degree programmes (Gellert, 1993). In countries like Italy for instance, following the European process towards harmonisation of degrees, the adoption of a shorter degree course called "laurea breve" is a clear response to European policy. Moreover, European policy has increased the mobility of students between Member States by introducing exchange programmes such as the European Community Action Scheme for the Mobility of University Studies (ERASMUS) and the Community Action Programme in Education and Training for Technology (COMETT). Two programmes have been created in order to increase the co-operation between Member States in the field of scientific research.[175]

Among the reforms that have been described above, the policy change that will be examined in chapter four by comparing the experience of different European countries is the policy related to the introduction of new degrees and areas of study. The choice of this aspect of higher education policy can be justified as follows. First, the expansion of higher education among other factors is clearly related to the fact that the technological advance has created the demand for a more educated labour force and has also created the demand for a different type of skills.[176] The introduction of the ICT technologies that has been described earlier has led

[174] De Witte (1993, p.186).
[175] SCIENCE, for natural science and SPES for economics (De Witte, 1993, p.193).
[176] Evidence of this change in the demand for skills will be shown in chapter five where returns to education will be estimated. Moreover, the literature related to changes in wage premium across European countries and the United States will be reviewed.

institutions to intervene in new areas such as biotechnology and communications. Moreover, this policy can be compared across countries and reflects the historical shift of institutional concern: from "quantity", that was a major issue in the 1960s when opening the access to higher education was central to the policy debate, to "quality" that has become of great importance particularly as a result of the introduction of the ICT.

2.4.2) Vocational training

In order to complete the description of the evolution of human capital since the end of the Second World War, I should provide a measure for vocational training. However, as Maddison (1996, p.49) suggests, "it seems improbable that one can get a satisfactory comparative view of the situation in the countries under observation". This paucity of detailed information can be justified as follows: statistics at country level are not complete for the immediate post-war period as there is an enormous lack of documentation. This is mainly due to the fact that the state is not the only agent that organizes the provision of training in many European countries. Vocationalism is highly heterogeneous, it includes "job-specific apprenticeship training and, at the other, technically oriented higher education".[177] In countries that follow the British liberal market model for instance, either the market or individual companies determine the content of vocational education and training and there is virtually no public provision in terms of funding. On the other hand, in countries following the German model there is a joint participation of the state, unions and entrepreneurs.[178] In addition to this, European systems are characterized by great dissimilarities that make the different vocational qualifications not readily comparable.

One of the major innovations was brought by the establishment of the "Permanent Commission for Vocational Training" that was organized by the European Coal and Steel Community (ECSC). This body became gradually effective in encouraging the exchange of information and documentation among the Member States. These are

[177] Ryan (2003, p.148).
[178] These information have been extracted from CEDEFOP (1984).

the reasons why international organizations such as ILO, OECD and the European Centre for the Development of Vocational Training (CEDEFOP),[179] which is the main reference for vocational training at European level, have provided accurate data only for recent times.[180] In the following paragraphs I will start by examining what is available in terms of internationally comparable data, after I will describe the different typologies of vocational training that characterize the European landscape.

According to Toner (2005) one of the best ways of measuring the output of an apprenticeship system is by means of the training rate. That is the number of apprentices as a share of the workforce. This data can be found in Broadberry and Wagner (1996) having been extracted from Gospel (1993) for Britain and other national sources for Germany and the United States for the post-war period. I present what is available in terms of training rates for Britain, Germany and the United States in the post-war period; data for other countries are not available. Data are limited to the sector of manufacturing and engineering for Britain and to metals and engineering, manufacturing and the whole economy for Germany. American data are available for both metal working and the whole economy. This small number of sectors does not really represent a shortcoming as great emphasis is commonly given to engineering and manufacturing "because of their role in developing and implementing technological change".[181]

[179] CEDEFOP is the European agency created in 1975 by the Council of Ministers of the European Community.
[180] There is only an early OECD publication that provides a comprehensive view on the different types of education in the 1970s but is limited to France and the United Kingdom. The author of this publication is Woodhall (1977) and the title is "Educational expenditure in France, Japan and the United Kingdom", Paris: OECD.
[181] Gospel (1991, p.1).

Table 2.18. Share of apprentices in post-war Britain, Germany and the United States

Britain			
	Manufacturing	Engineering	
1964	2.98	4.41	
1970	2.72	4.27	
1980	2.29	3.35	
1989	1.08	1.60	
Germany			
	Manufacturing	Metals and engineering	Whole economy
1950	4.6	8.0	4.6
1960	5.5	7.2	5.4
1970	4.4	5.4	4.8
1980	6.8	7.1	6.2
1988	7.4	7.5	6.5
United States			
		Metal working	Whole economy
1952		0.21	0.29
1960		0.34	0.26
1970		0.80	0.34
1975		...	0.31
1991		0.69	0.22

Source: Broadberry and Wagner (1996)

What is striking is the difference between the share of apprentices in the two European countries with respect to the United States. Data for the whole economy are not available for Britain; however, it is possible to observe that Britain and Germany exhibit high rates of training whereas the United States has a share of apprentices that is on average below 0.5 percent. Also note that the number of apprentices decreased in Britain after the war whereas Germany experienced increasing rates in the economy as a whole.

Broadberry and Wagner (1996) see the human capital stock of these countries as being intimately bound up with production strategies. They argue that the United States has followed a policy of standardized mass production which has been best

suited by high investments in general education in order to develop managerial and research capabilities and low investments in vocational education and training as mass production requires low skilled workers. On the other hand, the European focus on craft production has made high levels of shopfloor skills a necessity. In this regard, the decline of the British apprenticeship coincides with the reduced importance of heavy industry and artisan trades, the lowest level having been reached in 1970. On the other hand, Habakkuk (1962) considers the development of the American system of production as a result of skilled labour scarcity and natural resources abundance. By contrast Elbaum (1991) traces back the emerging transatlantic divergence to the colonial heritage. He argues that in spite of the fact that Britain transplanted this institution to the New World, the guild traditions did not become popular in the United States. This is because they were not appropriate to a dynamic settler society with high rates of migration and labour mobility. According to the author, this generated a lack of institutions able to train workers and later, the introduction of the training system based on the European model would have engendered too high social costs.

What is unambiguous thanks to the analysis carried out by Broadberry and Wagner (1996) as well as by Goldin (2001) and Broadberry and Ghosal (2002) is that the American adoption of the mass production system created the need for two types of skills. On the one hand, the system relied on a provision of low skilled workers. On the other hand, the need to organize this system of production called for the development of managerial capabilities. The educational system developed along the line of formal education. The United States clearly became the leader in the provision of "mass education".[182] In spite of this, the whole system has not guaranteed a provision of high quality education, as shown in an earlier section. On the contrary, in the majority of European countries the system of production was more flexible and this created the need for higher levels of skills at shopfloor level. This is why the vocational training system that provided workers with the skills necessary to carry out a quite complex but specific task proved to be adequate for the European system of production.

[182] Goldin (2001, p.4).

Table 2.19. Educational attainment of the employed population in Europe and the United States, 1990 (percentage)

	General education giving access to higher education	**Vocational education giving access to higher education**	**Still in education at age 18**
Austria	13.0	28.0	...
Denmark	32.0	54.0	67.9
Finland	46.0	...	...
France	31.0	40.0	71.0
Germany	24.0	...	81.0
Ireland	74.0	7.0	52.0
Italy	18.0	33.0	...
Netherlands	29.0	31.0	73.8
Norway	39.0	32.0	72.9
Portugal	44.0	5.0	...
Spain	34.0	30.0	50.5
Sweden	20.0	61.0	52.5
Switzerland	17.0	...	76.6
United Kingdom	35.0	16.0	37.6
European countries*	32.6	30.6	63.6
United States	75.0	...	57.7

Note: * The average has been calculated for the Western European countries presented in the table
... Data are not available
Source: Crouch et al. (1999)

Table 2.19 provides a snapshot of the European and American workforce divided according to the type of education received in 1990. It shows the greater European endowment in terms of vocational education. Countries like France, Italy and Sweden have a greater endowment of vocational qualifications giving access to higher education whereas in the United Kingdom the same rate is very low. Also, countries like Ireland and Portugal show greater endowments of general education. The particularly high proportion of the employed population with general education in the United States confirms the great dissimilarity with respect to the European model that has been previously emphasised. Finally, on average European

institutions are more successful in retaining students in school at the age of eighteen than the United States.

The final report of a research network organized by the CEDEFOP has traced the historical profile of the European vocational education and training systems[183] from the common origins of the guild system in the Middle Ages until the process of convergence that has characterized the European training systems during the last fifty years. It argues that in spite of many similarities of the guilds of the twelfth century, the training systems diverged as a result of the industrialization process as well as a consequence of the spread of different political, philosophical and cultural movements. Apart from the major difference between the "supply-led" and "demand-led" systems that will be explained in detail later and will represent the core of the analysis in chapter four, broadly speaking three vocational training system models can be identified.[184] The German dual model is considered as the most successful apprenticeship system.[185] Since the *Berufsausbildungsegesetz* of 1969,[186] the state, unions and entrepreneurs have shared the responsibilities for the provision and the organization of the training system. On the other hand, the French system is characterized by the central role of the state. It is the state that organizes the system of vocational education and training, determines the content of this type of education and finances the system. Finally, the British model is more liberal with respect to the other systems, as the content of training is not predetermined but depends on the contingent market demand. Furthermore, the general organization of the system is "negotiated in the market place"[187] between entrepreneurs, labour representatives and vocational school representatives. In a widely cited contribution Prais (1995) extends the analysis to the Netherlands and Switzerland. The latter as well as Austria follows in many respects the German traditions whereas Sweden has developed a training system that is more similar to the French one.[188] In another widely quoted report prepared for the NIESR, Mason et al. (1992) show the main features characterizing the Dutch model such as "less centralised and less

[183] CEDEFOP (2004a), "A history of vocational education and training in Europe. *From divergence to convergence*".
[184] Information concerning the different models of vocational training have been extracted from CEDEFOP (1984) and CEDEFOP (2004a).
[185] Among the great number of existing publications on this topic, particularly insightful appear to be: Soskice (1992), Prais (1995) and Franz and Soskice (1995).
[186] This is the law that codified the different responsibilities of the state, unions and entrepreneurs for the organization of the training system.
[187] CEDEFOP (2004a, p.9).
[188] Crouch et al. (1999, p.117).

prescriptive approach to education than France or Germany"[189] as well as a practical curriculum that enables students to acquire skills they will need in their working activity. It is important to notice that a neo-liberal reform agenda has been progressively implemented and the country is acquiring many characteristics of the "quasi-market" education systems.[190] Mason et al. (1992) also claim the superiority of this vocational training system by emphasising the higher levels of manufacturing productivity with respect to those reached in Britain and Germany.

In the recent literature, some scholars like Krueger and Kumar (2004) have argued that the better performance of the United States with respect to Europe in terms of ICT adoption is due to the greater focus on general education that characterizes the American educational system. It is possible to observe that apprenticeship and vocational education have undergone major transformations since the end of the Second World War (Ryan, 2001). In both traditional sectors such as metal working and fast developing sectors like banking and communications, institutions have undertaken policy changes in order to adjust the existing system to the technological requirements. As has been argued before, a comparison of training systems across countries is very difficult because training provisions are closely related to the production system of each country. However, limiting the analysis to formal vocational education only, that is work-related learning in secondary and higher education, makes "the task more manageable".[191] In this context, well-defined policy changes were undertaken by European countries to face technological challenges after the Second World War and clear institutional responses have been undertaken with the introduction of the ICT-related apprenticeship programmes. This issue calls for analysis: there have been major differences across European countries in the timing of the introduction of these new vocational programmes as well as in the content of the programme. Also, it would be interesting to examine the chronology of the institutional response in parallel with the adoption of the ICT technologies in order to understand whether the policy response has been adequate in eliminating the skill shortages and whether there have been major differences across European countries.

[189] Mason et al. (1992, p.45).
[190] Green et al. (1999, p.69).
[191] Ryan (2003, p.148).

In this section of the chapter the expansion of education has been examined by highlighting the extraordinary growth of enrolments at secondary and higher education levels. The pattern of expenditure has been described as well as the main institutional reforms in terms of institutional expansion, decentralization, changes in governance and introduction of central examinations in order to monitor the quality of schooling. Finally, what is available in terms of data related to the evolution of the participation in vocational education and training has been provided for some European countries and the United States. Moreover, the analysis has shed some light on significant differences characterizing the vocational training systems in Europe.

2.5) Conclusion

In this chapter I have presented the historical framework of the thesis. I have started by showing the pattern of growth in the second half of the twentieth century, by highlighting the unprecedented growth rates experienced by most European countries during the Golden Age and the subsequent sluggish performance after 1973. Then, I described the state of technology since 1945 by emphasising the importance of two phenomena that created a major technological gap with respect to the United States. A great "Atlantic divide" was evident at the end of the war when the years of warfare and destruction had created retardation in technological development. This was reflected in the lagging productivity rates. Subsequently, in the first decades after the war many European countries adopted the Fordist mass production system by importing American technologies that were better suited to the European environment than ever before. However, when later a general purpose technology was introduced, many European countries found themselves locked in institutional arrangements that were opposite to what the ICT required in terms of quality production and flexibility. The introduction of this new general purpose technology required major institutional adjustments. In this economic context the evolution of human capital has been analysed. The great expansion in terms of schooling enrolments since the end of the war has been emphasised as well as the pattern of expenditure has been described and compared to the American one. The main issues that have animated the policy debate in terms of educational expansion, institutional reforms and quality of schooling have been illustrated. Finally, what is available in terms of data related to vocational training has been shown and the great dissimilarities existing among European countries as well as the important divergence with respect to the United States have been outlined.

In this general framework it appears important to examine the human capital policies undertaken by European institutions in order to reduce the technological gap and to foster growth. This is because the central role that human capital has played in the process of technology adoption since the end of the Second World War has been acknowledged by scholars and it has been described in the first two chapters of the thesis. Therefore, the rationale behind these policy changes as well as the consequences should be investigated in order to fully understand the process of adjustment. This is left for the next chapters. As I have argued before, the focus of

the next chapters will be on European policy only. This is because the interest of the thesis is to look at the policy changes undertaken by European countries by examining the heterogenous response of the different systems that constitute the European scenario. In addition to this, European countries do not seem to have imitated the American educational system.[192] Rather, by following their own pattern to modernity they have developed quite distinctive educational models. Finally, a practical reason makes the study of the American policy reforms in education and training not readily feasible. Data collection and information gathering would require an effort equivalent to the one required to write another thesis. This is the reason why this task is left for future work and we now turn to a major educational policy change that has occurred in Europe after the Second World War at primary and lower secondary levels.

[192] The case of Britain that abolished vocational education in the 1980s to imitate the American model has been acknowledged and is limited to this country (Broadberry and O'Mahony, 2004).

Chapter Three

AN HISTORICAL ANALYSIS OF THE CHANGE IN COMPULSORY SCHOOLING LAWS IN EUROPE AFTER THE SECOND WORLD WAR

3.1) Introduction

In this chapter the first of the education policy changes of the thesis will be examined. The analysis is based on the study of the expansion of compulsory schooling in fifteen Western European countries over the period 1950-2000.

The expansion of compulsory schooling after the Second World War represented a very important policy change: a reform that can be considered among the first structural adjustments common to the majority of European countries. The increase in school-leaving age laid the basis for further educational expansion. Specifically, over the period 1950-2000, the fifteen Western European countries extended the school-leaving age by one year or longer; mainly during the twenty-five years after the war. What is interesting is that the change in legislation was undertaken by countries with different traditions and experiences in educational policy such as Nordic, Anglo-Saxon and Continental countries. In fact, European countries were different and the war had a dissimilar impact on their economies. However, new equilibria at both national and international level led countries to undertake this policy change in education. This can be considered as a structural adjustment in order to address the needs of the post-war society.

Many theories have been proposed in the sociology and political science literature to explain the expansion of education during this "period of extensive development of the educational and training system".[193] However, these important contributions have not explained the timing of the changes in school-leaving age laws. In the existing literature there are two kinds of analyses related to the expansion of education. On one hand, there are macroeconomic studies;[194] these suffer from the limitation of not considering the role of institutions, thus lacking an historical contextualization of the policy changes. On the other hand, the country-level studies are too specific to allow any inference about how common factors may have influenced the way in which countries have shaped their education policy. Consequently, this topic has not been adequately studied so far. What is missing in the existing literature is a comparative analysis of the education policies undertaken at European level. Comparative work by Diebolt and Fontevielle (2001) and Ringer (1979) represents a good start but is

[193] Diebolt (1999, p.30).
[194] For instance, Mankiw, Romer and Veil (1992).

not sufficient to understand what were the factors, beyond the national boundaries, driving the expansion of compulsory schooling.[195] Nor do they explain the timing of the changes in school-leaving age laws that occurred in most European countries after the war.

I aim to contribute to the existing literature in two ways. First, I will adopt a comparative approach by undertaking a quantitative analysis using a new dataset constructed for a panel of fifteen European countries over the period 1950-2000. The second intended contribution is methodological: I make use of the technique of duration analysis that has been recently used in political economy analysis to study the determinants of specific policy changes. The analysis has merit as descriptive evidence, the causal link is more difficult to establish.

The paper proceeds as follows. First, I review the origins and the main features of the compulsory schooling laws that characterised the European experience after the war. Then, I will analyse the main theories that scholars have proposed to explain the expansion of education and I will derive from these the hypotheses that I will test empirically. After, I will describe the dataset I have constructed and I will explain the methodology for the quantitative analysis. Finally, I will provide comments on the results of the empirical analysis, a brief discussion and concluding remarks.

[195] The focus of these analyses is limited to a small number of countries: to France and Germany the former and to France, Germany and the United Kingdom the latter.

3.2) Historical background

Following the definition provided by the OECD, compulsory schooling is "the span of years during which every normal child must be receiving a formal education".[196] Compulsory schooling was introduced in most Western countries between the second half of the nineteenth century and the beginning of the twentieth century.[197] Economic historians have been interested in the topic of formal education in order to understand how institutions can create the conditions to promote economic development and growth.[198] Landes' (1969) work has shown that cultural, social and educational factors were essential in determining the development of more advanced technologies. Therefore, one may wonder how important was education in the process of industrialization. Interestingly, compulsory schooling was introduced only at a relatively late stage of industrialization whereas basic human capital, measured by literacy rates, was already widespread (Cipolla, 1969). In fact, the basic skills of reading, writing and arithmetic were provided by a variety of religious and non religious institutions in Western Europe at this time.[199] Some historians have provided evidence in favour of the importance of the spread of basic knowledge for the process of industrialization to start. According to Cipolla (1969), Britain had a large pool of literacy before the Industrial Revolution, whereas Cameron (1985) shows how countries like the Netherlands, Switzerland and the Nordic countries, lacking a large supply of coal, could successfully industrialize as a result of their skilled population that acted as a substitute for natural resources. Conversely, Cameron explains the late industrialization of Southern European countries as a consequence of the low levels of literacy and the late development of formal education. Why was compulsory schooling not institutionalized before the nineteenth century and only after the beginning of the industrialization process in most European countries?

Mitch (1983) argued in his doctoral dissertation, that an earlier introduction of compulsory schooling would have been socially desirable but not economically necessary as there was a lack of demand for educated workers. In fact, literate

[196] OECD (1983, p.12).
[197] Maynes (1985, p.25). The exception is represented by Germany. In Prussia compulsory schooling was introduced in 1763 and extended to the German Empire in 1871.
[198] See for instance Cipolla (1969), Nicholas (1990) as well as Tortella (1990) and Sandberg (1982).
[199] Maynes (1985, p.7).

workers did not benefit from any wage premium with respect to their illiterate counterparts. In general Mitch (1990) rejects the "indispensability" of formal education by providing historical examples of the successful development of trade and financial activities for which the labour force had acquired on-the-job skills and not formal education. Later, things changed: "indications that the demand for literate workers was shifting to the right are the shift after 1840 of the labour force toward occupations making relatively active use of literacy and evidence indicating increasing use of literacy within given occupations".[200]

The shift in demand was probably generated by the greater complexity of the productive activity and by the need of having a disciplined, responsible and industrious working class as Bordieu and Passeron (1977) have claimed. This would suggest that schooling became compulsory first in more industrialized countries where the demand for education was already high. This is what Landes and Solmon (1972) have argued happened in the United States where the institutionalization of schooling may be seen as the formalization of a social change that was taking place in the American society. Scholars have not yet reached a definitive conclusion for Europe, but enrolments in primary school were already high when compulsion was established.[201] The introduction of compulsory schooling in Europe was a revolutionary policy change. In this regard, the process of nation building is likely to have been another factor that accelerated the need to introduce secular education in Western European countries.[202] It is important to acknowledge that the number of years of schooling that was initially made compulsory was very low especially in Southern Europe. In Italy, for instance, the Casati Act of 1859 established two years of compulsory schooling, whereas in Denmark seven years of compulsory education were enacted in 1814 but attendance was only compulsory three days per week.[203] This may also be due to the fact that the higher the level of education the more disconnected it was from the productive activity as "education above the primary level had practically nothing to do with business".[204] Educational programmes with modern subjects became available as an alternative to the classical secondary

[200] Mitch (1983, p.287).
[201] Craig (1981, p.184).
[202] Cipolla (1969, p.70).
[203] Flora et al. (1987).
[204] Ringer (1979, p.2).

education only in a later phase of industrialization.[205] Moreover attendance was low, especially in the countryside at harvest time,[206] and the power of the state to enforce compulsion was low due to budget constraints.

After this major economic and social change that created the common impetus for reform in Western Europe, education expanded by following national patterns and there was no other institutional response that was undertaken in the same epoch by various European countries. Moreover, the economic depression that followed the Great War and the slow recovery during the interwar period imposed important constraints on government expenditure for social services such as public education. In fact, even if governmental intervention increased after 1918, the important increase in public expenditure as a share of GDP between 1913 and 1937 was largely due to the depression rather than a real increase in public spending for social services (Tanzi and Schuknecht, 2000, p.9).

After 1945, with the end of the war, things changed dramatically. Countries started experiencing unprecedented growth rates and the recovery was faster than the more optimistic could have expected (Eichengreen, 1996). Moreover, the new economic and socio-political conditions created the pressure for governments to modernize the education system. The expansion of compulsory schooling was an institutional reconfiguration of the schooling system undertaken in countries very different from each other, with dissimilar economic conditions and different cultural and educational traditions. In addition to the expansion of education, many countries reshaped their educational system.[207] The timing of the passage of the school-leaving age laws of fifteen European countries over the period 1938-2000 is presented in table 3.1.[208]

[205] Ringer (1979, p.5).
[206] Maynes (1985, chapter 7).
[207] E.g., the 1970 reform in Spain was the first since the Moyano Act of 1857 to reshape the entire educational system (EURYDICE, 2005).
[208] Germany has not been included in the analysis of this chapter. As previously suggested, this is because of the difficulties arising from the different schooling legislation in the Federal Republic of Germany and the German Democratic Republic until reunification occurred in 1990. This is left for future investigation.

Table 3.1. The extension of compulsory schooling in Europe, 1938-2000 (starting year=1938)*

COUNTRY	NUMBER OF YEARS BEFORE	DATE OF CHANGE	NUMBER OF YEARS AFTER	STARTING AGE	OVERALL CHANGE
Austria	8	1962	9	6	+1
Belgium**	8	1983	12	6	+4
Denmark	7	1971	9	7	+2
Finland***	6	1972	9	7	+3
France	8	1967	10	6	+2
Greece	6	1964	9	6	+3
		1967	6		-3
		1976	9		+3
Ireland	8	1972	9	6	+1
		2000	10		+1
Italy****	5	1963	8	6	+3
		1999	9		+1
Netherlands[+]	6	1950	8	7	+2
		1971	9		+1
		1975	10		+1
		1985	12	5	+1.5 (on avg)
Norway	7	1969	9	6	+2
		1997	10		+1
Portugal	3	1956 (men)	4	6	+1
	3	1960 (women)	4		
		1964 (all)	6		+2
		1986 (all)	9		+3
Spain	7	1970	8	6	+1
		1990	10		+2
Sweden[++]	8	1950	9	7	+1
Switzerland[+++]	8	1970	9	5 or 6	+1
United Kingdom[^^]	9	1947	10	5	+1
		1973	11		+1

Note: *The dates considered refer to the enactment of the school-leaving age law, that is to say when compulsory schooling was increased, enforcement was effective and education was provided at virtually no private cost

**The reform was adopted in the three Communities. Compulsory schooling is full-time until 15 (at 16 only if the student is 15 and has not been enrolled in the first two years of secondary school), after it is part-time until 18

***For countries where the reform was implemented more gradually the date of change considered is the year when the compulsory schooling law started being implemented. These countries are Finland, Sweden (see note below) and Switzerland

****Information have been extracted from Shavit and Westerbeek (1998) and Brandolini and Cipollone (2002)

[+]The 1985 reform has led to a change in the school starting age. School starts the first month after children turn 5 and full-time education is compulsory until students have attended 12 complete years of schooling, in any case until the end of the school year when they turn 16; then students are required to take one year part-time courses. Therefore, on average, the 1985 change implied a 1.5 years increase. Before this reform students started school at the beginning of the academic year when they turned 7. Information on the Dutch reforms has been kindly provided by Professor Oosterbeek, Universiteit van Amsterdam, Dr Webbink, Centraal Planbureau and Eurydice(2005b)

[++]It is acknowledged that in some municipalities compulsory schooling lasted 7 years before the change. This policy change is known as the "1950 Education Reform" was gradually implemented across municipalities over 1949-62 and the legislation passed in 1962. Here, the starting point is 1950 as the reform was implemented in the second half of 1949 and only 1.3% of the municipalities had adopted the change in 1949 (Meghir and Palme, 2005, table 1)

[+++]This reform corresponds to the first implementation of the policy change undertaken in the country. Differences exist across Cantons

[^^]The first reform was implemented in England and Wales in 1947, in Scotland in 1946 and in Northern Ireland in 1957

Source: Arnet (2000), Eurydice Database on Education (2006), Flora et al. (1987), Marlow-Ferguson (2002)

Two groups of countries can be identified according to the starting level of compulsory schooling at the end of the Second World War. Austria, Belgium, France, Switzerland, Ireland, the United Kingdom and the Nordic countries started with high levels of compulsory schooling, varying from 7 to 9 years. On the other hand, Southern European countries[209] had lower initial levels of compulsory schooling, from 3 years for Portugal to 5 for Italy and 6 for Greece. This distinction was reflected in the actual levels of schooling achieved by the population. According to the dataset constructed by Cohen and Soto (2001), that will be used later in this chapter, the rate of educational completion was lower in Southern European countries. However, the Southern European countries overall have increased the number of years of compulsory schooling more than the other countries since 1945. They achieved a significant catch-up. Spain and Italy increased compulsory schooling twice and the overall change consisted of 3 and 4 additional years of compulsory schooling. Portugal is the European country that has increased compulsory schooling most since 1945. According to Alves and Canário (2002, p.656), since the end of the war, "schooling has become the primary focus of education policy". This was accompanied by a democratisation of access. A Portuguese politician interviewed by Alves and Canário (2002, p.658) argued that "the fundamental change in the system [has been] expansion". On the other hand, Nordic countries and the other countries that started with higher levels of compulsory schooling increased the school-leaving age by a year or two. The experience of the United Kingdom is an exception. A education act was already passed by Parliament in 1939 to raise the school-leaving age by one year. However, the law was suspended because of the outbreak of the Second World War.[210] A plan to increase compulsory schooling was included in the 1944 Butler Act but did not become effective until 1947 (Dent, 1954). The case of the Netherlands deserves a comment. In fact, after the first legislation making education compulsory was passed in 1900, the Act was amended several times but a new legislation replacing it was provided only in 1950 and after in 1971 with the implementation of the "Leerplichtwet", the Compulsory Education Act.[211]

[209] Spain is the exception as in 1945 it already had seven years of compulsory schooling.
[210] Kurian (1988, p.1485).
[211] Marlow-Ferguson (2002, p.948). The law passed in 1969 but was implemented in 1971.

It is possible to notice that most European countries increased compulsory schooling for the first time in the twenty-five years following the end of the war. In fact, by 1970, 11 countries had passed the school-leaving age laws. After 1990, only Ireland Italy and Norway increased the school-leaving age by one year and this was the second change for the three countries. For many countries this change was the result of a reconfiguration of the education system that was perceived as necessary by governments during the post-war period. In Austria, for example, after the Second World War "educational reform became one of the major issues facing the new republic".[212] However, the school-leaving age law did not pass until 1962 because of the divergent education policies between the Austrian Socialist Party and the Austrian People's Party, the two largest parties.[213] Also, in France there was a great need for reforms after the war and the policy change in compulsory schooling was undertaken under the Pleven government. On the other hand, in Spain the need for reform was not addressed under Franco's authoritarian regime before 1970 when the Ley General de Educación[214] was enacted.

In this context, it would be interesting to understand what the determinants of this policy change were. Namely, what were the new conditions characterising the post-war era that led countries to increase compulsory schooling? These issues have remained largely unexplored in the existing literature and call for an investigation. This is what I propose to do in the following sections.

3.3) Theoretical framework

Many theories have been proposed by sociologists and political scientists to explain the development and the expansion of schooling. However, it is important to acknowledge the fact that there are country-specific determinants of the school-leaving age laws that cannot be observed by doing a cross-section analysis over

[212] Kurian (1988, p.8).
[213] Kurian (1988, p.9).
[214] Marlow-Ferguson (2002, p.1272).

time,[215] and which have played an important role in leading to the passage of the laws. Indeed, cultural factors, legal systems or other institutional settings may have been relevant for the enactment of the compulsory schooling laws. But the question here is what caused the changes in compulsory schooling to be concentrated in the post-war period. Finding an answer depends on finding empirical evidence for the determinants, among those proposed by the theorists of educational expansion.

In the following paragraphs I will analyse the main theories, later I will formulate the hypotheses and describe the variables used to test which theory best accounts for the passage of the school-leaving age laws in Europe after the Second World War.

3.3.1) Technical-functional theory (modernisation)

According to the "technical-functional theory" modernisation, in the sense of technological advance and greater complexity of the organization of production, creates the demand for a more educated labour force. According to Collins (1971), this happens when the proportion of jobs requiring more educated workers increases and more education is required to perform tasks that previously required less education. As an institutional response to this, states can intervene through education policy. That is, governments can increase the number of years of compulsory schooling in order to endow citizens with the skills necessary to enter into a more complex labour market. This framework differs from human capital theory in that the policy change is not only considered as the private response to monetary incentives (Craig, 1981). How can this theory apply to the European experience in the later twentieth century? Central to the European experience after the war was a technological gap with the United States, low productivity levels and a backlog of unexploited capital. However, the new conditions at both national and international level laid the foundations for a rapid recovery and the adoption of more advanced technologies through import and imitation. Thus, a policy change to increase the amount of time spent in school by the population may have been undertaken by

[215] In order to address this issue, later in the panel regression analysis, fixed effects will be used to take into account country-specific attributes.

governments to endow the future generations with the skills that a more complex production system requires.

3.3.2) Neo-institutionalism (political economy factors)

This theory has been developed to address the unanswered questions left by the technical-functional theory. In particular, what has been observed is that the expansion of education at all levels is something that goes beyond the experience of rich and developed countries. To understand the driving forces behind this world-wide educational experience, sociologists have analysed global phenomena that may have affected the development of similar institutions across different countries. This is the reason why Meyer and Schofer (2005b, p.5) have focused on "how much the institutions of modernity (as opposed to the actual income and resource levels nominally associated with these modern institutions) diffuse around the world independent of socioeconomic developments". In the context of the European expansion of compulsory schooling countries at different stages of development, with dissimilar levels of GDP per capita and technology, have enacted the school-leaving age laws to increase compulsory education. Therefore, it seems necessary to investigate whether political economy factors may provide a good explanation for this change in education policy.

The common history of European countries is characterized by important socio-political factors that may have been influential for the expansion of compulsory schooling after the 1950s. First, is the ideology developed since the aftermath of the Second World War according to which education is essential for progress.[216] This new way of thinking marked a radical change from the pre-war period when it was believed necessary to limit the spread of education in order not to have a supply of educated workers that would have been greater than the economy could absorb.[217] This change was caused by many factors. At international level, the competition among countries, in particular with the Soviet bloc since the mid-1950s, intensified

[216] The right to receive formal education was introduced in many European post-war constitutions.
[217] Abramovitz and David (1973, p.435). They argue that the technological development made a skilled labour force necessary and dismissed the belief that an expansion of education would have caused skilled workers' wages to decrease.

the responsiveness of Western European countries in terms of increasing the education level of the labour force in order to be more competitive in technology and innovation. In fact, the international tension that originated in the aftermath of the war with the Space Race played an important role in amplifying the cultural and technological competition between the Soviet Union and Western countries during the Cold War (Mitchell, 2004).

In addition, the process of European integration may have played a role in leading countries to adopt similar changes in education policy. That is, the aim of gaining entry into the European Union may have led countries to modernize the educational system and compulsory schooling reforms may have been part of this framework. Indeed, there was a consistent lag between the year of application and when new members joined the European Union. Ireland for instance, applied in 1961 and joined the European Union in 1973 whereas Portugal and Spain were admitted in 1986 after applying in 1977. During these time periods both Ireland and Portugal enacted school-leaving age laws. In Greece, the application was submitted when the democratic regime was restored in 1975. Many educational reforms that had been invalidated during the regime were re-established[218] and the country could become member of the European Union in 1981.

The influence of European policy on the expansion of education may also have been indirect. In fact, since the creation of the European Coal and Steel Community in 1951, the progressive development of a common market may have influenced the education and training policy of the participating countries.[219] On the other hand, the development of human capital theory led to the increased awareness of the benefits that education can create in terms of increasing workers' productivity and finally in promoting sustained growth. The writing of Schultz (1961), Becker (1964; 1993) and Mincer (1974) became very influential among policy-makers at this time. Another factor that may have affected the expansion of compulsory schooling is the development of institutions favourable to the expansion of education, this is democracy. In this institutional setting the needs of the individual become central to

[218] Kurian (1988, p.517).
[219] This externality can be considered as the "contagion effect" and will be discussed in greater detail later.

society and the right of the individual to acquire the knowledge and the skills to fully develop his personality is recognized in the constitutions of democratic countries.

3.3.3) Role of the state

This theory differs from those previously introduced in that it provides a supply-side explanation. In this framework the timing of the enactment of the school-leaving age laws is considered not to be a result of post-war economic and socio-political conditions but rather as a function of the state's capability to support the expansion of education. Consequently, strong states that emerged at the end of the Second World War had the possibility to devote resources to education and to expand the level of compulsory schooling with the belief that "sustained economic growth needed an *(sic)* increasingly skilled manpower".[220] This framework also contrasts with the class-conflict theories as it recognizes that as the state becomes more complex and structurally organized, then the possibility for class-conflict is greatly reduced[221] and the "scope for negotiation increases enormously" as Archer (1979, p.237) suggests. Within this general framework a stream of the literature has focused on the strength of the state in promoting change in the educational system.[222] In a very insightful study, Hage and Garnier (1992) have contrasted the strength of the French state and the weakness of the Italian state in promoting the expansion of education at primary and secondary level over 1881-1975. Their definition of strength is based on many indicators such as "the relative power and legitimacy of state bureaucrats, the creation of a highly differentiated educational system, the closing of access to some parts of the educational (*sic*) system, the emphasis on the quality of education, the enforcement of attendance laws and the state's ability to handle educational crises".[223] These variables seem to be important, however they are difficult to compare across fifteen European countries. Therefore, the empirical

[220] Demeulemeester and Diebolt (2005, p.3).
[221] That is to say that the class-conflict model can provide a convincing explanation for the introduction of compulsory schooling that occurred in most European countries towards the end of the nineteenth century when many countries were still experiencing nation-building. On the other hand, after the Second World War this was no longer the case, as Western European countries were unitary states with a single system of law and government. Therefore the power of the state to induce educational change becomes more important as the state becomes the main actor.
[222] Archer (1979), Hage and Garnier (1992) and Thelen (2004) for vocational training.
[223] Hage and Garnier (1992, p.157).

analysis will be restricted to some of the variables in line with the theory of the role of the state for which the data is available and comparable across countries.

I should acknowledge the existence of another aspect of this topic that I was unable to investigate further and that appears to be a promising area for future research. This is the "contagion effect". Spatial dependence as an area of research is still evolving and Smythe (2005) recently found that contagion was among the most important factors in determining the passage of the Uniform Sales Act in 34 American states between 1906 and 1947. However, in the existing literature, it is possible to observe that many other attempts to model this effect have been less successful.[224] In the context of my research, the potential importance of the effect that an increase in school-leaving age in a country may have had on the expansion of compulsory schooling in other countries has been acknowledged. In fact, factors such as geographical proximity, similar characteristics of neighbour countries as well as European integration may have led countries to become more responsive to policies adopted in other European countries. I have tried to model this variable in three ways. First, this was done by considering for each country the ratio of the countries that passed the law with respect to its neighbours. Then, I tried to model the contagion effect by controlling for participation in European integration[225] and by normalizing it by the total number of countries that passed the law in a given year. The last experiment relied on the specification of neighbours according to the industrial structure, *viz.* countries with a similar industrial structure were considered as neighbours. However, none of these variables was significant once I introduced them separately in the regressions. This is an important issue that deserves additional study possibly with specific reference to the contagion theory. This theoretical framework is used in economics to explain a variety of phenomena such as the spread of a financial crisis and the positive peer effect on students' performance. In this context, it may be that countries that increased the number of years students should spend in compulsory schooling led other countries to enact similar legislation. This issue needs further investigation.

[224] See for instance Carruthers et al. (2005).
[225] Done by taking into account whether a country had joined the European Union.

3.4) Methodology and analysis

3.4.1) Descriptive statistics

I start by looking at some statistics and how they have changed over the period 1950-2000 in the fifteen European countries under study. The evolution of average years of school, GDP per capita and technology per capita over the period 1950-2000 can be observed in table 3.2.

	Avg Years School*				Real GDP per capita				Technology per capita**			
Country	level 1950	1970	1990	2000	level 1950	1970	1990	2000	level 1950	1970	1990	2000
Austria	6.54	127	155	167	4213.72	265	470	562	0.339	346	480	409
Belgium	5.84	128	160	173	6099.82	199	326	390	0.838	212	158	141
Denmark	7.25	125	150	162	8423.95	190	259	316	0.356	192	130	446
Finland	5.23	141	194	210	5026.91	227	403	473	0.180	166	275	274
France	5.14	136	181	190	5428.66	227	369	412	0.412	120	145	145
Greece	4.29	139	184	208	2792.56	302	429	523	0.060	548	324	957
Ireland	5.99	123	149	160	4265.51	170	332	618	0.160	167	152	979
Italy	3.91	150	204	235	4042.98	272	470	531	0.147	372	213	293
Netherlands	6.89	124	150	160	6948.53	192	280	350	0.212	91	530	504
Norway	7.28	126	156	164	6632.66	169	309	409	0.499	127	126	108
Portugal	1.62	200	314	387	2216.42	284	555	718	0.088	266	65	726
Spain	4.28	136	175	197	2829.70	320	512	638	0.150	145	130	264
Sweden	7.14	125	154	157	7624.51	194	273	310	0.501	339	371	310
Switzerland	9.88	113	126	129	10451.40	197	250	253	1.435	195	168	119
UK	6.73	134	167	188	7524.62	157	240	290	0.268	277	210	212
US	8.93	117	137	140	10702.59	153	247	311	0.283	113	128	197
Mean EU[226]	*5.87*				*5634.80*				*0.376*			
Standard Deviation EU	*1.86*				*2126.63*				*0.344*			
Coefficient of Variation EU	*0.32*				*0.38*				*0.915*			

Note:* Years of schooling of the population aged 25 and over who is studying or not.
** Number of patents for inventions granted each year to residents and non-residents per capita
Source: Cohen and Soto (2001), Penn World Tables (2002) and WIPO (2005).

[226] The mean and the other descriptive statistics have been calculated for the 15 European countries presented in the table.

The table shows how average years of school, GDP per capita and technology per capita have changed since 1950. I examine a stock variable related to human capital such as the average years of school in order to avoid problems of comparability that can arise by using the flow variables. With such flow variables as enrolment rates, differences in national classifications could produce a misleading comparison. International agencies such as the UNESCO divide the number of students enrolled at a certain schooling level by the cohort of the same age group across countries without taking into account the differences that may arise in different schooling systems. By using this approach, rates greater than 100[227] can be found. This type of data are an important but not accurate source of information. This is why I prefer using stock variables such as average years of schooling here and completed primary, secondary and higher education later. The shortcomings that may arise by using flow variables to measure education have been explained in detail in the previous chapter. Average years of schooling have been measured by Cohen and Soto (2001) as the years of schooling of the population aged 25 and over, whether studying or not. In 1950, the United States had higher average years of schooling, 8.93, than the average for the 15 European countries, 5.87. According to Marlow-Ferguson (2002), the United States "emerged from the Second World War as the unchallenged leader of educational initiative".[228] However, this is not what Swiss data suggest as the average years of schooling were 9.88 in 1950. Switzerland was an exception among European countries and according to Tortella (1994, p.10) was a "pioneer in popular education". This indicator of human capital has increased over the period 1950-2000 in every country. The increase has been more important in the "olive belt" countries, like Portugal, Italy, Spain and Greece. These are also the countries that had the lowest average years of schooling in 1950: 2.21 in Portugal, 4.86 in Italy, 4.72 in Spain and 4.82 in Greece. On the other hand, the lowest growth in terms of average years of schooling was in Switzerland, which, as already indicated, had high levels in 1950. In other countries such as Austria, Denmark, Ireland, Sweden, where the average years were already quite high (with the exception of Ireland), growth has been below 50 percent with respect to 1950.

[227] Rates greater than 100 are also found because the number of students who repeat an year of schooling are not separated from those who are enrolled for the first time.
[228] Marlow-Ferguson (2002, p.11).

GDP per capita has grown very fast. The increase of GDP per capita again has been faster in countries that started at very low levels such as Portugal, Spain, Italy and Greece but also in countries like Austria and Finland. The lowest growth rates were over the period in the United Kingdom, Switzerland and Denmark. The United States had higher GDP per capita level in 1950, $10,703 dollars, than the European average $5,635 dollars and also than any individual European country. (These are international dollars in 1996 constant prices).

The evolution of technology, measured by using the number of patents granted every year to the residents and non-residents of the country per capita is not uniform. Belgium, Denmark, Greece, Italy, Portugal, Spain, Switzerland and the United Kingdom experienced an increase in the number of patents per capita granted over 1950-1970 and a subsequent decrease over 1970-2000. In the remaining countries the number of patents granted has increased over time. The greatest increase has been in Austria, Netherlands and Sweden. In Europe, France and the United Kingdom had the greatest number of patents granted in 1950 and again in 2000 with respect to the other European countries. On the other hand, the United States did not have the most patents per capita in 1950 but they had the greatest absolute number of patents granted during the entire 1950-2000.

It is clear from the account above that there are two groups of countries that have followed a different pattern of development: the Northern and Southern. This is not a new classification but has been introduced by economic historians like Sandberg (1982) and Tortella (1994). The latter author identifies a "Latin pattern of modernization"[229] characterized by economic backwardness in the nineteenth century and a rapid catch-up since the 1950s. Following this argument and Abramovitz's (1986) analysis, one could argue that many factors contributed to the rapid recovery and extraordinary development of these economies over the second half of the twentieth century. Among these were, the removal of institutional barriers, the end of authoritarian regimes, greater openness to foreign trade and in general the creation of the appropriate institutional and economic conditions for creating modern states. These factors and many others allowed the less developed Western European countries to reach a "virtuous cycle" characterized by an

[229] Tortella (1994, p.4).

expansion of education, the adoption of more advanced technologies and sustained economic growth.

Table 3.3. Share of the population according to the highest level of completed education,[230] 1960-2000

	Completed Primary			**Completed Secondary**			**Completed Higher**		
Country	1960	1980	2000	1960	1980	2000	1960	1980	2000
Austria	0.40	0.19	0.04	0.24	0.42	0.51	0.04	0.06	0.09
Belgium	0.62	0.45	0.30	0.09	0.16	0.27	0.04	0.11	0.21
Denmark	0.56	0.23	0.04	0.14	0.28	0.45	0.04	0.13	0.21
Finland	0.85	0.52	0.26	0.01	0.26	0.33	0.04	0.12	0.25
France	0.84	0.53	0.32	0.08	0.21	0.33	0.03	0.09	0.17
Greece	0.65	0.66	0.50	0.07	0.12	0.22	0.02	0.06	0.13
Ireland	0.76	0.56	0.37	0.08	0.15	0.27	0.04	0.10	0.18
Italy	0.77	0.62	0.37	0.03	0.11	0.24	0.02	0.04	0.07
Netherlands	0.69	0.39	0.19	0.13	0.26	0.37	0.05	0.14	0.21
Norway	0.59	0.27	0.06	0.19	0.37	0.50	0.05	0.15	0.22
Portugal	0.22	0.41	0.44	0.01	0.04	0.08	0.01	0.03	0.08
Spain	0.74	0.75	0.50	0.02	0.05	0.11	0.03	0.06	0.16
Sweden	0.63	0.30	0.20	0.11	0.26	0.45	0.06	0.16	0.11
Switzerland	0.30	0.12	0.03	0.40	0.51	0.55	0.07	0.15	0.20
United Kingdom	0.64	0.29	0.05	0.13	0.30	0.53	0.05	0.11	0.21
United States	0.41	0.19	0.07	0.31	0.41	0.51	0.15	0.28	0.32
Mean EU[231]	*0.62*	*0.42*	*0.24*	*0.12*	*0.23*	*0.35*	*0.04*	*0.10*	*0.17*
Standard Deviation EU	*0.03*	*0.18*	*0.03*	*0.10*	*0.13*	*0.02*	*0.02*	*0.04*	*0.06*
Coefficient of Variation EU	*0.05*	*0.43*	*0.13*	*0.83*	*0.57*	*0.06*	*0.50*	*0.40*	*0.35*

Source: Cohen and Soto Database (2001)

As a general trend it can be observed from table 3.3 that the United States clearly had a greater stock of human capital over 1960-2000 than the European average. The only exception was Switzerland, where the share of the population completing secondary education was higher than in the United States throughout the period. Yet, the Swiss completion rate of higher education remained much lower than in the United States. European countries had relatively low rates of completion of secondary and higher education in 1960. However, it can be observed that the

[230] The three indicators are calculated as the percentage of population aged 25 or over who completed primary, secondary and higher education respectively.

[231] The mean and the other descriptive statistics have been calculated for the 15 European countries presented in the table.

European population has become progressively more educated over the period examined. Thus, the share of the population who only completed primary education has decreased, except in Portugal where the achievement of primary education has increased over time. This is probably because Portugal had the greatest share of population with no schooling at the beginning of the period. This was 58 percent in 1960 and it declined to 18 percent in 2000.[232] On the other hand, the share of the population that completed secondary and higher education has increased. The growth of attainment at secondary level has been more notable than the increase in higher education. It is the expansion of secondary education that really characterizes the European experience of the last 55 years. The Nordic countries, Belgium, the Netherlands, Switzerland and the United Kingdom are the countries where at least 20 percent of the population has completed higher education in 2000. Italy and Portugal started with a very small share of the population that had completed higher education and the completion rate remained below 10 percent in 2000.

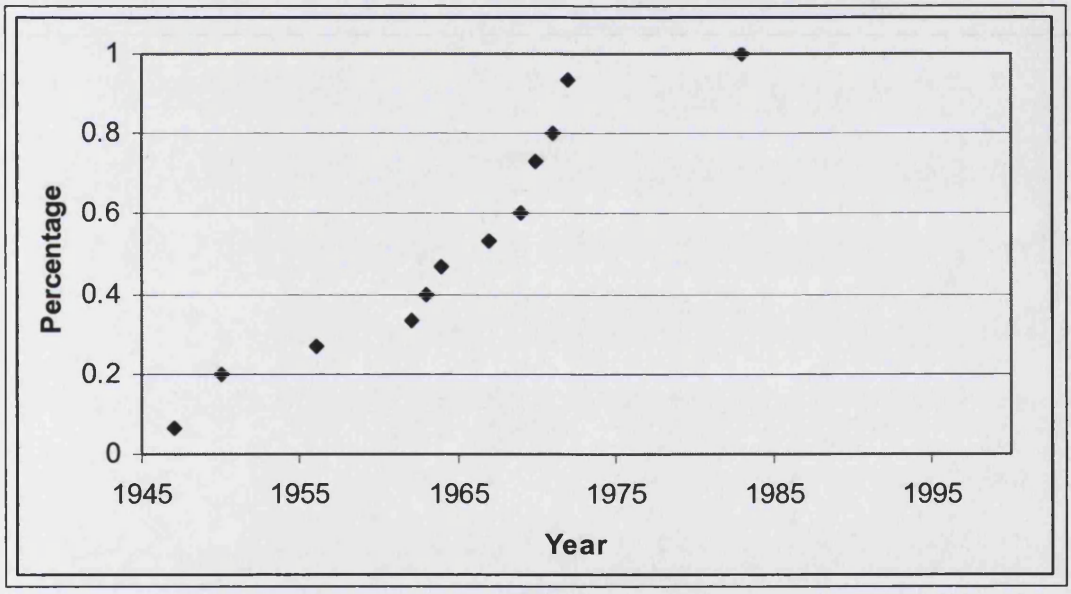
Table 3.3 also shows a distinctive pattern of schooling expansion in Southern Europe. In 1960, these were the countries with the highest share of the population with no schooling experience[233] and the lowest share of the population that has completed secondary and higher education. This is not surprising if one observes the evolution of the spread of literacy across European countries over the nineteenth century.[234] Many factors, cultural, religious and economic have been considered as part of the explanation for this retardation. However, equally striking is the catch-up that has occurred in the forty years considered. These countries have got closer to the levels of schooling of the more advanced countries in the sample and the catch-up in terms of schooling participation has been particularly important for Italy.

Having examined the characteristics of the individual countries, I divide the period into three sub-periods. The focus will be on the first passage of the compulsory schooling law. The interest of this is whether countries that have passed the law for the first time in different periods also have dissimilar characteristics. The three

[232] The data related to the share of the population with "no schooling" is presented in Cohen and Soto (2001).
[233] Data related to the share of the population with "no schooling" experience that are not presented here are extracted from Cohen and Soto (2001).
[234] Data related to literacy are available in Cipolla (1969), Maynes (1985) and Tortella (1994).

periods considered are 1950-1963, 1964-1970 and 1971-2000.[235] This division has been adopted in order to have a balanced number of countries in each sub-group.[236] I will call the countries that raised compulsory schooling laws for the first time during the first period "leaders", those countries that increased the school-leaving age in the second period "followers". In the last period I will have the remaining countries that passed the law and these are defined as "late" countries. The distribution of the first passage of the school-leaving age law is the following:[237] over 1950-1963 five countries expanded compulsory schooling, 1964-1970 five countries whereas over 1971-2000, four countries increased the number of years of compulsory education. The first change of the school-leaving age of the European countries I examine is mainly concentrated in the 25 years following the end of the war. This can be seen from the cumulative density function in figure 3.1.

Figure 3.1 The cumulative density function of the first SLALAW, 1945-2000



The division into three sub-periods is motivated by the need for a counterfactual. That is to say, in order to analyze whether countries that have passed the law in a

[235] To avoid any bias in the choice of the sub-groups, the same analysis has been carried out by choosing different samples. For instance, by dividing the overall period in three sub-periods of equal length and in another attempt by taking the median as cut-off point for the first sub-period. The analysis has been undertaken without obtaining significantly different results.
[236] It has not been possible to include exactly 5 countries in each sub-group.
[237] The United Kingdom has been excluded from the analysis of table 3.4 as the first change in compulsory schooling law occurred in 1947.

given period have different features with respect to those that have not passed the law in the same period I need to compare the summary statistics of the two groups of countries. By dividing the overall period in three according to the first passage of the law, in the two sub-periods 1950-1963 and 1964-1970 I will have both countries that passed the law and others that did not. Having created these samples I now carry out the following analysis: I examine the first two sub-periods and consider the two groups of countries: those that passed the law and those that did not. In the second period I remove from the sample the countries that passed the law before 1964. For some of the covariates[238] that will be considered later in the regression analysis and other variables, I examine whether there is a significant difference between the countries that did and did not pass the law in the first and second period respectively. In order to do this I examine whether the mean of the two samples is significantly different using a t-test.[239] Moreover, it would be possible to see whether some variables could have an impact on the enactment of the law in the first period and not in the second and vice versa. The results of the computation are shown in table 3.4.

[238] "Covariates" are the independent variables in duration analysis.
[239] I have also controlled for the possibility that a single country was driving the results I have found. I follow the same procedure for all variables.

Table 3.4. Summary statistics of the two sub-periods: 1950-1963 and 1964-1970

	Period 1950-1963					**Period 1964-1970**				
Variables	**Slalaw = 0**		**Slalaw ≥ 1**			**Slalaw = 0**		**Slalaw ≥ 1**		
	Mean	StdDev	Mean	StdDev	t-test	Mean	StdDev	Mean	StdDev	t-test
GDP_{pc}/GDP_{pcUS}[240]	56.76	22.85	62.93	20.16	1.54	70.79	22.49	60.32	21.64	1.59
$Technology_{pc}$	0.52	0.45	0.37	0.23	2.01	0.94	0.98	0.59	0.66	1.29
LfIndustry	34.79	8.35	38.51	5.77	2.63	37.72	5.97	32.78	8.49	2.52
State Capacity	2.25	0.30	2.41	0.52	2.53	2.47	0.30	2.54	0.11	0.88
GINI	36.56	8.58	34.15	6.92	1.63	34.80	5.32	36.83	3.38	1.39
Illiteracy	7.12	9.93	9.08	14.92	0.99	2.77	3.54	8.55	6.87	4.32
AvgYearsSchool	6.38	1.83	6.47	2.05	0.27	7.82	1.53	6.89	1.65	2.02
CompSchool50	7.27	1.15	5.90	1.60	6.12	7.33	0.72	6.87	0.92	2.02
Observations	157		39			48		15		

Note: GDP_{pc}/GDP_{pcUS} is GDP per capita with respect to the United States
$Technology_{pc}$ is technology per capita
LfIndustry is the share of the labour force in the industrial sector
State Capacity is the ratio of the active population (aged 15-64) with respect to the young population (aged 0-14)
GINI is the Gini coefficient
Illiteracy is the share of the population who is illiterate
AvgYearsSchool is the average number of years of schooling of the population
CompSchool50 is the number of years of compulsory schooling in 1950

I proceed by examining GDP per capita with respect to the United States (GDP_{pc}/GDP_{pcUS}) as the United States was the richest at the end of the Second World War and also remained the technological leader. In both periods the mean of this variable is not significantly different between the group of countries that passed the law and those that did not (at 5 percent level). This shows that countries that passed the law in the first period were not further from the United States in terms of GDP per capita than those that did not. Technology per capita ($Technology_{pc}$) is significantly different between countries that increased compulsory schooling and those that did not in the first period. Between 1950 and 1963 countries that augmented the school-leaving age for the first time had a lower level of technology per capita with respect to those that did not. On the other hand, the share of the labour force in the industrial sector (LfIndustry) is significantly different in both

[240] It is calculated as the GDP per capita relative to the United States, where the value for the United States is converted into 100.

periods. Countries that passed the law between 1950 and 1963 had a greater share of the labour force working in industry than those that did not. On the other hand, over 1964-70, countries that passed the law had a smaller share of the labour force working in this sector. This could be because countries with a greater share of the labour force moving toward the more advanced sectors of the economy were also those that needed to upgrade the skills of the population. State capacity is only statistically different between the two groups of countries in the first period. Countries that passed the law had a smaller share of young population with respect to the active labour force than those that did not. The difference related to the Gini coefficient (GINI) is not significant in both periods whereas the number of years of compulsory schooling in 1950 (CompSchool50) are statistically different between the two groups of countries in both periods. Countries that passed the law between 1950 and 1963 as well as over 1964-1970 had lower initial levels of compulsory schooling than those that did not. On the other hand, average years of schooling (AverageYearsSchool) are only significantly lower in countries that enacted the schooling reform in the second period. Moreover, illiteracy was significantly greater in countries that passed the law between 1964 and 1970.

These results only provide an initial thought on the possible determinants of the passage of the school-leaving age laws in the European countries. A panel regression analysis will be carried out in the next section, in which the different theories previously described will be tested against each other through regression analysis.

3.4.2) Regression analysis

The model

The aim of this chapter is to develop an understanding of the determinants of the implementation of the changes in school-leaving age laws across European countries by examining how different theories can explain the timing of the policy change. In order to provide empirical evidence for this, variables extracted from each theoretical framework will be used to test the theories against each other. It is important to notice that the choice of the variables for each theory can be justified by the relevance of each variable in the theoretical framework and by data availability.

Moreover, as previously suggested, the empirical analysis will provide descriptive evidence whereas the causal link is more difficult to establish. The method employed will suggest what factors increased the likelihood of the passage of the legislation and consequently what theory provides the best explanation of the timing of the policy change across Europe in the second half of the twentieth century.

The analysis will be carried out by using the panel data technique and a duration model. Duration analysis has recently become a key tool in economic investigation. This is because many events of interest for economists are related to the length of time before an event occurs.[241] Before being introduced in the economic field, these analytical techniques were mainly used in industrial engineering and biomedical sciences.[242] They were used in medicine to test the rate of survival of patients after a transplant by examining a set of variables, both constant and time varying, that might have affected the rate of survival of patients. This justifies the original name "survival analysis". These models were introduced by economists toward the end of the 1970s in studying unemployment.

Survival analysis asks: "what is the fraction of the population which will survive past a certain time? Of those that survive, at what rate will they die or fail? ... How do particular circumstances or characteristics increase or decrease the odds of survival?"[243] These are precisely the questions I am concerned with in the context of the school-leaving age laws. Moreover, I am trying to understand why some countries increased compulsory schooling before others. Therefore, what really matters are the conditions existing before the passage of the law. To understand this, it is necessary to examine the impact of the covariates on the likelihood of the passage of the law and this is precisely what the duration models measure. The duration model I will use belongs to a set of techniques that are now extensively used in this kind of policy studies. For instance, Fishback and Kantor (1998; 2000) used these methodologies in order to study the passage of the Workers' Compensation Laws in the United States. Also, Chen (2001) has used a discrete-time logit model in order to study the determinants of the passage of the State Fair Employment Legislation in the American states over the period 1945-1964 whereas

[241] Wooldridge (2002, p.685). The author argues that "some response variable in economics come in the form of a duration, which is the time elapsed until a certain event occurs".
[242] Kiefer (1988, p.647).
[243] Elandt-Johnson and Johnson (1980; 1999).

Box-Steffensmeier and Zorn (1998) used the Cox parametric approach in order to study the pattern of retirement among the justices of the U.S. Supreme Court over the period 1789-1993.

The reason why these models have become widely used in applied research is because they solve many of the shortcomings of the traditional models.[244] Among the limitations of the traditional models such as Ordinary Least Squares (OLS) and limited dependent variable models, one can find that they do not properly measure the time at risk. In fact, it is not easy to identify the time at which different countries are likely to enact the law. This is because, as will be explained in detail later, many countries have passed the law more than once and therefore after the first passage of the law they are again "at risk" of passing the legislation. This pattern of policy change cannot be modelled with OLS and only with many shortcomings by using models such as probit and logit. Moreover, the length of time between a passage of the law and the subsequent one varies between countries whereas for a number of countries, the passage is unique. This leads to an additional problem because the multiple spells of varying length cannot be properly analyzed by using the traditional models. Furthermore, the specific nature of the time-varying covariates makes OLS and limited dependent variable models inadequate for the empirical analysis. That is, the independent variables change over time across countries and this dimension cannot be captured by using OLS.[245] What is necessary to take into account for the empirical analysis is the specific nature of the dependent variable, the possibility of countries enacting the law more than once and the time varying covariates. These are some features of duration models that make them the best candidate to explain the educational policy change that occurred in Europe after the war. As Jenkins (2005, p.10) suggests, what is needed is to measure the "chances of making a transition out of the current state at each time period conditional on survival up to that point". This is done by using a function that measures the probability that a country will pass the law given the fact that it has not done so in the previous period. This is known as the "hazard rate".

[244] Jenkins (2005) provides an exhaustive analysis of the limitations of the traditional models from which I derive my discussion.

[245] An additional problem described in the literature consists of right or left censoring. It has not been described above because it does not arise in the analysis of this paper.

If we define T,[246] the duration variable, as the random variable that characterizes the time of the passage of the law, and t as the time variable, we can also define the cumulative probability of T as:

$$F(t) = Pr(T \leq t), \quad t \geq 0$$

Therefore F(t) measures the probability that a country passes the law before or at time t. The survival function, that is the complement of the cumulative distribution function, measures the probability that the law has been passed after t.

It is derived as follows:

$$S(t) = P(T>t) = 1 - P(T \leq t) = 1 - F(t) = Pr(T>t)$$

Where:

$0 \leq S(t) \leq 1$

$S(0) = 1$ and $S(\infty) = 0$

The quantitative analysis of the survival data implies the use of the hazard rate function, estimated as the probability of failure conditional on surviving up until that point.

The conditional failure rate will be:

$$h(t) = f(t) / (1 - F(t))$$
$$= f(t)/S(t)$$

Where:

$f(t) = (dF/dt)\ (t)$

[246] This notation is commonly used in the existing literature for instance by Heckman and Singer (1985) and Wooldridge (2002).

Having defined the main concepts of survival analysis I will describe the model I will use for the estimation. The choice of the model depends on the nature of the data and the underlying distribution of the hazard rate. Models can be continuous or discrete and parametric, semi-parametric or non-parametric respectively. As Lancaster (1992, p.34) comments, "there exists a whole family of parametric distributions". However, given the nature of my data and the fact that I do not know the exact distribution of the hazard rate,[247] I will use a semi-parametric model, the Cox proportional hazard. This model was introduced by Cox (1972) and has been widely used in the literature to examine the impact of different variables on the time taken for a particular event to occur. The model is semi-parametric, because it does not impose any parameter on the functional form of the hazard rate. It is only assumed that the effect of the different variables on the passage of the law is constant over time and additive. This implies that the model assumes a parametric form on the effect of the variables on the hazard but it does not impose any structure on the hazard rate. The other assumption of the model is the exogeneity of the time-fixed and time-varying covariates over time. This implies that the future values of time-varying and time-fixed covariates are independent of the current values of the dependent variable. This implies that the following propositions have to hold true:

$$V\, s \geq t, \quad E(Z_{i,s} \mid h_{i,t}) = 0$$
$$V\, s \geq t, \quad E(X_{i,s} \mid h_{i,t}) = 0$$

The model also requires data to be continuous. A partial estimation with discrete data can be carried out by re-arranging the original dataset but it seems more practical to estimate a continuous model. Moreover, as Heckman and Singer (1985) argue, it is better to use continuous data as the discrete Cox model would be implemented by using a logit model.[248] In order to use this model for the estimation I have checked that the initial assumptions hold.[249] I have annual data from 1950 until 2000 and it is correct to consider the hazard as proportional.[250]

[247] The survival function and the shape of the hazard are shown in table 3.C in the appendix.

[248] This is because the logit describes a binary random process that takes value 1 or 0 at each period; visibly this is not adapted to this problem because after the first time this process is equal to one it stays equal to one. The logit could be used if what is of interest is the fact of voting a law at a given period. The duration must be used if what is of interest is the fact of having voted a law.

[249] I have checked for the proportionality of the hazards and also for the shape of the hazard in order to see whether the use of a parametric model would have been appropriate. I have used the Akaike information criterion to discriminate between the different models. However, none of the distributions of

This is the specification of the hazard function of the Cox proportional hazard model:

$$h_{i,t} = h_{0,t}\, e^{[X_i \alpha + Z_{i,t} \beta]}$$

Where:

$h_{i,t}$ is the duration variable

$h_{0,t}$ is the baseline hazard function that is left unspecified

X_i is the vector of the time fixed covariates

$Z_{i,t}$ is the vector of the time-varying covariates

α, β are the coefficients to be estimated

The exponential distribution of the survival times derives from the assumption of constant hazard. By taking the log transformation and by expanding the model, the previous equation becomes:

$$\log h_{i,t} = \log h_{0,t} + \alpha_1 x_{i1} + \alpha_2 x_{i2} + \ldots + \alpha_k x_{ik} + \beta_1 z_{i1,t} + \beta_2 z_{i2,t} + \ldots + \beta_k z_{ik,t}$$

The dependent variable is the duration variable that reflects the timing of the passage of the law and will be described in the next sub-section. Among the covariates there are constant variables and time-varying variables. The outcome of the regression is very similar to the OLS regression. However, there is an important difference that needs to be considered. The coefficients related to the covariates used to do the estimation are expressed in terms of hazard ratio. That is to say that if the estimated hazard ratio is smaller than 1 this means that the covariate has a negative impact on the probability of the passage of the law. On the other hand, if the estimated hazard ratio is greater than one this implies that the covariate has a positive impact on the likelihood of the passage of the law. To facilitate the understanding of the results I have transformed the hazard ratios into traditional regression coefficients. Therefore

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the existing parametric duration models seems to fit the shape of the hazard function examined. Thus, a semi-parametric model has been chosen.

[250] The use of the continuous model does not seem to cause any problem as the annual interval is sufficiently short with respect to the total sample. The test of proportional hazards is based on the method developed by Grambsch and Therneau (1994). This tool tests the relationship between time and covariates in the model and is based on the Schoenfeld residuals. This test is considered to be more accurate than the graphical method based on the Kaplan-Meier curves as it also provides a check for proportionality when all the variables are included in the model (Stata Manual, 2003, p.143). The test has been carried out after each regression and the hypothesis of proportionality has been verified for each regression shown in this chapter. An example of this test is shown in the appendix, table 3.D.

it will be possible to read the coefficients as usual. The interpretation of the coefficients is slightly different from other regressions and requires a clarification. If a coefficient is significant and positive it means that the covariate considered made the change in schooling legislation more likely to happen. On the other hand, a negative coefficient means that the covariate had a negative impact on the passage of the law, reducing the likelihood of a rise in compulsory schooling. Therefore, what these coefficients measure is the impact of the covariate on the likelihood of the passage of the law. In the estimation I have considered the multiple passages of the school-leaving age laws as well as the possibility of ties by adopting the Breslow specification.[251] In addition, in order to take into account country-specific features that may be relevant for the outcome variable under study, fixed effects will be included in the panel regression. This helps in this kind of cross-country studies (Wei and Wu, 2002).

Dependent variable

The school-leaving age law (SLALAW) is a dummy variable that can take the following values: "0" when the law to increase the number of years of compulsory schooling has not been passed in the country under study, "1" when the country has enacted the law the first time, "2" for the second passage, "3" for the third and "4" for the fourth passage. This variable has been constructed by examining the fundamental principles and basic legislation of the European education systems described in the Eurydice Database (2005), the historical survey in Flora et al. (1987) and the World Education Encyclopaedias (1988; 2002). These reports are available for every country included in the study except Switzerland. For Switzerland I have used national sources kindly provided by the Federal Schooling Body.[252] The changes in school-leaving age laws since 1938 have been presented in table 3.1. The choice of this variable is motivated by the fact that the interest of the analysis relies on understanding the timing of the passage of the legislation. Thus, the duration model has been chosen for the analysis and the related dependent variable described

[251] This method is considered to be adequate in the case of ties of a small number of observations (Delong et al., 1994, p.611).
[252] Arnet (2000), "Das Schulkonkordat vom 29 Oktober 1970".

has been used for this purpose.[253] However, there is a limitation in the use of this variable. Considering only the increase in compulsory schooling overlooks the starting point of each country. It seems reasonable to assume that a country that starts with a very low number of years of compulsory schooling will have more scope for increasing the school-leaving age. This is precisely what happens in the case of Portugal compared to Austria, France and Sweden. In order to solve for this shortcoming I will use the number of years of compulsory schooling for each country at the beginning of the period as an explanatory variable. This is a way of considering the impact of the initial conditions on the subsequent increase in school-leaving age. Moreover, what has been considered in the analysis is the expansion of formal schooling. I could collect accurate information on school attendance and state enforcement capability for certain countries but not others. I acknowledge the fact that it is not possible to have a precise measure of the different rates of enforcement for the fifteen European countries I have in the sample.

Explanatory variables

In the following paragraphs the variables that will be tested for each of the theory previously discussed will be described.

Technical-functional theory (modernisation)

To capture the impact of modernisation I would use the variables Gross Domestic Product per capita and technology per capita. However, for the regression analysis when three theories will be tested against each other I will use as an independent variable only technology per capita. This is done in order to avoid problems of right-hand side correlation.[254]

Economic development can be considered as one of the elements that contribute to organizational and social advance of society. Meyer, Ramirez, Rubinson and Boli-Bennett (1979), by examining the rapid expansion of national educational systems

[253] In order to study the intensity of the policy change a different model should have been used (for instance a dynamic linear panel model and the number of years of compulsory schooling as dependent variable) but this goes beyond the purpose of this chapter.

[254] This is because by definition Gross Domestic Product is composed by labour force, technology and the inclusion of all these explanatory variables in the same regression would make the results invalid.

that occurred throughout the world between 1950 and 1970 find a positive impact of Gross National Product[255] on enrolments growth at every educational level. Also Meyer and Schofer (2005a), find that the growth of Gross Domestic Product had a positive and strong impact on the expansion of tertiary education in the developed countries over the twentieth century. They introduce in their model of educational expansion a variable related to technology. They find that the coefficient is not significant. This is against what the theory would predict. To provide a better specification I will introduce, among other variables technology per capita to test the validity of this theory. The neoclassical approach suggests that what matters is the level of development, that is the level of GDP per capita and technology. To control for this theoretical approach I will use a variable for technology per capita ($Technology_{pc}$).[256] I expect to find a negative coefficient for the technology variable as the lower the level of technology the greater would be the incentive for the country to create the conditions that would allow a transfer of technology or stimulate the expansion of education. Therefore, at different stages of development the "appropriate institutions"[257] may be different and the aims of the education policy may change. In the descriptive statistics the level of GDP per capita will be compared to the level of GDP per capita in the United States. This is done to examine whether the level of GDP per capita with respect to the United States in countries that passed the first school-leaving age law in a given period was different from those that did not.

Another variable that can be used to capture the degree of modernization is openness (Openness). The impact of the greater markets integration can be justified as follows. The phenomenon of globalization[258] can be considered as having a positive impact on the expansion of education. In fact, improvements in communication and transportation and the reduction of cost made easier the interaction between agents of different countries. As a result of this, the expansion of education increases the opportunities for this economic and cultural exchange. Therefore, education becomes

[255] They use Gross National Product because their study includes countries for which early data on Gross Domestic Product were not available.
[256] Technology per capita is measured as the number of patents granted to residents and non-residents in a given year. Please refer to section 3.4.1 for a discussion concerning this variable and to appendix 3.A for the sources.
[257] Acemoglu, Aghion and Zilibotti (2003, p.2).
[258] There is no unique definition of the word "globalization". Therborn (2000, p.154) defines globalization as follows: "tendencies to a world-wide reach, impact, or connectedness of social phenomena or to a world-encompassing awareness among social actors".

an instrument to acquire social and economic well-being and not only "a functionally necessary outcome of the demand created by progress".[259] Fiala and Lanford (1987), by comparing the aims of education in developed and developing countries, over the period 1955-65 find a convergence throughout the world. A positive coefficient for openness would support the modernization theory.

A further factor that can influence the increase in school-leaving age is the starting point (CompSchool50). It is reasonable to assume that it will be more difficult to enact the law in countries that in 1950 already had a high number of years of compulsory schooling. This is because an additional year of school at higher levels of education would be more expensive than the same increase at lower levels.[260] For teachers need to be better trained but also the opportunity cost of keeping students an additional year in school would be higher. On the other hand, we can expect countries with low starting levels of compulsory schooling to be more likely to pass the law. Therefore in support of the modernization theory I expect to find a negative coefficient for the variable CompSchool50.

Neo-institutionalism (political economy factors)

The majority of European countries already had democratic institutions at the beginning of the study period, 1950. However, the Western European countries that experienced the greatest expansion of compulsory schooling did not have a democratic regime before. This is the case of Italy, Greece, Spain and Portugal. In 1974 "the Regime of the Colonels" ended in Greece and the Carnation Revolution put an end to Salazar's regime in Portugal. On the other hand, in 1975, the authoritarian regime ended in Spain with Franco's death. In Italy for instance, radical school reforms were undertaken as a result of the fall of fascism and in Greece as well, when the military dictatorship ended, many schooling policy changes were undertaken. Lindert (2004) has shown how the spread of democracy increased enrolments at primary and secondary level more than this increased schooling

[259] Meyer and Schofer (2005a, p.13).

[260] This can be observed by comparing teachers' wages according to different levels of education. These information can be collected from the publication of the Department for Education and Skills "Statistics Education: Teachers in England" for the United Kingdom. Similar publications are available for other European countries. What can be noticed is that teachers at higher levels of education earn higher salaries. As teachers represent the main "input" in schooling, it follows that an increase of compulsory schooling at higher levels would be more costly.

participation could have caused democracy (this is the reverse causality assumption). I expect to find a positive effect of democracy (Democracy) on the enactment of the school-leaving age law, especially for the more backward countries I have in the sample. A negative coefficient could be expected for the sample of more advanced countries as they already had a democratic regime in 1950 and the spread of democracy in terms of extension of suffrage may have led to the expansion of higher levels of education.

Another political variable worth analyzing is the Gini coefficient. This is a measure of inequality of a distribution, first developed by Corrado Gini in 1912, that is commonly used to measure wealth inequality. Its main advantage is that it can be used to make comparisons across population and countries (Atkinson and Brandolini, 2005). According to Hicks (1999), the success of redistribution policies carried out by European countries depended on how power is organized among political institutions. That is, welfare redistribution through education depends on the structure of taxation and public spending (Bradley, 2003). Galor et al. (2006, p.8) show how "the degree of implementation of education reforms is an outcome of the balance of power in society". They provide historical evidence in support of the inverse relationship between land inequality and human capital formation across countries.[261] They show how the modernization of the education system occurred in Russia with the provision of compulsory elementary education after the agrarian reforms initiated by Stolypin were implemented. That is, shortly after the political power of wealthy landowners declined. A more recent example concerns South Korea. The land reform of 1948-1950, which followed the end of the Japanese occupation, greatly reduced the concentration of land ownership. In 1949, expenditure on education was greatly increased and policies aiming to increase schooling participation were implemented in the framework of the new Education Law.[262] Therefore, it may be reasonable to expect a negative sign for the Gini coefficient (GINI). In fact, we can assume that in countries characterized by high levels of income inequality there will be stronger resistance to increase expenditure on a social service that is likely to reduce the long-term income inequality. This is the evidence provided by De Gregorio and Lee (1999) who examine a large set of

[261] Galor et al. (2006, p.4).
[262] Galor et al. (2006, p.10).

countries over the period 1960-1990 and show that a higher educational attainment makes the income distribution less unequal.

Role of the state theory

To control for the role of the state I will introduce GDP per capita growth ($l(GDP_{pc}/GDP_{pc(-5)})$) as an explanatory variable.[263] This is motivated by the fact that the expansion of education will impose a high cost on the government budget. This is the direct cost of keeping students longer in school and the indirect expenditure that is represented by the opportunity cost of the foregone societal earning. Following this reasoning it seems plausible to assume that a greater growth in a previous period, in this case five years earlier, will have a positive impact on the increase of school-leaving age as governments would be more willing to increase the expenditure on education.[264] Consequently, I expect this coefficient to be positive. This factor may have been important in explaining the expansion of formal education in the post-war period. In fact, during the Golden Age, social spending increased and the welfare state of most Western European countries became very generous. Most European governments after the Second World War "channelled funds to every corner of national life [and] education was a prime beneficiary".[265] One of the reasons for using this variable is that in some of the works related to the role of the state theory I reviewed, clear reference was made to the impact of economic growth on the expansion of schooling (Ringer, 1979; Lindert, 2004). This is the reason why a measure that reflects economic growth has been used. The reason for not having chosen a variable more strictly related to education such as expenditure on education as a percentage of Gross Domestic Product is that this variable raises endogeneity problems: an increase in schooling expenditure is likely to have a positive impact on the passage of the school-leaving age laws as additional funds would be available to sustain the expansion of compulsory education. On the other hand, the expansion of compulsory schooling would require additional funds to face the cost of keeping students one year longer in school and therefore it would cause an increase in the public expenditure on education. This explains why there is no unambiguous

[263] I have also run the regression by taking as explanatory variable growth with respect to the previous period but the difference between the two results is negligible.
[264] The five years lag has been chosen in order to avoid potential problems of endogeneity that would bias the estimation. Another possible approach would have been to consider the business cycle that does not seem to be correlated with the variable change in school-leaving age laws.
[265] Marlow-Ferguson (2002, p.11).

relationship between these two variables and this is the reason why the expenditure on education as a percentage of GDP has not been chosen for the analysis. Moreover, by looking at the period that goes from the aftermath of the Second World War until the end of the Golden Age there is a positive correlation between GDP growth and expenditure on education as Tanzi and Schuknecht (2000) have illustrated.

A further factor that seems important is the demographic composition of the labour force, which is defined as the "State Capacity" (State Capacity).[266] This is central to the "population ecology hypothesis".[267] This is related to the ability that countries have to support the expansion of education when the share of the active labour force grows faster than the school-age population. That is, the rationale underlying this variable is that if the share of the schooling age population is relatively small with respect to the active labour force the expansion of schooling would impose a more limited burden on the budget of the government. On the other hand, in the case of a significant share of the school-age population the expansion of schooling would be more costly as the share of the population that could sustain this expenditure would be more limited. This variable has been previously used by Fuller and Rubinson (1992) to examine the expansion of schooling in Western countries over the twentieth century. A positive coefficient would suggest that a greater share of the active labour force would increase the state's capacity to further expand education.

The explanatory variables are not highly correlated with one another. The correlation rate varies between 0.0106 in the case of Gini coefficient-Democracy index and 0.4341 for the Years of compulsory schooling in 1950-Democracy index variables.

A complete list of the definitions of the variables used in the empirical analysis is provided in appendix 3.B. Here, the discussion is limited to those variables that necessitate special consideration.

Technology per capita:[268] has been constructed as the number of patents granted to residents and non-residents at a given year. The choice of this variable to measure technology is motivated by the state-of-the-art literature. In fact, many scholars such

[266] This is the ratio of the active population (aged 15-64) with respect to the young population (aged 0-14).
[267] Craig (1981, p.152).
[268] This variable has been smoothed by using 5-year moving average.

as Griliches (1986, 1990), Evenson (1984) and Eaton and Kortum (1996; 1998) have shown both advantages and disadvantages in the use of this indicators as a proxy for technology. These authors have also shown that other measures such as the level of scientific publication, R&D expenditure and performance in the high-technology industrial sector do not seem to work better. Patents remain, as Stern et al. (2000, p.18) say, "the most concrete and comparable measure [of overall technological performance] across countries and time". The choice of patents granted to both residents and non-residents is motivated by data availability. Data for residents only are not available for the whole period 1950-2000. To take into account a possible bias that could arise by considering patents granted to non-residents and therefore introducing a correlation between this variable and openness I have run the regression with the number of patents granted to residents only for 1970-2000. There is virtually no difference in running the regression with the two measures of technology. This may be motivated by the fact that the fifteen European countries under study do not have a very high share of patents granted to foreigners. Therefore, it seems reasonable to extend the use of this measure to the entire period.

Democracy: It is an index that measures the level of democracy by considering characteristics such as the existence of competitive and open elections, human rights protection, limitations on power holders. It has been taken from Marshall and Jaggers (2000) and Meyer and Schofer (2005a) from whom I have received these data. It can take a value from -10 ("strongly autocratic regime") to +10 ("strongly democratic regime"). It seems to be a better indicator than the dummy variable that is commonly used in the literature and that takes the value of "1" if there is a democratic regime and "0" otherwise. For it allows the analysis of the more subtle differences that characterize different democratic regimes.

Data sources

The paper employs a novel dataset that has been constructed by drawing upon a variety of national and international sources. It covers the period 1950-2000 and it consists of annual data. The dataset includes the following fifteen European countries: Austria, Belgium, Denmark, Finland, France, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United

Kingdom. The detailed information related to the source for each variable used in the analysis is provided in the appendix 3.A.

Empirical Results

I have used the model described above to test the theories presented in section 3.3 in order to establish which one provides the best explanation for the rise of compulsory schooling that has characterized the European experience in education policy in the post-war period. I have run the regressions by using a number of specifications: starting with the fifteen countries over 1950-2000. After, I have divided the time period in two according to the end of the Golden Age in order to examine whether different theories can explain the changes in compulsory schooling during these two epochs. Consequently, I run a regression that covers 1950-1973 and another from 1974 until 2000. Finally, I have divided the sample of countries in two according to the level of backwardness with respect to human capital. That is to say, I have divided the countries in two groups according to the initial level of average years of schooling, rate of completion of different levels of education and the number of years of compulsory schooling in 1950. In this regard, it is possible to observe a distinctive pattern that characterizes Southern European countries with respect to the other countries in the sample. The descriptive statistics in an earlier section have also discussed the pattern of development of human capital that has characterized the experience of Southern European countries since 1945. This is the reason why the first group comprises the less developed countries: Greece, Italy, Portugal and Spain. The second group comprises the more advanced countries: Austria, Belgium, Denmark, Finland, France, Ireland, Netherlands, Norway, Sweden, Switzerland and the United Kingdom. Italy is not usually included in the group of backward countries. However, at the end of the Second World War Italy had a very low level of human capital stock characterized by a high rate of illiteracy. In 1951 the rate of illiteracy was 12.9 percent but it fell to 4.5 percent in 1976.[269] This is why I decided to include Italy among the less advanced countries. In fact, in terms of human capital, Italy was very similar to the other less developed Western European countries that are in the sample. On the other hand, Ireland until the mid-1990s has not been traditionally included among the more advanced countries as a result of the low levels of GDP per capita and technology as displayed in table 3.2. However, this

[269] Kurian (1988, p.650).

country had relatively high levels of human capital as shown in table 3.3 and for this reason has been included in the second group. A further aim behind this organization of the empirical analysis is that it is important to identify the overall trend. Also, it is important to test whether some theories can provide a satisfactory explanation for one historical period but maybe not for the next. Finally, as I have argued before European countries have followed different patterns of development and it would be interesting to examine whether also the institutional change of compulsory education has followed a pattern that characterizes the more advanced with respect to the backward countries.

To assess the goodness of fit of the model it has not been possible to use the traditional regression diagnostics. This is because the Cox model fits the maximum likelihood hazard on survival time data. To avoid problems that may have arisen as a result of the fact that failure times are rather broadly grouped because yearly observations have been used, the robust variance estimator has been used following the method developed by Lin and Wei (1989). Consequently all the standard errors in the regressions have been expressed by means of "robust standard errors". This methodology provides more consistent estimations of the standard errors than the conventional variance-covariance matrix.[270] I have estimated these "robust standard errors" for every regression. I have analysed the Martingale residuals to examine the suitability of the model and I have used the pseudo-log likelihood in order to compare how well different models fit the data. This is an indicator that can only be used to make comparisons between different estimations of the model but the absolute value does not have any meaning.
I proceed now by estimating the following Cox proportional hazard models:

$$\log h_{i,t} = \log h_{0,t} + \alpha_1 \text{YearsComp50} + \beta_1 \text{Technology}_{pc} + \beta_2 \text{Openness} \quad (3.1)$$

$$\log h_{i,t} = \log h_{0,t} + \beta_3 \text{Democracy} + \beta_4 \text{GINI} \quad (3.2)$$

$$\log h_{i,t} = \log h_{0,t} + \beta_5 \text{StateCapacity} + \beta_6 (\text{l}(\text{GDP}_{pc}/\text{GDP}_{pc(-5)})) \quad (3.3)$$

[270] Guo and Lin (1994, p.632).

$$\log h_{i,t} = \log h_{0,t} + \alpha_1 YearsComp50 + \beta_1 Technology_{pc} + \beta_2 Openness + \beta_3 Democracy + \beta_4 GINI + \beta_5 StateCapacity + \beta_6 (l(GDP_{pc}/GDP_{pc(-1)})) \quad (3.4)$$

This specification of the model allows testing the three theories separately and after in the same regression. Table 3.5 shows the results of the estimation.

Table 3.5. Estimation results 15 European countries, 1950-2000

	Time period Dependent variable	1950-2000 SLALAW	1950-2000 SLALAW	1950-2000 SLALAW	1950-2000 SLALAW
Modernization theory	$Technology_{pc}$	-1.096** (0.473)			-1.071* (0.611)
	Openness	0.028* (0.016)			0.011 (0.020)
	YearsComp50	0.145 (0.183)			-0.296 (0.423)
Political economy theory	Democracy		0.063 (0.046)		0.085 (0.064)
	GINI		- 0.104** (0.052)		-0.100* (0.060)
Role of the state theory	State Capacity			1.447 (1.056)	1.408 (1.203)
	$l(GDP/GDP_{(-5)})$			3.802 (4.190)	5.916 (4.328)
	Country dummies	yes	yes	yes	yes
	Observations	690	765	690	690
	Pseudo log-likelihood	-58.370	-57.813	-58.719	-55.307

Note: *** p<0.01, ** p<0.05, * p<0.1; (robust standard errors in parentheses)

As previously suggested, the estimation of a duration model requires a slightly different interpretation with respect to the standard regressions: the coefficients that have been obtained by transforming the hazard ratios measure the impact of the variables on the likelihood of the passage of the compulsory schooling laws. In the context of duration models it is not possible to give an interpretation of the coefficient by telling exactly what 0.028 means.[271] It is possible to say that a greater

[271] For a coefficient β_k the value of $e^{\beta k}$ is called hazard ratio. In this case the hazard ratio is equal to $e^{(0.028)} = 1.028$.

level of openness by decreasing the duration increases the likelihood of the passage of the law. On the other hand, a negative coefficient would decrease the likelihood of the implementation of the schooling reform. In the first estimation, technology per capita is significant at 5 percent level whereas openness exhibits the expected sign and is significant at 10 percent level. This shows that countries with lower levels of technology had a greater probability of implementing the compulsory schooling reform. On the other hand, in the context of the political economy theory Gini coefficient is significant with the expected negative sign. That is, the greater the levels of income inequality the slower was the implementation of the school-leaving age laws. This is consistent with Galor et al.'s (2006, p.37) view: historically income inequality has been detrimental to the development of human capital promoting institutions. The other variable of this theory, democracy shows the expected positive sign but is not significant. The role of the state theory does not have explanatory power. When the three theories are included in the same regression, technology per capita and GINI coefficient are still significant. Also, by looking at the pseudo log-likelihood it seems that this regression is more accurate. The last column is informative because shows that results are robust and the variables of interest do not capture effects of variables of other theories. However, it is not possible to state what theory provides the best explanation for the change in compulsory schooling laws when the overall period is considered. This is because the two variables that are significant belong to different theories.

The estimation has been carried out also for the fifteen European countries over the period 1950-1973. However, the results are not shown here as only two variables were significant and the results were not robust once the three theories were tested against each other.[272] Only openness and GINI coefficient were significant at 10 percent level with the expected sign. This shows that it is not possible to draw a definitive conclusion on which theory provides the best explanation for this period.[273] That is, there are other factors not included in the model that played a role in determining the increase of compulsory schooling during the Golden Age. Among other things, this period coincides with the beginning of the European integration. The new agreements reached by European countries in various sectors of the

[272] This is also due to space limitations.
[273] I have also tried carry out the estimation by using different parametric duration models but I did not obtain better results.

economy such as heavy industry and agriculture may have been a driving force behind the adoption of similar systems of production and therefore they may have created the common need for a more skilled labour force. However, as explained above, I have tried to model the "contagion effect" in many ways without obtaining significant results. The next estimation is based on the period 1974-2000 and the results are shown in table 3.6.

Table 3.6. Estimation results 15 European countries, 1974-2000

	Time period Dependent variable	1974-2000 SLALAW	1974-2000 SLALAW	1974-2000 SLALAW	1974-2000 SLALAW
Modernization theory	$Technology_{pc}$	-1.931** (0.949)			-1.475*** (0.468)
	Openness	0.022 (0.045)			-0.061 (0.064)
	YearsComp50	-4.178*** (0.532)			-4.236*** (0.775)
Political economy theory	Democracy		1.714 (1.295)		0.305 (0.240)
	GINI		-0.158 (0.188)		-0.081 (0.154)
Role of the state theory	State Capacity			0.452 (1.172)	0.763 (1.202)
	$l(GDP/GDP_{(-5)})$			7.380 (6.633)	2.394 (1.689)
	Country dummies	yes	yes	yes	yes
	Observations	405	405	405	405
	Pseudo log-likelihood	-14.067	-14.121	-14.590	-11.989

Note: *** p<0.01, ** p<0.05, * p<0.1; (robust standard errors in parentheses)

The coefficient of technology per capita is significant at 5 percent level and with the negative sign as suggested by the theory. It has a strong impact on the passage of the compulsory schooling law with a coefficient equal to -1.931. It indicates that the lower is the level of technology of a country the greater is the probability that the country will increase compulsory schooling. This suggests that one feature common to the European countries that passed the law was the low level of technology. This is consistent with the modernization theory that argues that as countries modernize

and production becomes more complex, then governments need to endow the labour force with higher levels of skills which require more education and training. Therefore, these results may reveal that governments perceived the technological gap and increased the number of years of compulsory schooling in order to endow the future labour force with the skills necessary for the adoption of more advanced technologies. This may have been the case for many countries included in the sample. Countries like Denmark, Ireland, Italy, Portugal, and Spain were agricultural societies until the end of the Second World War. Since then a rapid process of economic development has taken place and the expansion of compulsory schooling may be regarded as a specific consequence of the process of modernization. Moreover, the level of technology per capita has grown at a very rapid pace over 1974-2000 for those countries that started with low levels such as Greece, Ireland and Portugal. Nevertheless, also in countries like Austria, Denmark and the Netherlands the level of technology per capita was in 2000 more than four times greater than the value of 1950, as shown in table 3.2. The variables for openness, shows the expected positive sign but is not significant. On the other hand, the initial level of compulsory schooling is significant at 1 percent level and had a strong impact on the implementation of the schooling reforms. That is, countries that started with low levels of compulsory schooling in 1950 also experienced a greater increase in the level of compulsory schooling between 1974 and 2000. This suggests that after the Golden Age schooling reform was characterized by a catch-up: the lower the level of mandatory schooling the faster was the implementation of school-leaving age laws in the countries examined. With respect to the other theories, variables of the political economy and role of the state theory exhibit the expected sign but are not significant. These results are robust when covariates are estimated in the same model. Therefore, the modernization theory provides the best explanation for the period 1974-2000.

The last regressions consider the differences between the two groups of countries, the more backward and the more developed. The choice for the division in the two groups has been explained before and it mainly relies on the initial conditions with respect to the human capital stock. This analysis is carried out to test whether factors that differ across groups of countries have characterized the expansion of school-leaving age. The first estimation is related to Greece, Italy, Portugal and Spain whereas in the second regression the remaining countries are included. The results of

the estimation for the Southern European countries are not reported here as none of the variables apart from technology per capita is significant. This variable exhibits the negative sign. Again, this is in support of the argument that, under certain conditions, the greater the technological gap the greater was the need for a country to implement schooling reforms. This also reveals that factors different from those included in the theories did have an impact on the expansion of compulsory schooling in Southern Europe. Table 3.7 shows the results of the analysis for the other Western European countries in the sample.

Table 3.7. Estimation results 11 European countries, 1950-2000

	Time period Dependent variable	1950-2000 SLALAW	1950-2000 SLALAW	1950-2000 SLALAW	1950-2000 SLALAW
Modernization theory	Technology$_{pc}$	-0.484 (0.774)			-1.333 (0.926)
	Openness	0.030 (0.023)			-0.035 (0.028)
	YearsComp50	0.150 (0.616)			-1.428 (1.230)
Political economy theory	Democracy		-1.055** (0.437)		-1.865** (0.934)
	GINI		-0.178** (0.087)		-0.214 (0.191)
Role of the state theory	State Capacity			4.083** (1.814)	9.487** (4.271)
	l(GDP/GDP$_{(-5)}$)			5.615*** (1.463)	7.329** (3.027)
	Country dummies	yes	yes	yes	yes
	Observations	506	561	506	506
	Pseudo log-likelihood	-33.823	-32.841	-31.296	-28.425

Note: *** p<0.01, ** p<0.05, * p<0.1; (robust standard errors in parentheses)

The last estimation includes the following countries: Austria, Belgium, Denmark, Finland, France, Ireland, the Netherlands, Norway, Sweden, Switzerland and the United Kingdom. The role of the state theory performs better in explaining the rise in school-leaving age for this group of countries. Both state capacity and growth with respect to the five previous years are significant with the expected sign. These results can be reconciled with the historical evidence as follows. The greater the share of the

labour force with respect to the young population, the greater was the impact on the passage of compulsory schooling laws as the labour force could sustain the expansion of schooling. Also, economic growth had a positive impact on the passage of the school-leaving age laws. This is consistent with the view in the existing literature according to which the economic expansion is accompanied by the expansion of schooling (Meyer et al., 1979; Lindert, 2004). These results are robust when the three theories are tested in the same regression. Among the variables of the political economy theory, Democracy is significant but with the negative sign. It may be the case that the extension of suffrage led more advanced countries, which already had well established democratic institutions, to broaden the access of education at higher levels. Also, it is possible that in these countries the intensified process of technological innovation created the need for a greater share of highly educated workers in order to implement and develop new technologies. This would support the idea that different education policies may be adequate at different stages of development. This is a question that requires further analysis and will be explored in the next chapters. What is important is that countries like France, the United Kingdom, and the Nordic countries have experienced an unprecedented expansion of higher education since the 1960s (Gellert, 1993). GINI coefficient is significant but this result is not robust when the three theories are tested against each other. On the other hand, there is no variable among those considered for the modernization theory that is significant. Therefore when the sample of the eleven European countries is considered, the role of the state theory performs better.

In order to summarize the results of these estimations. it is not possible to draw any conclusion on what theory performs better when the 1950-1973 period is considered and when Southern European countries are examined. Modernization theory seems to provide a good explanation for the expansion of compulsory schooling in both Southern European and more advanced countries after the Golden Age. By examining the determinants of the expansion of compulsory schooling in the more advanced countries in the sample it is possible to observe that the role of the state theory performs better. On the other hand, it is not possible to discriminate between these two theories when the period 1950-2000 is examined.

The purpose of this chapter has been of explaining the determinants of the changes in school-leaving age laws. In chapter five compulsory schooling laws will be used

as an instrumental variable in order to estimate the returns to education. This apparently contradictory purpose calls for an explanation. The fact that different theories have explained the change in school-leaving age laws in different time periods and for different groups of countries, and in some cases the theories presented have not been able to explain the changes in legislation can be considered in support of the exogeneity of the instrument. Therefore, it seems that the use of the school-leaving age law as an instrument should not represent any major concern. Further checks on the adequacy of this instrumental variable will be carried out in chapter five.

3.5) Robustness analysis: endogeneity

The problem of endogeneity has not been addressed so far and deserves a discussion. One could argue that there exists a reverse causality between schooling and technology. That is to say that higher levels of wealth and more advanced technologies create the need for a more educated labour force and this leads to an institutional response in terms of increasing the school-leaving age. On the other hand, higher levels of schooling could create a more prosperous society and lead to the creation of advanced technologies as a result of the greater pool of skilled workers.[274]

I argue that the correlation between technology and the expansion of compulsory schooling reflects only the impact of the former on the latter and not the reverse. To test this I cannot use the tools that are commonly used in the literature to tackle the endogeneity problem as lagged variables and instrumental variables. This is because the former methodology by using a lagging of explanatory variables relies on temporal requirements of causality. In this case it would not be effective as the

[274] In what follows I provide a proof for technology as the problem of reverse causality for GDP and schooling has been extensively studied by scholars (i.e., Barro (1991), Bils and Klenow (2000), etc.). Most results show that faster growth can induce more schooling but a definitive answer has not been reached.

passage of the school-leaving age law strongly relies on the fact that compulsory schooling has not been increased before.

The instrumental variable approach does not seem viable in this case as it is very difficult to think of variables correlated with technology but not with the error term. Natural experiments such as the one used by Acemoglu et al. (2005) to show how institutions have an impact on long-run growth by illustrating the outcome of the introduction of very different types of institutions in North and South Korea cannot be found in this case. Therefore, the Hausman specification test cannot be used here to test for endogeneity. Thus, it does not seem possible to deal with the problem of endogeneity by using the traditional techniques.

To address the issue I show[275] that only higher education matters for technology and that school-leaving age laws only concern primary and secondary levels of schooling. I do this by demonstrating that the assumption $E(Z_{i,s} \mid h_{i,t}) = 0$ is true. I proceed as follows, first I regress the level of technology on three schooling variables: completed primary, secondary school and completed higher education.[276] If I find that only higher education has an impact on technology this would support the hypothesis of absence of endogeneity. This is because the rise in compulsory schooling has occurred at primary and secondary level and if these variables do not have an impact on technology this would falsify the possibility of reverse causality. Moreover, it seems a reasonable assumption as it is the share of workers with higher education that is more likely to work in the research and development sector and to contribute to the advance of technology. The results of the cross-sectional time series with fixed effects are presented in table 3.8.

[275] This methodology has been suggested by Dr Murtin and Dr Petrongolo, LSE Department of Economics.

[276] In this case the linear functional form has been assumed. In addition, different functional forms have been tested and have led to similar results.

Table 3.8. Results of the cross-sectional time series regression

$Technology_{pc}$	
constant	0.266 (0.187)
comprim	0.051 (0.233)
comsec	0.308 (0.401)
comhigh	0.423* (0.240)
Observations	150
Groups	15
R-squared	0.337

Note: *** p<0.01, ** p<0.05, * p<0.1; (robust standard errors in parentheses)
$Technology_{pc}$=technology per capita
comprim=share of the population that has completed primary school
comsec=share of the population that has completed secondary school
comhigh=share of the population that has completed higher education

From the above results it is possible to observe that only higher education has a positive and significant impact on technology. Therefore, it is possible to reject the hypothesis of endogeneity. This does not mean that primary and secondary school are independent from the technological capacity of a country. As suggested by Vandenbussche, Aghion and Meghir (2006), primary and secondary schooling can foster growth when a country is far from the technological frontier, that is to say when a country makes use of "imitative technology". On the other hand, when a country is closer to the technological frontier, higher education becomes important for growth because it allows the country to develop "innovative technology". Thus, the expansion of higher education is important for the development of the more advanced technologies and not for the importation of basic technologies from other countries. This is coherent with the explanation provided here as the technological variable used in this study, patents, represents innovative technology only and the empirical results show that it is independent from primary and secondary schooling.

3.6) Concluding remarks

This chapter has addressed the research question: "what have been the determinants of the increase in the number of years of compulsory schooling that has characterized the experience of many European countries since the end of the Second World War?" I have adopted a new method in order to deal with this historical question. I have used a comparative approach by looking at the experience of fifteen European countries over the period 1950-2000, whereas previous analyses have mainly focused on single country experience. Also, I have used an analytical approach against the descriptive approach of the majority of the existing studies. To examine the factors that led to the expansion of compulsory schooling, I have tested the explanatory power of three theories from the literature of sociology and political science. Empirically, I have assembled a dataset by using a variety of national and international sources and I have used it in an innovative way. In using it, I have introduced to economic history the technique of survival analysis that is commonly used in medical studies and has been recently used for political economy investigations.

The empirical evidence I have found is in support of the importance of the technological gap in determining the expansion of compulsory schooling when the overall period is considered and especially after the Golden Age. That is, the technical-functional theory performs better after 1973. This is when the technological gap was perceived by European governments as particularly important and the globalization process greatly enhanced the need to modernize the educational system. However, during the Golden Age and when less advanced countries are studied, it is not possible to conclude on which theory performs better in explaining the passage of the school-leaving age laws. On the other hand, the role of the state theory performs better in explaining the change in legislation in the more advanced European countries in the sample. This is because the strength of the state had a significant impact on the expansion of schooling. It has also been observed that the progressive "scientization" of technology required a more educated labour force by creating greater complementarities between highly educated workers and the new equipment. Therefore, the empirical findings are in support of the theory put forward by Vandenbussche, Aghion and Meghir (2006) the idea that the "appropriate

institutions"[277] vary according to the level of development of a country. The importance of national factors, of "contagion" as well as of the process of European integration in determining the expansion of formal education is acknowledged and it appears to be a promising area for future research.

[277] This idea was initially introduced by Gerschenkron (1962).

Chapter Four

INSTITUTIONAL RESPONSE TO THE TECHNOLOGICAL GAP IN VOCATIONAL EDUCATION AND HIGHER EDUCATION

4.1) Introduction

The change in the education and training systems generated by the need to increase workers' level of human capital as a result of the introduction of the ICT technologies is a topic that has attracted great attention among scholars. In fact, academics and policy-makers of different fields have addressed this issue in different ways. Educationalists and practitioners have looked at the impact of the new technologies used in school on students' achievements as well as at the changes in the organization of the schooling system. On the other hand, economists have examined what types of skills are more likely to foster the adoption of the new technologies and policy-makers of national and international organizations have provided guidelines to governments concerning strategies for an effective adoption of ICT.

The study that is closest to my research interests comes from the economics literature: Krueger and Kumar (2004) compare the education systems, the pattern of ICT adoption and the growth performance of Western Europe and the United States. They conclude their analysis by arguing that the European education system was adequate in the 1960s when technological change was slow whereas for the more recently developed ICT technologies, the American education system was more appropriate because it has a greater focus on the provision of general skills.[278] In spite of some minor technical limitations,[279] the study presents a much greater shortcoming: it does not consider European heterogeneity. In fact, it considers as stylized facts phenomena that are much more difficult to model given the great differences characterizing the education system and the pattern of ICT adoption of Western European countries.

Nevertheless, Krueger and Kumar's (2004) study draws the attention on issues that are central to my thesis: the response of European institutions in education and training policy in order to foster the adoption of the new technologies as well as the

[278] Krueger and Kumar follow the line of research adopted by Galor and Tsiddon (1997), Galor and Moav (2000) as well as by Lester (2006). According to these authors when technological change becomes faster workers with general skills can more easily use the new technologies with respect to workers endowed with specific skills because they can quickly adapt to new technological environments. Following on from this argument Krueger and Kumar (2004) explain that the adoption of ICT has been faster in the United States given the large supply of workers endowed with general skills.
[279] The critical review of this study is provided in section 4.2.1.

question related to the nature of the European Union and its impact on the education and training policy of the Member States. This analysis leads to some interesting questions: how have European education and training systems been adjusted in order to respond to the technological change? That is, how have European institutions responded to the introduction of the ICT technologies at vocational education and training (VET) and higher education levels? What has been the impact of the EU policy? In order to address these research questions the focus of the analysis of this chapter will be on the experience of three countries: Germany, the Netherlands and Portugal. The choice of these countries is motivated by the necessity of taking into account the heterogeneity that exists across Europe and showing how the institutional response has varied across the Member States as well as by data availability.[280] The period covered for the analysis will be 1980-2002. The period chosen is motivated by data availability and the fact that before 1980 the adoption of ICT was not very significant.[281]

The analysis will proceed as follows. Section 2 provides a brief literature review, addresses the research question and describes the methodology that will be used for the analysis as well as offers an overview of the education systems of the countries under study by highlighting the reforms that have been undertaken. Section 3 highlights the empirical evidence on returns to ICT qualifications. Section 4 examines the pattern of ICT adoption across the three countries by using indicators extracted from various sources. The next section addresses the issues of ICT skill shortages by presenting studies undertaken both at national and international level. Section 6 analyses the ICT-related degrees that have been introduced in the three countries in both vocational and higher education by looking at the timing of the launch of these programmes and the content of these courses. Section 7, gives a brief overview of the evolution of the participation rates in general with respect to vocational education and in an ICT-related degree programme that has been introduced in the three countries examined. Section 8 provides a critical discussion of European Union policy and its impact on the education policy of the Member States by critically examining whether there has been a convergence in terms of ICT-related education and training policy. Section 9 offers a discussion on the general findings of

[280] Please refer to section 4.2.2 for an explanation concerning the choice of the three countries examined in this chapter.
[281] See chapter 2, section 2.3.2.

the chapter and the need for a EU policy response. The final section provides a summary of the findings and concluding remarks.

4.2) Literature review and general overview of the analysis

4.2.1) Literature review

This chapter examines changes in education and training as a result of the introduction of the information and communication technologies. This is a very complex issue that has been tackled in different ways according to the different literatures. In fact, practitioners, policy-makers and academics have focused on different aspects related to this topic and have addressed the need of increasing the educational level of the workforce by using different approaches. In what follows the strands of the existing literature that are more relevant to my research topic will be reviewed. These are the history of education and education policy literatures, the policy-oriented and social policy as well as the economics literature.

In the history of education and education policy literatures a great deal of attention has been devoted by scholars to studying the impact of the introduction of the new technologies at different levels of education. Three different strands related to these literatures can be identified. The first is related to the impact of the new technologies at different levels of education and at the administrative level. Bates (2000) argues that a successful adoption of the information and communication technologies requires major changes in the overall organization of the schooling and university systems whereas Valovic (2000) emphasizes the importance of the right culture and the need to innovate the entire management of the school system. In support of this need for a major change in the educational sector, Carnoy (2004) highlights that much remains to be done in education to see an increase in productivity. In order to show this, he compares the changes brought by ICT in the business sector with respect to what has occurred in the educational sector. The author argues that the increased productivity in the business sector is largely due to the better management of information processing whereas, he finds, the new technologies have not been

fully exploited so far in the educational sector. This study is revealing of some specific factors that determine the adoption of the new technologies in the schooling system. Among these factors, key is the role played by teachers.

The second stream, which to a certain extent is related to the previous one, refers to changes in teachers' training. Scholars like Shavelson and Salomon (1985) have emphasised the importance of teachers' training in order to exploit the potential of the information technology. Lawson and Comber (1999) have compared different schools and colleges that varied according to the level of ICT adoption. They found human resources in terms of teachers, ICT coordinators as well as senior management to be key elements in fostering a successful adoption of the new technologies. In another study that focuses on higher education only, Collis and van der Wende (2002) have done a cross-country comparative analysis in order to understand what are the new scenarios in the higher education system that are emerging as a result of the ICT adoption and what are the likely future scenarios. The questionnaire was distributed in higher education institutions in Australia, Finland, Germany, Netherlands, Norway, the United Kingdom and the United States to 693 people among the decision makers, support staff and instructors. The authors found that teachers are gradually making more use of ICT in their teaching practices. However, the change is slow and there is neither reward nor incentive for teachers to make a greater use of ICT technologies.

Another research area in this field concerns student's achievements: the focus of the analysis has been on examining whether the use of computers can have a positive effect on pupils' schooling and university students' performance. Kulik's (1994) study represented an important advance in this type of literature. This is because the author undertook a meta-analysis by collecting the findings of 500 studies undertaken over 1978-91 mainly in the United States. He compared the achievements of students who had received some kind of computer training with respect to those who had not at postsecondary level. The results of this analysis show that on average "students who used computer-based instruction scored at the 64th percentile"[282] with respect to the other students who scored at the 50th percentile. These results have been criticized in the context of subsequent research because by comparing two different methods of instruction: computers and lecture it is not possible to take into

[282] Schacter (1999, p.4).

account the quality of teaching.[283] In order to solve some of these limitations, Flowers et al. (2000) have collected data from a survey carried out in 1992 for 3,480 students from 23 colleges. The test was undertaken on first, second and fourth year college students and many controls were used for the empirical analysis. The impact on student results of computer use in course work and email use was found to be positive for two-year college students whereas for four-year college students computer use did not improve students' performance.

These studies represent a good source of information on the potential impact of computer use in improving students' performance. However, they have some limitations concerning the way they control for unobserved heterogeneity characterizing students' scores and it is not possible to draw any definitive conclusion on how these new technologies can improve students' cognitive capabilities (Kuh and Vesper, 1999). Recently, a very interesting analysis has been carried out by Fuchs and Woessman (2005). The authors examined the impact of computer use at home and in schools on students' performance in science and mathematics by using the data of the Programme for International Student Assessment.[284] They show that once they control for students' social background the positive correlation between computer use and test scores in mathematics and science disappears. That is, they found a high positive correlation between the availability of computers at home and in school and students' social background. Therefore, once these characteristics had been taken into account, the positive effect of computer use disappeared. This paper represents the state-of-the art literature also because the multivariate analysis undertaken by the authors solves many of the shortcomings of the bivariate analysis undertaken in previous studies. On the other hand, Carnoy (2004) addresses the question on whether ICT is adequate for the transmission of knowledge especially for those children who have difficulties in learning with traditional methods but this remains one of the "many unanswered questions regarding the role of ICT in education".[285]

[283] Flowers et al. (2000, p.639).
[284] This is an international test that covers basic subjects like mathematics, science and reading. It is organized by the OECD and has the merit of providing test scores readily comparable across countries. It has been previously mentioned in section 2.4.1.D.
[285] Carnoy (2004, p.14).

Policy-makers of different institutions have examined the interaction between education and ICT in order to provide guidelines for policy and to inform governments. International organizations have focused on policy-oriented analyses whereas many research centres have focused more on the changes in the type of skills required at industry level and in the labour market. In this review policy studies at three levels will be considered. First, the national policy will be considered, then studies undertaken by international organizations will be surveyed and finally analyses undertaken by policy-oriented research institutes will be reviewed.

The policy formulation at national level will be examined in detail in a later section when the general organization of the education and training systems as well as the main reforms undertaken since the 1980s will be analysed for three European countries. Many international organizations have created research programmes and formulated policy guidelines with the aim of helping governments to deal with the introduction of the information and communication technologies in the schooling system. In the framework of the programme "Education for the Knowledge Economy", which has been created with the objective of providing assistance to developing countries, the World Bank has devoted research and funding mainly to help countries in two ways: by encouraging the expansion of education at all levels and by constructing "an effective national innovation system"[286] with the objective of creating a greater co-operation between firms, research centres and universities in order to foster the technological advance and the spread of the new technologies. The focus of the research has been largely on general education. This is because of the view of the World Bank, according to which general education is more likely to have a beneficial impact on growth than vocational education and training.[287] That is, the World Bank supports the development of an education and training system similar to the American one with a greater focus on general education.

On the other hand, the focus of the research undertaken by the OECD and the European Commission has been both on vocational and general education given the support of these institutions for the development of effective training systems across

[286] World Bank (2006a, p.1).
[287] This has been suggested by Dr Steedman in a conversation we had at the beginning of last year. It can also be observed by looking at the policy guidelines prepared by the World Bank for developing countries. The focus is on general education rather than on vocational education and training.

Member States. Reports reviewing the pace of ICT adoption in the educational systems of the Member Countries have been prepared[288] with the aim of creating a broader knowledge and greater awareness of the level of development of the new technologies across the different participating countries. These reports rely on questionnaires that have been administered in the different Member States and case studies that focus on the experience of specific institutions. Following the analysis of the findings of these studies, these official reports provide guidelines to Member States on how to integrate ICT in education at vocational education level, EU Commission Report (2005a), as well as at higher education level, OECD (2005). The focus of the UNESCO (1998 and 2002) policy research has been on teachers' education that is considered by this international organization as one of the key factors in determining students' acquisition of ICT skills. Overall, the reports of the international organizations I have surveyed have examined some indicators related to the spread of ICT at the different levels of education and have tried to understand what are the key factors that have allowed this development. In addition to this, they have formulated policy guidelines for Member States.

Among the policy-oriented research centres, the NIESR has provided insightful analyses. The focus of the existing studies has been on the change in the type of skills required in the economic activity as a result of the introduction of the ICT technologies. Kirby and Riley (2006) have examined the effect of ICT on the returns to general and specific skills in the United Kingdom over 1994-2001. The policy guideline that can be derived from this study is that "general skills are arguably more useful in acquiring the new skills that may be required in implementing new technologies".[289] In fact, returns to general skills has increased over the time considered with respect to the return from job-specific skills. However, the authors acknowledge the possibility that general skills are complementary to the organizational change generated by the ICT adoption.

Other studies have addressed the issue of skill shortages at industry level. Forth and Mason (2004a; 2004b and 2006) have examined the possible negative consequences on enterprises performance arising from the "lack of skills".[290] In particular, they

[288] See for instance the Final Report to the EU Commission of the DG of Education & Culture (2005a) as well as the project of "E-learning in Tertiary Education" of the OECD (2005).
[289] Kirby and Riley (2006, p.37).
[290] Forth and Mason (2004b, p.2).

refer to the shortage of ICT skills in the United Kingdom over the periods: 1997-99, 2000-01 and 1999.[291] They find a negative relationship between the skills gap and company performance. However, in the latter two studies they do not find direct evidence for the skill gaps limiting the adoption of ICT at firm level. Finally, Steedman, Wagner and Foreman (2003) examined the composition of skills of workers employed in the ICT sector in Germany and the United Kingdom. The findings of their research will be reviewed later in the analysis.

Other research centres have investigated the effectiveness of computer technology at the different levels of education and how the skills produced by the education system are used in the new occupations in order to recommend the better strategies for the adoption of the ICT technologies. The RAND Corporation[292], a policy-oriented research institute, has created the RAND's Critical Technologies Institute (CTI) in order to provide governments with advice on what strategies they can play in order to foster an effective use of the ICT technologies in the educational system. The Employment Studies Research Unit of the Bristol Business School has provided policy guidelines related to what are the skills produced by the education systems and what are the new skills required in the different occupations. In this context, Elias and Purcell (2003) investigated whether there is a mismatching between what students have learnt and the skills that they have to use in their employment. They develop a new classification of occupations in order to provide a better understanding of the evolution of the occupational structure and "the position of graduates within this structure" over the period 1975-2000. Among the categories they introduce: "traditional graduate occupations" that includes solicitors, medical practitioners, and teachers; "modern graduate occupations" for software engineers, computer programmers and "new graduate occupations" for jobs such as social workers, marketing and sales as well as welfare officers. Among their findings: since 1975 the proportion of workers in the categories "modern" and "new graduate jobs" has doubled. Moreover, contrary to what happened in the past, graduates have access to occupations that do not make use of the skills they acquired through formal schooling. Only for some of the traditional occupations and "new graduate

[291] These are the time periods covered in Forth and Mason (2004a), Forth and Mason (2004b) and Forth and Mason (2006). Different datasets related to the survey data for UK enterprises, ICT Professionals Surveys and post-survey financial data have been used for these studies.
[292] The name of the American think tank was derived from a contraction of the term research and development.

occupations" this does not happen. This study provides valuable information for broad categories of occupations.

In the economics literature the great majority of the empirical studies[293] focus on general education rather than vocational education and training as recorded by the European Centre for the Development of Vocational Training (CEDEFOP, 1998). However, it is important to observe that vocational education and training play an important role in the educational systems of European countries. For instance, in the 1990s, on average 58 percent of European workers had received vocational education at upper-secondary and post-secondary level.[294] Therefore, the issue of vocational training cannot be neglected. The contemporary literature has started studying the different kind of curricula that can have an impact on the diffusion of technology with particular reference to the adoption of the ICT technologies that has occurred during the last decades.

Benhabib and Spiegel (2002) extend the work by Nelson and Phelps (1966) by analysing the role of human capital in reducing the gap between the technological frontier and the current productivity level. Human capital is considered in this strand of the literature as a factor that facilitates the diffusion of the new technologies and it is not considered as a factor of production. The interesting aspect of their analysis relies on the specification of the logistic function for technological diffusion. It introduces an important innovation with respect to the exponential model used in the traditional literature. In fact, this model allows for a permanent TFP divergence. This implies that the "catch-up" process is not automatic and technological transfer is not sufficient for it. Instead, it highlights the role of a minimum level of human capital necessary for the adoption of the new technologies and consequently for the convergence to happen. They test the model for 84 countries over the period 1960-95 and they consider the United States as the technological leader and the country that represents the benchmark for convergence. Among their findings: the positive role of human capital to foster TFP growth. This study is an important contribution to the literature as it focuses on how the role of human capital can be a determinant of the

[293] See for instance Woessman (2003a), Sianesi and Van Reenen (2003) and Vandenbussche, Aghion, and Meghir (2006) for a review.
[294] OECD, *Education at a Glance* (1997, C4.1).

convergence process. However, the results have some limitations. It seems that taking "1.78 average years of schooling" as a predictor of TFP growth is a very crude measure. In fact, issues such as quality and the institutional design of what skills are necessary for the labour force to effectively use the new technologies are not addressed. Moreover, the experience of those countries that were endowed with relatively high human capital levels but that had a relatively low TFP growth is not considered. Following this study, what seems to be necessary is to examine the experience of the European countries in greater detail, with a specific analysis on the kind of teaching curriculum that can endow workers with the skills necessary for the adoption of the new technologies.

The pioneering work by Becker (1964; 1993) that considers the difference between "general skills" and "specific skills" (the ones provided on-the-job training), is a fundamental contribution in the theory of human capital. Nonetheless, this model considers agents as perfectly informed and consequently the optimal quantity of general and specific training to be provided within the economy as known. In particular, the model does not allow for any structural change or the diffusion of new technologies that would require some time to adjust and some institutional change.

An important contribution to the recent literature that follows some of these lines is provided by Helpman and Rangel (1999). They analyse the interaction between human capital with different technologies while trying to understand how economies adjust to the technological change. They consider two kinds of technologies: one that substitutes workers' skills and the other that increases the necessary schooling level by creating a complementary relationship between workers' skills and the new technologies. The latter kind of technological change causes an initial slowdown due to the adjustment necessary whereas the former is likely to generate a sudden increase in the growth rate, according to the authors' explanation. This seems an interesting model that captures the role of human capital in facilitating the diffusion and the transition to the new technology. However, this model cannot be readily estimated. This is because of the specification they use for "education" and "experience". They consider "education" by means of general knowledge provided either by formal schooling or on-the-job training and "experience" as the specific skills that cannot be transferred for the use of different technologies. This distinction seems reasonable. However, from an empirical point of view, it is very difficult to

test as it is almost impossible to separate the general from the specific skills acquired on-the-job learning. In fact, for this theoretical model the authors do not provide an empirical estimate. Moreover, in this model there is no role for institutions. This is to say, we do not know whether apart from the choice of rational agents over how to adjust their skills in order to meet the requirements of the new technologies, there is also an adjustment that institutions need to undertake to expand the educational sector and in what directions. Therefore, this model provides an interesting theoretical starting point from which to develop an historical analysis supported by empirical evidence.

The model in the existing literature that is closer to the purpose of the analysis of this chapter, as it analyses in greater detail the interplay between the different educational curricula and the adoption of the ICT technologies, is the model developed by Krueger and Kumar (2004). They build the rationale of their model on three stylized facts: the growth gap between the United States and Europe since the 1980s, the gap in the diffusion of the ICT technologies and the greater focus of the European educational system on vocational training with respect to general education. Starting from these considerations, they construct a general equilibrium model. In the following paragraph I will briefly describe the general setting of the model and the results as I have received the technical unpublished appendix of the model from the authors. In the setting Krueger and Kumar (2004) define, there are three agents: firms, households and government. There are two kinds of firms: the ones that operate in the high-tech sector and those that operate in the low tech-sector without adopting the new technologies. Households, who provide labour to firms, optimally decide whether to acquire general or vocational education. High-tech firms optimally decide on the adoption of new technologies. Government optimally decides the expenditure in the two educational sectors: general and vocational education. The authors also introduce in the model the negative effect on growth of labour and product market regulations by looking at the cost of firing a unit of labour and the fraction of the profit from sale that a firm has to pay as a tax. In order to determine the recursive equilibrium, Krueger and Kumar identify what are the policy function for workers, the policy function for adopting and non-adopting firms, the education policy function as well as the government expenditure in education function and the aggregate law of motion that maps aggregate states of the different time periods, that

make agents solve their optimization problems and allow markets to clear. After, the authors provide a definition and a characterization of the balanced growth path.

They calibrate the model by using data for the United States and Europe with a particular focus on Germany and Italy because according to the authors, these are the two countries that exhibit the greatest dissimilarities in the education and training systems with respect to the United States. It is true that Germany and Italy have participation rates in vocational training and general education that are very different from the American ones. However, it is misleading to argue that this is representative of the "European attainment".[295] In fact, important differences exist across Europe and later in the analysis I will try to capture this heterogeneity.[296] The authors consider 20 years period for the calibration of their model by using data from 1980 until 2000. Their results support the hypothesis that education did play an important role in the growth process. Moreover, they argue that the greater focus of European countries on vocational training was beneficial to growth in the 1960s and 1970s. This is because technological change was slow and a large pool of workers endowed with specific skills did not represent a shortcoming. On the other hand, this became a disadvantage in the subsequent decades when the introduction of ICT led to a more rapid change in many sectors of the economy. In this context, a rapid change also required greater adaptability of the labour force. According to Krueger and Kumar and other scholars previously mentioned, a labour force endowed with general skills is better suited for this task.

Krueger and Kumar's (2004) analysis represents an important development of the recent literature as they try to quantify the impact on growth of different kinds of education. Nevertheless, it is necessary to take into account the shortcomings of this study. First, the variable used to measure education deserves particular attention. Krueger and Kumar (2004) use a dummy variable that divides the population aged between 25 and 64 according to the highest level of education attained. The levels of education considered are primary, lower secondary, upper secondary, post-secondary

[295] Krueger and Kumar (2004, p.183).

[296] This is the reason why I will study European countries that exhibit great dissimilarities in terms of schooling system and participation rates. The countries I have chosen are Germany, the Netherlands and Portugal. The motivation underlying this choice will be provided in the next section. The case of Italy will not be examined as it is similar in many ways to Germany and it also shares some features with the other Southern European country, that is Portugal.

and non-tertiary as well as university education. In order to construct this variable they have relied on two tables of the OECD (2001), Education at a Glance Report. In the first table (table A2.1) the education attainment of the population is recorded. However, the attainment in vocational education and training is not detailed. This is the reason why the authors have complemented this information with more detailed data related to the pattern of enrolments at upper secondary level (table C2.1). Nevertheless, the data that can be extracted from this table refer to enrolments in general, pre-vocational and vocational courses. That is, the authors have assumed that "enrolment mirrors attainment".[297] This is a questionable approach given the high drop-out rates in upper secondary education that until recently have characterized the Italian system.[298] According to the OECD (2004), the completion rate of higher education between 1995 and 2002 was only 23 percent with respect to the OECD average 32 percent. Moreover, they calibrate their general equilibrium model by using as benchmark the year 1999. It is true that changes in the participation rates in general education with respect to vocational education and training have occurred very slowly in Western Europe,[299] as it will be shown in section 4.6. However, no justification is provided for the choice of this year. Second, the authors do not consider the heterogeneity that characterises the European scenario both in terms of ICT adoption and education and vocational training systems. In fact, the countries that will be examined in this chapter show very different patterns of ICT adoption. In addition to this, European schooling systems greatly differ from each other. There has been an institutional response as a result of the introduction of the ICT technologies that has proved to be different across countries and this dissimilarity calls for an analysis. Referring to the German and Italian participation rates in education as the "European attainment" does not seem to be appropriate.[300] In this regard, participation rates with specific reference to general and vocational education and training courses have followed different patterns depending on the country considered. The purpose of the remaining of this chapter is to try to fill these major gaps. What Krueger and Kumar (2004) seem to imply is that

[297] Krueger and Kumar (2003, p.33).
[298] Among the scholars who have studied the drop out phenomenon in Italy: Cingano and Cipollone (2003), Boero, Laureti and Naylor (2004) as well as Bruni and Bertaccini (2006).
[299] Portugal represents an exception in this regard as vocational education was abolished under Salazar's regime and re-established in the mid-1980s. Please refer to section 4.2.3, for an overview of the Portuguese education system.
[300] Krueger and Kumar (2004, p.183).

there has been a common pattern of ICT adoption and there exists a common education and training policy undertaken by Western European countries.

This leads to the historical debate on the nature of the Europe Union that has characterized the experience of Western Europe since the end of the Second World War and which refers to the relationship between the EU and the nation-state. That is, the tension between the nation-state and the supranational authority in the decision-making process. In the deservedly famous "*The European rescue of the nation-state*",[301] which is considered as the first historical investigation on the origins and the rationale of integration,[302] Milward (2000) argued that the process of consolidation of the nation-state and the process of integration have been mutually reinforcing since the founding of the European Economic Community. This is because, as Rosamond (2000) has outlined, at the end of the Second World War some policy areas, including defence, were best delivered by international cooperation and the integration process represented a new way of providing them. In addition to this, Milward saw the involvement of the European authority in many fields a means to rehabilitate the role of the state, "it was to rescue the nation-state that a common surrender of sovereignty was accepted".[303] This explains why Milward by undertaking the historical analysis of the origins of the European Union did not see a surrender of sovereignty as a negative consequence of the greater involvement of the supra-national authority. Instead, he claimed that the decision-making power would remain in the hands of national governments whose role is reinforced through the integration process.[304] In this regard, Milward examined the creation of common settings that appeared in the majority of European countries after the end of the war. Among these, the broader political consensus and the greater participation of the state in the agricultural sector were considered to be important. Also, the emergence of the welfare state was considered to be a key element to legitimise the state from the destruction of the war.[305] Milward observed the increase in social insurance as well as housing and education expenditure. However, he only

[301] In spite of some critiques (see for instance Adamthwaite (1993) who criticized the lack of predictive power and the structure of the book considering it as a "series of set pieces", (Adamthwaite, 1993, p.373) and Laurent (1993) who disapproved Milward's minimalist view concerning the role of the "founding fathers" in starting the integration process), this book is considered as a highly valuable source of information as its evidence draws on primary sources of eight countries and the archives of the European Community.
[302] Laurent (1993, p.1197).
[303] Milward (2000, p.4).
[304] Milward (2000, p.44).
[305] Johnson (1990, p.123).

mentioned the increased effort of European countries in the educational sector with respect to the greater involvement in research and development. Surprisingly, the author did not refer to the education policy and its evolution at national and supra-national level. However, this issue seems to be very important as education is mainly provided by public institutions across Western European countries and therefore an analysis of how the administration of this policy area has changed over time between the nation-state and the supra-national authority is key for the understanding of the European policy response in the education and training sectors. In this historical context, the purpose of the analysis of this chapter appears of great interest: understanding what has been the institutional response in vocational education and higher education undertaken by Western European countries in order to close the ICT technological gap with the United States. The focus will be on both the national level, by examining the experience of three European countries that represent different welfare and social models, as well as the European level, by looking at the EU policy dimension in vocational training and higher education. That is, it would be interesting to develop an understanding on whether there has been convergence across the European countries and what has been the role of the EU education and training policy in this process.

This brief review of the existing literature has shown the importance of the topic by highlighting the great complexity of the subject. This is because of the great heterogeneity that exists at European level in terms of ICT adoption and policy response in the educational systems. Also, the specific nature of the ICT technologies, the rapid technological change, and the slow change that characterizes the evolution of the education sector make the analysis more complicated. The literature review has also shown how the need of increasing the skills of the labour force as a result of the introduction of the ICT in the economic activity has been perceived in the different fields. By drawing on the literatures that have been reviewed, I would like to take a different approach. By taking into account the European heterogeneity I would like to examine how European institutions have responded in vocational training and higher education to the need of providing the labour force with new skills. This analysis will be complemented by the investigation of the pattern of ICT adoption. This is because it seems necessary to look at the institutional response with respect to the technological development of the countries observed. Moreover, I would like to examine the EU policy dimension in order to see

whether it has led Member Countries to converge in their policies or whether these countries have followed their own national strategies. In the next section the research question will be addressed and the methodology used for the analysis will be described.

4.2.2) Research question and methodology

The survey of the previous section has shown the great amount of research that has been devoted to the topic across the different disciplines. On the other hand, it has emphasised the great complexity of the issue and the intricacy of the process of adjustment arising from the introduction of the new technologies. A consequence of the skill shortages in ICT that have been of great concern for many Western European countries,[306] it appears important to examine how their governments have addressed the need of endowing workers with the skills necessary to use the new technologies.

The research question that will be addressed in the following paragraphs is: what has been the institutional response in vocational education and training as well as in higher education to close the gap with the United States? That is, how did European institutions adjust the existing education and training systems in order to address the increased demand for ICT skills? The interest of looking at the institutional response instead of limiting the analysis to the supply-side changes can be explained by two main factors. First, the supply of vocational education and training as well as higher education is mainly public in Europe. This explains why attention should be drawn to institutional policy. In fact, the large majority of European students receive secondary and possibly tertiary education in public institutions. This is one of the reasons why "there is a critically important role for government policy in these areas"[307] as de Ferranti et al. (2003) have suggested. The second motivation has been outlined in an earlier chapter and is strategic. It is possible to imagine that in order to create the skills required for the new occupations, governments can intervene in

[306] This is central to the European Competitiveness Report (2001) that will be reviewed in one of the next sections.
[307] De Ferranti et al. (2003, p.10).

order to generate a faster response than what could be generated by the market alone. Thus, it seems important to examine the timing and to see whether the response has been equally spread across the different educational sectors or whether it has been more concentrated at a given level of education. However, a word of caution is necessary here. With respect to the introduction of ICT-related degrees it is very difficult to distinguish between supply-side and demand-side determinants. That is, it is difficult to determine whether the introduction of a new degree is the result of a supply-side government policy or an institutional response to demand-side pressures. It could be both and it is empirically difficult to disentangle. Therefore, it should be kept in mind that governments can have introduced new programmes of study by perceiving future needs in terms of skills or in response to the demand by employers and students. In the remaining of the chapter the focus of the analysis will be on the introduction of new degrees in higher education and new programmes in vocational education and training without addressing this issue any further.

Three countries will be examined over the period 1980-2002: Germany, the Netherlands and Portugal. The choice of these countries is motivated by data availability and the necessity of showing the European heterogeneity in terms of education and training systems and institutional response. These countries are representative of the dichotomy that exists across the European vocational and training systems: Germany is a demand-led system whereas Portugal is supply-led.[308] The Netherlands are an interesting case as the cooperation with the labour market has become increasingly important since the early 1990s. Moreover, the response to ICT adoption in education and training has varied across these countries. In addition to this, the three countries symbolize some of the different European economic and social models: Portugal is a Southern European country[309] whereas Germany, according to Esping-Andersen's (1990, p.27) classification, belongs to the cluster of countries with a corporatist-statist legacy. That is, in these countries the state has been historically the main provider of welfare services. On the other hand, it has not

[308] A description of these two different systems will be provided in the next section. It is also important to acknowledge that this is a classification that facilitates cross-country comparisons that is largely used in the existing literature. According to Greinert (1994), this may be an oversimplification as all systems are a mix (p.16).

[309] According to Johnson (1990, p.130), Portugal, Spain, Italy and Greece are Mediterranean countries that share similar features with respect to the system of social protection that finds its roots in the "Bismarckian" model. However, it is important to notice that the education and training policies undertaken in Portugal differ in many respects from the ones adopted in the other Southern European countries. Moreover, Italy has been a democracy since the end of the Second World War.

been possible to include in the analysis a country representative of the "liberal" welfare state like the United Kingdom. This is because as the supply of vocational education and training qualifications is entirely organized by the market, the suppliers of training courses have great autonomy and there is no central authority that can provide information related to the content and timing of introduction of the ICT-related degrees. This sort of difficulty has been acknowledged also by Broadberry (1997) who considers the British system "much harder to document".[310] This is the reason why the Netherlands have been chosen. Among the corporatist welfare states, they are more open and closer to the market model in the area of education and training.[311] These countries are also representative of very different patterns of development of vocational education and training system. In fact, as will be explained in greater detail later, Germany has been highly-regarded by policy-makers and scholars for a long-time as a very successful model of apprenticeship system.[312] On the other hand, the Netherlands have followed a pattern of development since the 1980s that is quite similar to the British one. The case of Portugal can be considered as a kind of "natural experiment". In fact, the vocational system was abolished in 1974 with the military coup that ended Salazar's regime and subsequently reintroduced in 1983 under the pressure of the European Commission.[313]

After considering the structure and the main reforms undertaken by the three countries since the 1980s, I will examine the pattern of ICT-adoption as well as some measures indicating the evolution of the skills shortages in the different European countries. In this context, I will examine the timing of the introduction of the new degrees in information technology, communication science and software across the different educational levels in the countries under study. In addition to this an analytical framework showing the pattern of adoption of ICT and the introduction of the ICT-related programmes will be provided. The evolution of the participation rates in computer science and in other ICT-related degrees will be considered. Finally, EU policy will be reviewed in order to understand what has been its impact on the development and the convergence of the education and training systems under study.

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[310] Broadberry (1997, p.115).
[311] Green et al. (1999, p.69).
[312] Culpepper (1999, p.3).
[313] Pereira and Martins (2001, p.215) and Report of the Ministry of Science, Technology and Higher Education (2006, p.120).

4.2.3) Overview of the education systems

Germany, the Netherlands and Portugal have been chosen as they represent different models with respect to the provision of education and training. As suggested by Gospel and Foreman (2006), the supply-led systems, here Portugal, are characterized by a greater involvement of the state in the provision of training. In fact, in these systems the government is the main agent that provides funding and organizes the training system. Therefore, the state is also responsible for the introduction of new degrees and qualification profiles. As Fonda and Hayes (1988, p.115) put it: "employers choose what is offered and have relatively little influence over the content of provision and skill shortages and gaps". On the other hand, in the demand-led systems of VET, here Germany, there is a greater involvement of the stakeholders and social partners. This is because in this framework employers' organizations, chambers of workers as well as unions play a key role in the organization of the system. In this context, "member requirements drive the training".[314] That is, stakeholders and social partners identify the training needs of the market and can influence the introduction of new programmes. Fonda and Hayes (1988) emphasise the responsiveness of this type of system as the business sector plays a fundamental role in the provision of training and can shape the qualification profiles according to the changes in production and the needs of the labour market.

The focus of the remaining of this section will be on the vocational education and training system at secondary level and on the university sector and higher vocational education at tertiary level. On the other hand, the detailed analysis of the ICT-related courses introduced in vocational education and training at secondary and tertiary levels and in general education in the university sector will be provided later.

Germany

The focus of the analysis will be on Western Germany as this model of VET and higher education was extended to Eastern Germany after 1990 when the country was

[314] Gospel and Foreman (2006, p.208).

reunited.[315] The secondary German schooling system is composed by both general education and VET. The general education system is composed by an academically oriented course (*Gymnasium*) that gives access to higher education.[316] On the other hand, the VET system can be considered as a "state-controlled market model", as defined by Greinert (2004), in the sense that the provision of vocational education and training is dual. This "dual system", is characterized by a two levels provision of education and training programmes provided by both the state and the private sector.

The origins of the German training system can be traced back to the late 19th century.[317] Greinert (1994) argues the creation of this training system was largely due to the economic and social decline of the craft trades and small retailers, the need to provide workers with skills more relevant to the chosen profession and the middle class policies of the German Empire. Since 1870, the German VET has expanded under different political systems.[318] At the end of the Second World War, an important debate took place between the Allied Forces in order to decide on whether the German educational institutions should be dismantled.[319] However, given the heterogeneity of the education systems of the occupying countries an alternative would have been chosen with difficulty. After a long debate, the dual system was maintained and "became more firmly established through the Vocational Training Act of 1969".[320] This act was very important as it defined all the principles and rules on which the system is based. The basic mechanism underlying the VET system was preserved and remained close to the one that existed in the pre-war period.

The German system of vocational training is a "demand-led system".[321] This is because the organization of the system is characterized by the cooperation between employee and employer associations with the federal government and Länder governments.[322] That is, on the one hand, the state provides vocational schools whereas companies provide the training sites. This specific setting has a great influence on the general organization of the system, the legislation and the provision

[315] For a review of the introduction of the West German training system in Eastern Germany please refer to Wagner (1999, pp.53-64).
[316] Val D. Rust (1988, p.456).
[317] Greinert (1994) considers the founding era of the German system of VET to be 1870.
[318] Greinert (1994, p.20). The author refers to the Weimar Republic, the Third Reich and the Federal Republic of Germany.
[319] Engel and Rosenthal (1970, p.13).
[320] OECD (1994b, p.13).
[321] This is the model that exits also in Austria and Switzerland.
[322] CEDEFOP (2000, p.11).

of training. The system is highly regulated, a specific training legislation regulates the provision of training, the standards required and also the qualifications awarded by the companies need to be approved by the state. Moreover, the government can only decree apprenticeship regulations with the approval of social partners.[323] According to Sung et al. (2005), this setting can limit public intervention but on the other hand, the greater participation of the private sector is likely to make the system more responsive to the changes in the labour market.

The German "dual system" has been traditionally regarded by policy-makers and scholars as a successful example of joint supply of training.[324] However this and other characteristics of the system have been its strength in the post-war period but have progressively become a weakness in the 1990s. The viability of the system has been put under pressure.[325] Culpepper (1999) and Wagner (1999) argue that there are two main factors that can explain this. First, German reunification imposed a high cost for the support and the transfer of the training system to the Eastern Länder.[326] Second, the economic recession, especially severe in the manufacturing sector in the early 1990s, led to an important loss of jobs in this sector. By 1992, 11,500 training places in metalworking had been lost.[327] The latter aspect had important consequences on the German system because of the high dependence on the labour market. That is, the system relies on private financing as companies provide the greatest share of funding. In this regard, estimates of the Federal Ministry of Education and Research give an overview of the cost and benefit of in-company training and show how the funding of training is divided between the contributors for a benchmark year. During the year 2000-01, companies covered 67.5 percent of the total cost whereas federal government and Länder 15.5 percent and Federal Employment Services 17 percent.[328]

The problem is that in times of economic downturn firms may be less willing to bear costs of apprenticeship. This is also one of the reasons why only large firms may find it profitable to train apprentices whereas for the medium size and small businesses it

[323] Sung et al. (2005, p.99).
[324] Please refer to Culpepper (1999, p.2).
[325] See Greinert (1994, p.116), Wagner (1999, p.38) and Uhly et al. (2005, p.2).
[326] However, it is important to acknowledge that a different apprenticeship system was already in place in East Germany before 1990 (Wagner, 1999, p.53).
[327] Greinert (1994, p.120).
[328] According to this estimate provided by the Federal Ministry of Education and Research, the total expenditure for the dual system in 2000-2001 has been equal to 14.7 Billion Euros.

has become a serious burden. Sprenger (2006) shows that 23.3 percent of all German companies offered training in the year 2000 and among these, 16.5 percent of small companies (1-9 employees) offered training whereas 93.3 percent of large companies (more than 500 employees) supplied training.

As a result of the fact that the demand for training places could not be met by the private sector alone, the role of the state in the provision of training has become increasingly important.[329] This is because the state guarantees the provision of training in special schools that are meant to provide the same sort of training that should be provided by companies. Among these, there are the extra-plant training centres that are organized by employers' associations and they are "neither schools nor enterprises"[330] as Greinert (1994) points out. Therefore, to a certain extent the system is becoming more similar to that of the majority of the European countries where there is a more limited participation of the private sector in the provision of training.

In spite of the challenges faced by the German VET model, according to Culpepper (1999) and Greinert (1994), the system has been able to respond in an effective way to the reduction of the apprenticeship places funded by the private sector. Many scholars have argued that there has been a continuous process of adjustment that has characterized the German VET system since the end of the war. In the late 1950s, and later the early signs of the economic crisis after the *Wirtschaftswunder*, "revealed the need for new responses based on a rational concept of 'occupation'".[331] In this context, some specialists were in favour of a more systematic curriculum and less specialisation. In order to achieve these aims a policy shift was progressively undertaken towards more general education: from 900 occupations after 1945, to 627 in 1970 and 376 occupations in 1990. This was done by providing students with more general skills in order to enable them to have a greater flexibility with respect to the rapid changes in the labour market. This was done also by allowing students who have completed the secondary level of certain programmes of vocational education to continue their studies in higher education institutions. This can also be explained by the deepening of the economic crisis that increased the demand for

[329] Uhly et al. (2005, p.4).
[330] Greinert (1994, p.95).
[331] OECD (1994a, p.16).

higher education qualifications and lowered the demand for the vocational education ones. For example, since 1990 the number of applicants in craft and trades has been reduced by 43 percent, in retail trade by 34 percent and in metalworking by 20 percent.[332] On the other hand, new qualification profiles in the field of information and communication technology have attracted greater participation rates among students and have contributed to an increase in participation rates with respect to the mid-1990s. According to the statistics of the Federal Institute for Vocational Training (BIBB, 2002), in the year 2000, 620,000 training contracts were signed and these were 50,000 more with respect to 1995. Thus, the system seems to have been responsive with respect to the introduction of ICT. In 1983, pilot projects were launched in order to introduce training for the use of information and communication technology in vocational education and training.[333] These programmes were launched in different sectors. Moreover, training programmes in ICT were introduced and "became the prototype of more flexible and adaptable VET standards".[334]

The debate that currently animates the German vocational institutions is related to the survival of the system.[335] According to Herrigel and Sabel (1999) it is not possible to forecast whether the dual-system will survive. On the other hand, Wagner (1999) is more optimistic and Greinert talks about a "crisis-ridden adjustment process"[336]. In 2005 the original Vocational Training Act was amended. Länder have been given greater autonomy in the organization of the school-based management of vocational education and training whereas the Federation is responsible for the passage of the legislation related to the organization of vocational training provided outside the schools.[337] This was done with the purpose of increasing the overall flexibility of the system.

The tertiary education level is composed by both technical and academic higher education. Technical education is provided in the applied universities called *Fachhoschulen*. This type of higher education offers a four years course and a

[332] Greinert (1994, p.120).
[333] Bundeinstitut für Berufsbildung (BIBB) (2002, p.5).
[334] BIBB (2002, p.5).
[335] Culpepper (1999, p.13).
[336] Greinert (1994, p.123).
[337] Federal Ministry of Education and Research (2005, p.4). This Reform Act was implemented on April 1st, 2005.

semester of internship at a company.[338] The higher education system shaped by von Humboldt who founded the Berlin University in 1810, soon became to be considered as a model and was studied and imitated by many European countries. This is because he fostered the creation of an educational institution "free of political or religious interference".[339] This system is mainly organized by a joint effort between the state and universities.[340] That is, the state is responsible for financing the system whereas universities are responsible for the general administration. The Federal General Higher Education Law of 1976 has led to a greater homogeneity in the administration of the university system across the Länder that until then had quite dissimilar types of organization. However, the individual Länder have the main responsibility for the implementation of the courses of study. Other reforms include structural adjustments in response to the increased demand for higher education and the compliance with European agreements. Among the effects of the EU policy, central is the progressive reduction in the length of the degree programme, that originally lasted seven years.[341]

To summarize: the German secondary system of education is characterized by the existence of a general education track and a vocational education and training system. The latter is known as the "dual system" as a result of the participation of the state and the members of the industry sector in the provision of training. The system has been effective in the provision of training and until recently has been considered as a model by many countries. However, since the end of the 1980s the system has been under pressure as a result of the economic slowdown that has made it difficult for small companies to offer training places. The state has responded by becoming more involved in the provision of training. The higher education system has a structure that is more similar to the other European countries, whereby its management is shared between the state and the federal administration. Given the participation of different actors in the organization of the secondary and tertiary education system it would be interesting to examine whether the introduction of the ICT-related degrees has been more effective than in other systems. That is, in countries where the education system is more centralized and the state is the main actor.

[338] Steedman et al. (2003, p.3).
[339] Marlow-Ferguson (2002, p.495).
[340] Val D. Rust (1988, p.457).
[341] Marlow-Ferguson (2002, p.23).

The Netherlands

The educational system in the Netherlands was first regulated in 1801 when a minimum programme for elementary school and teacher qualifications was introduced.[342] Subsequent legislation meant to develop a mass education system that was characterized by an important freedom of education guaranteed by the constitutional legislation.[343] In fact, after the end of the Second World War, the three sub-systems of education: secular education (organized by the state), Catholic and Protestant education were maintained and the equal recognition of the public and private schools guaranteed in 1920 was preserved (Val D. Rust, 1988). The organization of the Dutch education system is regulated by a number of acts that shape the functioning of the system.

The most important legislations that regulate secondary education are: the *Secondary Education Act* of 1968 and the *Apprenticeship Training Act* of 1966 that shapes the general framework of the apprenticeship system. The former defines the structure of the pre-university system. It is mainly composed by the old grammar school, the *Gymnasium*, that offers classic education and the *Athenea,* which is more oriented towards business subjects. On the other hand, the *Lycea* is a combination of the other two types of education.[344] Vocational education and training expanded particularly after the Secondary Education Act was implemented in 1968.[345] In this legislative framework, the Dutch system of vocational education and training is "supply-led".[346] In this model the role of the state is key in the organization of vocational education and training. In this system traditionally there has been little provision of training at company level[347] and this is why Greinert (1994) defines this system as "school model". This type of education is financed by public funding; it is often very bureaucratic and inflexible. Also, it is centrally organized and it responds to the requirements set by the government as the type of training provided is not determined by the demand in the labour market.

[342] Val D. Rust (1988, p.911).
[343] The freedom of education is recognized by article 23 of the Dutch Constitution, Marlow-Ferguson (2002, p.948).
[344] Val D. Rust (1988, p.915).
[345] CEDEFOP (1994, p.43).
[346] Among the other European countries that share the same model: France, Italy and Sweden.
[347] However, sometimes the provision of training exists at company level but for a short time (Greinert, 1994, p.14).

On the other hand, vocational training is organized for many occupations in the fields of mechanics, metalworking, building, agriculture, retail trade, domestic science, teacher and art training. The apprenticeship system expanded greatly after the Second World War. This was when the reconstruction of industry created a greater demand for a skilled workforce.[348] Different programmes of vocational education have been created at different levels. The *junior secondary vocational education* (LBO), the *senior secondary vocational education* (MBO) and the *senior secondary personal, social services and health care education* (MDGO). These programmes were introduced in the late 1970s and the restructuring of some of these courses in order to adapt the content to the requirements of the economic activity was completed in the 1980s.[349]

In the 1980s, the Dutch government faced new pressures to modernize the education system, the high rate of unemployment, the economic slowdown and the consequent change of the economic structure. Since then, there has been a greater involvement of the industrial sector in the provision of training.[350] This was a result of the reports of the Wagner Commission (1984) and Rauwenhoff Commission (1990) that recommended strategies to make the sector more competitive. According to the CEDEFOP (1999), this report led to the implementation of two important changes. The first was the creation of a minimum level of qualification that should be awarded to those who only take the basic, level one, training. The other major change led to greater autonomy given to the vocational and training system and the greater number of "possibilities to form partnership with the business-sector.[351] This was required to make education closer to the needs of the labour market. This issue was addressed in the Rauwenhoff report by proposing plans to create a greater participation of the industry sector in vocational education.[352] As a result, the system has consolidated more and more heavily its dual organization. In fact, training of most of the existing programmes is provided by vocational institutions organized by the state and the companies as companies alone could not bear the cost.[353] Therefore, over time the cooperation with the other stakeholders has increased.

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[348] OECD (1994b, p.13).
[349] OECD (1994b, p.14).
[350] CEDEFOP (1994, p.46).
[351] CEDEFOP (1999, p.22).
[352] OECD (1994b, p.31).
[353] CEDEFOP Panorama (2004, p.19).

The vocational education and training system is organized at three levels:[354] at the national level, the Ministry of Education is responsible for the legislation and the introduction of new courses of study[355] but there is a greater participation of the private sector in the decision-making process related to the organization and the provision of training. At sectoral level, there are nineteen intermediary organisations called "national expertise centres for vocational training and the labour market" (*Kenniscentrum Beroepsonderwijs Bedriifsleven*).[356] They have been reorganized in the context of the Adult and Vocational Education Act of 1996. Each of these centres has a board consisting of representatives of employers, employees and education as highlighted in the CEDEFOP Panorama Report (2004, p.21). According to this report, this structure at sectoral level is quite unique but represents an essential link between the labour market and education. At regional level, forty-three training centres exist and provide training in the different fields. The increasing importance of ICT in economic activity and the need of endowing workers with ICT skills has been addressed in various ways. The "Investing in Progress" action plan has been recently adopted in secondary education.[357] It introduced the teaching of ICT in the core curriculum and in some of the vocational education sectors. In addition to this, an "innovation platform" was established in 2003.[358] In this framework the Prime Minister, members of the Ministry of Education as well as representative of the industry sector formulate guidelines related to the adjustments necessary to make the vocational education system more responsive to the requirements of the knowledge society. On the other hand, the legislation concerning the education system remains in the hands of the Ministry of Education. However, as suggested in the CEDEFOP Panorama Report (2004) "they are inter-dependent because they both have access to a part of the policy instruments".[359] That is, employer organisations that represent the interests of industry and unions provide advice to the government on issues related to vocational education and training.

The provision of higher education is regulated mainly by the *University Education Act* of 1961 under which thirteen universities are recognized.[360] This legislation

[354] CEDEFOP Panorama (2004, p.20).
[355] Val D. Rust (1988, p.919).
[356] CEDEFOP Panorama (2004, p.21).
[357] Marlow-Ferguson (2002, p.952).
[358] CEDEFOP Panorama (2004, p.15).
[359] CEDEFOP Panorama (2004, p.25).
[360] Four out of thirteen universities are private as reported by Val D. Rust (1988, p.912).

regulates the existence of three types of higher education: the *Higher Professional Education*, *University Education* and the *Open University.*[361] The first is related to tertiary but non university education that is higher vocational education. It provides training for the occupations in the sectors of social science, welfare, environment, economics and many others that require a specialization greater than the one provided by the secondary level of vocational education and training. It is known as the *Hoger Beroepsonderwijs*, (HBO). This system was introduced in 1968 with the Secondary Education Act as a separate form of higher education.[362] Initially it was regarded as a "considerably cheaper"[363] alternative to the university system. This is the reason why, according to the CEDEFOP Report (1994), attempts were made to create closer links between higher vocational and university education. However, after the mid-1980s, with the passage of the Higher Vocational Education Act in 1986, the HBO experienced a development independent from the university system. An important process of modernization has been going on in this sector. A greater autonomy was given to the HBO and a process of concentration has taken place since the mid-1980s. According to Goedegebuure et al. (1993), the initial 350 institutions have merged into 85, many of which have become multi-purpose. The distribution of decision-making power between government and the labour market in the HBO system has followed a development similar to the one of the VET at secondary level described earlier.

According to the OECD (1994b), the policy that has been followed by the Dutch government has been "quantitative" in terms of broadening participation and making the higher education system a "mass education" system whereas after the mid-1970s with the budgetary constraint and a rapid technological development that has created the demand for a different type of skills and in general for more educated workers, the focus of policy-makers has been more on the "qualitative" side. In this regard, university education has been partly reformed since the end of the 1980s. This is because policy-makers perceived the need of making higher education more practical and closer to the needs of the labour market. In this context, Dutch universities have acquired greater autonomy in the organization of the general programmes and in terms of funding. In fact, with the passage of the Higher Education and Research Act

[361] This is the institution where distance learning is taught.
[362] Goedegebuure et al. (1993, p.190).
[363] Goedegebuure et al. (1993, p.191).

of 1992, the regulatory capacities of the government have been greatly reduced.[364] That is, institutions have acquired greater autonomy for introducing new programmes. In fact, new degrees can be introduced based on the initiative of the institutions. Starting in 1993, if the Ministry of Education is not in favour of the new degree programme, it has to prove that "the new programme harms the efficient supply of programmes".[365] These provisions are important as by reducing the role of the government in the regulation of the degree programmes they are likely to increase the responsiveness of the education system to the requirements of the labour market and the overall flexibility of the system. However, as OECD report suggests, it is not yet possible, to see clear results. What can be observed is that the efficiency of the university system in the Netherlands has improved in terms of costs reduction and shorter time to graduation but it is too early to see whether there has been an effective response in terms of production of skills required by the labour market.[366] In the context of ICT, there have been some recent developments in higher education policy. Following the publication of the Advisory Committee of the European Commission (IRDAC, 1991) there has been recognition of the importance of creating a labour force endowed with the skills necessary to work in a more complex labour market. This is the reason why, expenditure on ICT has increased over time and a special policy bias towards certain types of education has led the government to introduce new degrees in some sectors of the higher education system and to fix *numerus clausus* in others (Goededebuure et al., 1993).

The Open University system is a recent development of the Dutch education system. It was established in 1984 with the Open University Act.[367] Since then, it has provided both technical and general higher education in the form of distance learning. However, the main forms of higher education remain the traditional ones that have been described earlier.

Therefore, the Dutch vocational education and training system has been characterized since the 1980s by an increased cooperation between the social partners and the state. The higher education system provides both vocational and general education programmes as in the other countries studied. What is different

[364] Goedegebuure et al. (1993, p.197).
[365] Goedegebuure et al. (1993, p.198).
[366] OECD (1994b, p.91).
[367] Goedegebuure et al. (1993, p.189).

with respect to the other countries examined is that the Dutch education system is a "quasi-market system of education".[368] That is, the system is more similar to the Anglo-Saxon model and is characterized by an important autonomy given to schools and training institutions. Many initiatives have been adopted in order to foster the adoption of ICT. Later in this chapter the analysis will focus on the institutional response in terms of introduction of the ICT-related degrees in order to compare the responsiveness of Dutch education system to the education system of the other countries.

Portugal

Portugal is a Southern European country that until recent time has been among the most backward and has lagged behind in terms of development of the education system and participation rates. According to the Portuguese Development Plan for Education (PRODEP, 1990)[369] in the mid-1980s, 75 percent of the labour force had only achieved the primary schooling level. The education system is regulated by the Law 5 of July 25, 1973, of the authoritarian regime, the second revolutionary constitution of 1982 and the *Lei De Bases do Sistema Educativo,* which is the Framework-Act for the Education System that was implemented in 1986[370] and introduced important changes in the education system.

Secondary education is composed of both general and vocational education. The development of vocational education is worth a brief historical overview. In spite of the fact that as early as in 1772, the state, introduced the legal foundations for the development of a public education system and created the vocational training system, reforms remained largely uncompleted.[371] The economic development of the country was very slow and also the development of the schooling system lagged behind other Western European countries as the historical overview of the Report of the Eurydice Database (2006) has suggested. After Salazar's coup d'état of 1926, the military regime that was established prevented the country from developing a secular

[368] Green et al. (1999).
[369] This is the education development framework for Portugal co-funded by the European Social Fund.
[370] Kurian (1988, p.1022).
[371] Kurian (1988, p.1023).

education system. In this regard, compulsory schooling was reduced from five to three years.[372] Vocational education was developed but under Salazar's regime the education system experienced a period of stagnation (Pereira and Martins, 2001). According to Lindert's (2004) explanation for the development of the mass schooling systems, authoritarian regimes do not have incentive to expand the schooling system as this could have undermined their authority and existence. That is, a greater share of educated workers could have become less supportive of the regime. Conversely, Lindert (2004) shows that the spread of democracy and the related extension of suffrage fostered the development of the mass schooling system in the western world. Moreover, it has been suggested before that the country was still very backward economically. In this context, demand for a more educated labour force was very low. This explains why still in the early 1970s some of the vocational education programmes dated back to the beginning of the upheaval of 1926.[373]

With the democratic revolution of 1974, vocational education was abolished. According to Pereira and Martins (2001) this was a consequence of the fact that the policy change was in favour of a greater equality of opportunities and the new democratic regime did not see a technical stream helping towards this aim. However, the vocational system was re-established with the 1983 reform[374] partly under pressure from the European Community that saw the development of a technical stream as a way to reduce the low schooling participation.[375] According to the report of the CEDEFOP (1992) it was not until Portugal joined the European Union that the VET could expand as a result of the financial assistance provided by the EU. Since then, vocational training has expanded and it has also been considered by the Portuguese government as an instrument to reduce unemployment and to increase workers' productivity[376] in a country where schooling levels have traditionally been very low.[377]

When vocational education was reintroduced, new apprenticeship programmes were launched involving a greater participation of the private sector.[378] According to

[372] EURYDICE Database (2006).
[373] EURYDICE Database (2006).
[374] Pereira and Martins (2001, p.215).
[375] Report of the Ministry of Science, Technology and Higher Education (2006, p.120).
[376] This role of the vocational education system has been suggested by Hartog, Pereira and Vieira (2000).
[377] CEDEFOP (1992, p.18).
[378] CEDEFOP Panorama (2001, p.18).

Leclercq (1994) the main tendency since the mid-1980s has been towards "institutionalised co-operation"[379] even if the system continues to be supply-led. That is, the organization of the provision of vocational education is conceived at state level although since the end of the 1980s there has been an increased participation of the private sector in the delivery of training. In this regard, the Decree-Law 401/1991, has regulated the provision of vocational education and training within the education system and the labour market.[380] The Ministry of Education is responsible for the vocational education provided in schools whereas the Ministry of Labour and Solidarity has become responsible for the provision of training at company level.[381] The vocational education and training system in Portugal is mainly centralized.[382] However, as outlined in the report of the CEDEFOP Panorama (2001), the administrative structure is organized at regional level and the Department for European Social Fund Affairs, which provides support for the projects funded by the European Social Fund, is organized at sectoral level. The legislative and decision making power is mainly shared between the Ministry of Education and the Ministry of Labour and Solidarity. However, there has been a progressive increase in the involvement of the social partners.[383] In this context, the *Basic Law on the Educational System* of 1986, established the National Council for Education. This is composed of representatives of the government, unions' and employers' confederations who provide advice and opinions on the design and implementation of policy changes concerning the VET system.[384] Other advisory boards like the "Standing Committee for Social Concertation" as well as the "Economic and Social Council" were created by later legislation with a similar purpose.[385]

The Portuguese educational system is open. That is, having completed the basic primary education track, students can choose whether to enrol in general or vocational education at secondary level.[386] These courses are work-oriented and provide students with qualifications for specific jobs. The training in formal education is complemented by apprenticeship training that did not exist before the

[379] Leclercq (1994, p.50).
[380] CEDEFOP (1992, pp.48-9).
[381] CEDEFOP Panorama (2001, p.19).
[382] CEDEFOP Panorama (2001, p.20).
[383] CEDEFOP (1992, p.62).
[384] CEDEFOP (1992, p.62).
[385] According to the CEDEFOP (1992), the Standing Committee for Social Concertation was created by Decree Law No 74 of 2 March 1984 and the Economic and Social Council was regulated by the Law No 108 of 17 August 1991 and Decree Law No 90 of 21 May 1992.
[386] Kurian (1988, p.1022).

"consolidation phase"[387] of the 1980s. Concerning the reforms, Portuguese policy-makers have undertaken many measures in order to "enhance the quantity and quality of both the education and training provision".[388] Concerning vocational education, the number of courses offered has increased. Also, new schools "escolas profissionais" that offer both vocational education and training have greatly expanded.[389] At the end of the three year polytechnic courses, students are awarded with the bachelor degree (*bachelarato*) whereas the completion of an university degree programme provides students with the licentiate (*licentiatura*).[390] According to the Report of the Ministry of Science, Technology and Higher Education (2006), the expansion of the VET is a result of the "expectations or demands of the European Union".[391] This is because according to the policy guidelines of the EU, the implementation of an effective vocational education and training system would foster the modernization of the Portuguese educational system. In addition to this, the European Union has provided funds for this system since 1986 when Portugal joined the European Union. In fact, the European Social Fund represents the main financial support of this vocational and training system.[392]

Higher education includes both universities and polytechnics and it is provided by private and public institutions.[393] The university system has a theoretical orientation whereas the polytechnics provide more practical training, strongly profession-oriented. Before the 1974 revolution, the higher education system in Portugal was very elitist and closed to the masses.[394] According to the CEDEFOP Report (1992, p.18), in 1988 70.4 percent of employees only had primary education whereas in 1991 it decreased to 68.1 percent. With the establishment of the democratic regime and the subsequent entry in the EU things changed dramatically. Participation has increased at all levels of education. According to Meijer (1991), in 1984 the total number of apprentices was 750 whereas in 1989 they were 9,000. Also participation in higher education has increased in the recent past, especially since 1986 when Portugal joined the EU. In fact, polytechnics were established in the 1980s with the

[387] This is how Pereira and Martins (2001, p.214) define the period between 1983 and 1995 because the reforms undertaken during this phase are the ones that shape the current structure of the education and training systems.
[388] Meijer (1991, p.19).
[389] Meijer (1991, p.19).
[390] EURYDICE Database (2006).
[391] Report of the Ministry of Science, Technology and Higher Education (2006, p.120).
[392] Report of the Ministry of Science, Technology and Higher Education (2006, p.120).
[393] Kurian (1988, p.1025).
[394] Kurian (1988, p.1022).

aim of increasing participation in higher education and avoiding the high rates of abandon among young students. However, according to Steedman (2005), the introduction of the possibility for students who undertake technical studies at secondary level to continue in higher education has not been very successful in the sense that these students are not willing to continue more academic oriented courses once they have completed secondary school. On the other hand, in France, this option has increased students' participation at higher levels of education.[395] According to Hartog, Pereira and Vieira (2001), returns to education have increased since 1986 especially as a result of the modernization process that the membership in the European Union has generated and the liberalization of trade that has created the opportunity for the country to adopt more skill-biased technologies. Among the main reforms in higher education, on the top of the agenda of Portuguese authorities there has been the expansion of participation rates. The pattern of enrolments has been shaped through the reduction of fees.[396]

Among the recent policy changes, it is important to acknowledge the recent introduction of the "Technological Specialisation Programmes".[397] Among these courses: computer applications to management, network management as well as information systems technologies and programming. These courses were introduced in 2005 to endow students with ICT-related technical skills. On the other hand, according to Gordon and Parkes (1995), the government has found it quite difficult to develop a coherent and long-term ICT policy as there were different interests addressed by the social partners. First among the priorities set by the policy-makers has been the implementation of the EU policies. In particular, Portugal has adhered to the very recent Bologna Process.[398] This is the EU plan that promotes the harmonization of the higher education systems by imposing a standardization of the higher education programmes by imposing the first training stage to last three years and the second stage two years.

Portugal is one of the most backward Western European countries and is also the country among those studied that has experienced the most radical political and

[395] Steedman (2005, p.7).
[396] Oliveira and Pereira (1999, p.116).
[397] Report of the Ministry of Science, Technology and Higher Education (2006, p.120).
[398] This Plan was presented publicly in December 2004 and will become effective between 2005 and 2010. (EURYDICE Database, 2006).

socio-economic changes over the last thirty years. In 1974 the end of the Salazar's regime led to the restoration of the democratic state and to major changes in the education and training systems. Furthermore, training was re-established in the mid-1980s under the pressure of the European Union. These factors make Portugal an interesting case to compare to the other European countries in order to see what system has been the most effective in creating ICT-related programmes of study. The introduction of these new programmes will be compared to the evolution of ICT adoption which is the topic of the next section.

4.3) Rates of return to ICT qualifications

It is important to draw attention to the labour market rewards to ICT. However, there is little empirical evidence in this area. There is no study that compares returns to ICT qualifications across European countries. This is because most existing studies do not compare returns to education across different disciplines (Sloane and O'Leary, 2004, p.2).[399] The empirical evidence I could find for an ICT-related degree, computer science, is limited to the United Kingdom. By estimating a standard OLS human capital model and using data extracted from the Labour Force Survey over 1994-2002, Sloane and O'Leary (2004, p.12) find that for men the discipline with the largest markup over Arts[400] is Maths and Computing (31.7 percent). For women the markup related to Maths and Computing is equal to 19.26 and comes after Medicine and related for which the markup equals 21.14 percent. These results are robust to the introduction of an index of student quality.[401] Blackbay et al. (1999) find that males whose highest qualification is a degree in computer science can expect their weekly earnings to be 31.8 percent greater than those of workers with no qualifications. (The sample is too small to draw definitive conclusions for females). In chapter five returns to education will be estimated for seven European countries over 1985-2000 but with no specific reference to the field of study. The Netherlands and Portugal will be included in the study whereas Germany will be excluded as the gradual

[399] For instance, the study by Walker and Zhu (2005) consider field of study but in broader categories.
[400] Arts degrees are chosen as they exhibit the lowest returns: 2.07 for men and 25.91 for women (Sloane and O'Leary, 2004, p.12).
[401] See Sloane and O'Leary (2004, p.6-7) for an explanation on how it has bee constructed.

implementation of the school-leaving age laws across the German *Lander* would make the analysis more complex.

4.4) Pattern of ICT adoption

For an overview of the general features of ICT, the impact of these technologies on the economic performance of the European countries and the United States as well as for a synopsis of the factors that facilitate their adoption please refer to chapter two, section 2.3.2. In the following paragraphs the timing of the adoption of ICT at aggregate level and its decomposition according to the type of ICT will be presented for the three countries under study.

Various indicators have been used in the existing literature in order to measure the rate of ICT adoption. The majority of the existing indexes are derived from the "International Data Corporation" (IDC).[402] This is a database that provides estimates on the expenditure on information technology goods that are considered as a proxy for investment. These series have been partly corrected for few European countries by Colecchia and Schreyer (2001). The best indicators of the ICT adoption that are currently available appear to be the indexes developed by Timmer et al. (2003).[403] These indexes are very accurate as the authors have complemented the official statistics by using their own estimates referring to the investment rates in ICT. They also have the advantage of being disaggregated according to the different levels and sectors. The aggregate investment rate in ICT as a share of GDP has been presented in an earlier chapter in table 2.7 and has been reported in table 4.1 for Germany, the Netherlands and Portugal.

[402] The IDC is a subsidiary of the International Data Group (IDG). It was founded in 1964 by Patrick McGovern. It is considered as one of the world leading providers of market intelligence, advisory services and services related to the ICT for companies in eighty-five countries around the world (www.idc.com/about/about.jsp).

[403] The first version of these indexes has been developed by van Ark et al. (2002, revised 2003).

Table 4.1. Investment in ICT as a share of GDP, 1980-2004 (current prices)

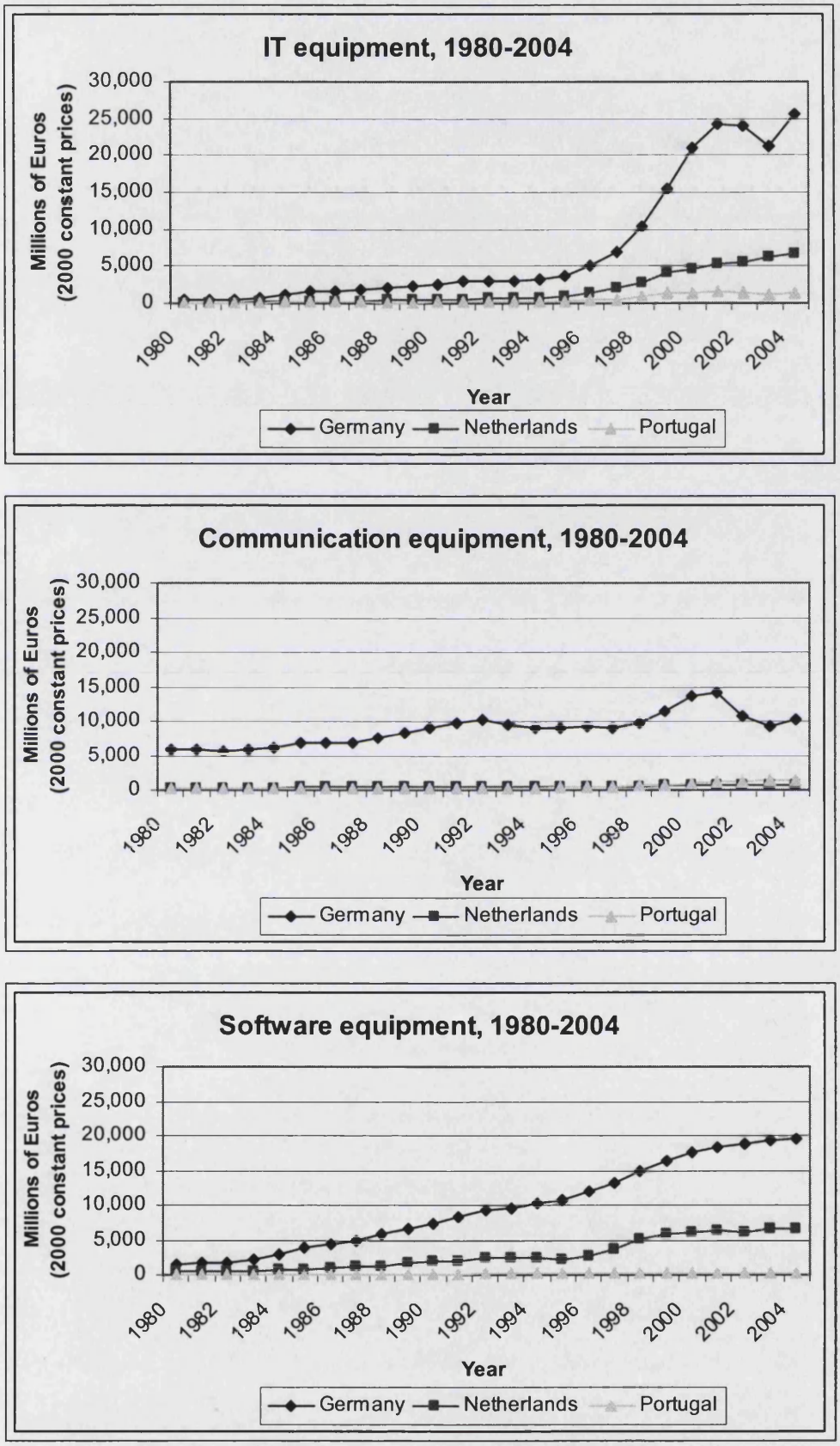
	1980	1990	2001	2004
Germany	1.3	2.4	2.5	1.9
Netherlands	1.6	2.4	2.9	2.4
Portugal	1.2	1.8	2.1	1.9

Source: Timmer et al. (2003), table 3 and appendix tables updated June 2005

It is possible to observe that Portugal exhibits the lowest levels of public spending in ICT whereas the Netherlands have invested in ICT the greatest share of GDP over the period 1980-2004. Timmer et al. (2003) have decomposed the overall investment according to different ICT assets. Here, three indicators will be used for the analysis:[404] investment in *IT equipment* which refers to office, accounting and computer equipment; investment in *communication equipment* that includes radio, TV and products related to telecommunication such as: telecommunication equipment, international telephone circuits, telephone lines; *software equipment* comprises the entire third category, including pre-packaged, own account and customized software. The evolution of these indicators in absolute value and as a share of GDP for Germany, the Netherlands and Portugal over the period 1980-2004 is presented in the next pages.

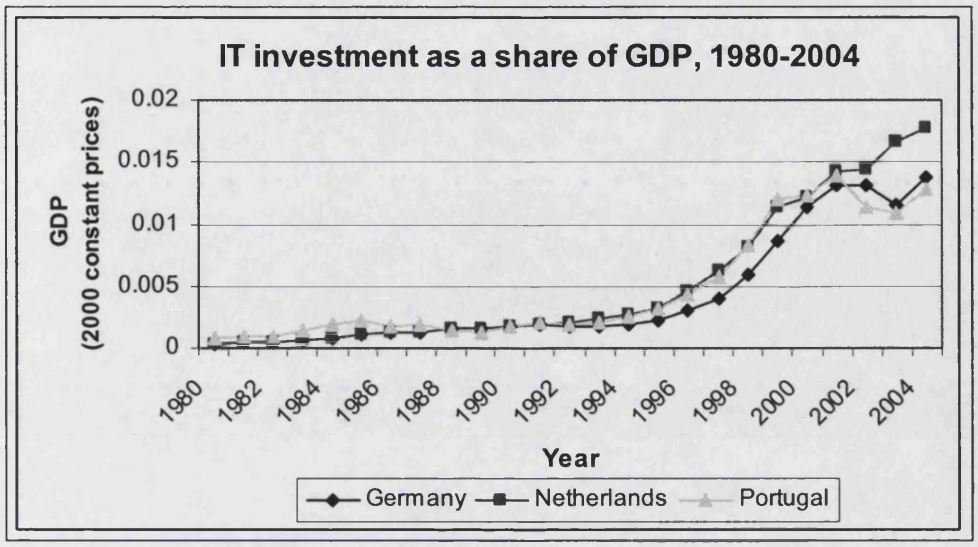
[404] For a detailed description of these indexes see Timmer et al. (2003, p.4).

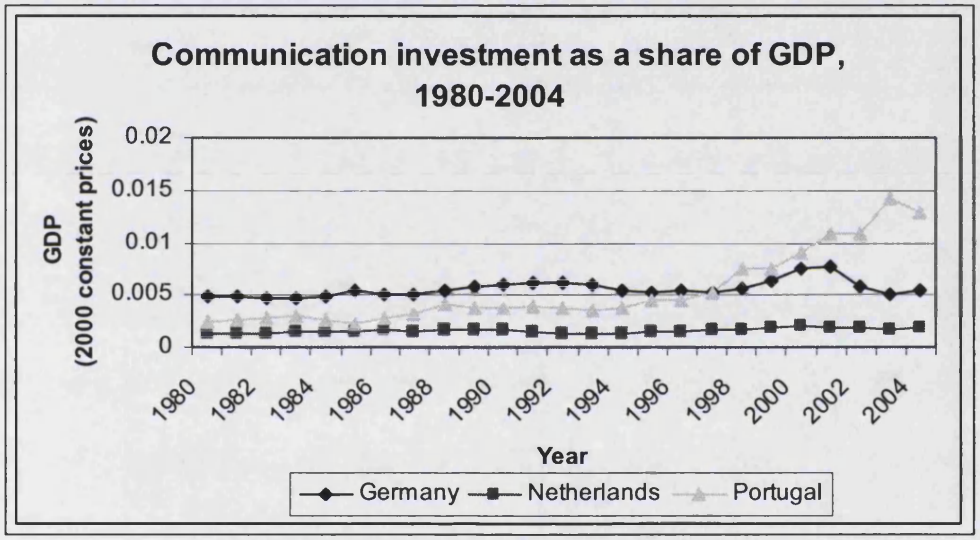
Figure 4.1 Evolution of IT, communication and software equipment, 1980-2004

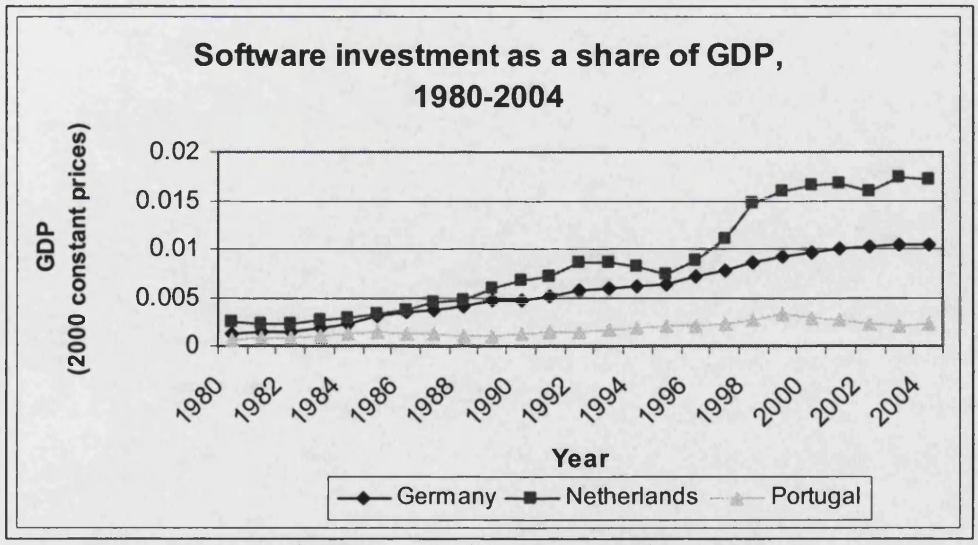


Source: Timmer et al. (2003), appendix tables updated June 2005

Figure 4.2 Evolution of IT, communication and software equipment as a share of GDP, 1980-2004







Source: Timmer et al. (2003), appendix tables updated June 2005

From the graphs it is possible to observe that as a general guideline, Germany exhibits the greater rate of ICT adoption in absolute value as shown in figure 4.1. However, by looking at the investment as a share of GDP, the overall picture looks quite different. The level of investment in IT equipment has been close for the three countries over the period 1980-86 and again starting from 1992 whereas over 2001-03 in Germany and Portugal the investment in IT has decreased more than in the Netherlands and after it has started growing again.

Germany has invested a greater share of GDP in the communication sector with respect to the other countries until 1998 when Portugal overtook it. In fact, the Portuguese investment in telecommunications, radio, TV and other communication devices has grown considerably since 1998. The Netherlands exhibit lower levels of investment and a quite steady growth.

The overall investment in software has been growing for the three countries over the period 1980-2004. The Netherlands have outperformed in this sector. In fact, the increase in the level of investment has been particularly important since 1996 and after 1998 growth has been still sustained but less rapid. In Germany the level of investment has increased quite steadily but at a slower pace with respect to the Dutch experience. On the other hand, Portugal is lagging behind the two countries and until recently has exhibited the lowest levels of adoption of the whole category of software among the countries of the European Union. As Tejada (2003) suggested "Portugal's high-technology sector remains small relative to the size of its economy".[405]

However, it is also important to notice that in spite of the lower Portuguese investment rates, this country is catching up and investment in communication has grown more substantially than in the other two countries since 1980. According to international observers like CEDEFOP (1992) and OECD (2005), particularly beneficial to the country has been the entry into the European Common Market in 1986 and the end of the Salazar's fascist regime. On the other hand, over the whole period, the country has lagged behind in the expenditure related to the information technology equipment and software. The evolution of the average growth rates for the three indicators over the period 1980-2004 is reported in table 4.2.

[405] Tejada (2003, p.9).

Table 4.2. Average growth rates of the IT, communication and software investments (percentage), 1980-2004

		Germany	Netherlands	Portugal
IT	1980-1990	17.4	18.7	11.0
	1990-1995	7.7	13.3	14.3
	1995-2000	34.1	30.5	31.0
	2000-2004	5.1	10.0	1.4
Communication	1980-1990	4.3	4.2	7.7
	1990-1995	-0.3	0.2	4.9
	1995-2000	8.5	10.3	17.7
	2000-2004	-7.2	-1.8	10.0
Software	1980-1990	16.2	12.7	9.8
	1990-1995	8.0	3.7	13.0
	1995-2000	9.7	19.7	10.9
	2000-2004	2.6	1.7	-6.5

Source: Timmer et al. (2003), appendix tables updated June 2005

Inklaar et al. (2003) have examined what are the industries that make the greatest contribution in terms of ICT adoption. They have compared the experience of four European countries with respect to the United States. They have found that in Europe[406] the greatest contribution to ICT capital deepening over the period 1979-2000 has come from the ICT-using industries. Included in this category are industries like machinery, wholesale trade, finance, financial intermediation, business services as well as paper, printing and publishing. The contribution of each industry has been calculated as the ICT capital deepening weighted by the share of the industry's ICT

[406] The four European countries included in the study are: France, Germany, the Netherlands and the United Kingdom. There is no analysis related to Portugal.

capital compensation in aggregate ICT capital compensation.[407] The contribution of the European ICT-using industries has accelerated between 1995 and the year 2000.

As suggested by Pohjola (2003), there is another set of data that are complementary to the ones related to the investment in ICT. These are related to the diffusion and the use of the information and communication technology across countries. I have received some of these indicators from Dr Magpantay of the International Communication Union (ITU). This dataset provides data for many countries and has the advantage of providing a long time series for the indicators related to the telecommunications. The indicators related to the personal computers per 1,000 inhabitants, the internet users as well as the telephone mainlines and mobile phones for 1,000 inhabitants are shown in table 4.3.

Table 4.3. ICT indicators for Germany, the Netherlands and Portugal, 1980-2004

		1980	1985	1990	1995	2000	2004
Personal Computer per 1,000 inhabitants	**G**	...	...	81.9	178.8	336.3	537.9
	NL	...	...	93.6	200.5	396.4	687.9
	P	...	...	26.2	55.2	104.5	138.8
Internet users per 1,000 inhabitants	**G**	...	...	1.3	18.4	301.7	427.2
	NL	...	...	3.3	64.7	440.5	619.2
	P	...	...	0.0	15.0	167.2	292.1
Telephone mainlines per 1,000 inhabitants	**G**	260.9	326.8	401.7	514.4	611.0	662.3
	NL	345.9	401.8	464.2	525.5	622.3	646.7
	P	101.2	141.5	239.8	365.4	420.6	422.5
Mobile phones per 1,000 inhabitants	**G**	0.0	0.02	3.8	45.5	586.0	864.2
	NL	0.0	0.3	5.3	34.8	672.7	912.1
	P	0.0	0.0	0.7	34.4	665.0	984.1

Note: ... data not available
Source: ITU World Telecommunications Database (2005)

From the table it is possible to observe how rapid has been the ICT diffusion across countries especially between 1995 and 2000. The use of telecommunications has greatly increased over this period whereas internet use is a recent development and in ten years has shown a great expansion. In fact, the indicator of internet users per 1,000 inhabitants has grown from 3.3 to 440.5 in the Netherlands between 1990 and 2000 and from 1.3 to 301.7 and from 0 to 167.2 in Germany and Portugal

[407] See Inklaar et al. (2003, p.16) for a further clarification.

respectively. This is related to the dramatic spread of computers over 1990-1995. Moreover, it is important to notice the extraordinary diffusion of mobile phones that has occurred in the three countries between 1990 and 2004. In 1990 the number of mobile phones per 1,000 inhabitants was 3.77 in Germany and 5.28 in the Netherlands whereas in 2004 the indicator for these countries was 864.2 and 912.1. On the other hand, Portugal is the country that has shown the most substantial increase in the number of suscribers: 0.7 in 1990 and 984.1 in 2004. Existing studies have acknowledged the importance of the introduction of competition in the telecommunication sector (Gruber and Verboven, 2001) and related lower tariffs offered to suscribers (Hodge, 2005) but no definitive conclusion has been reached with respect to the role of GDP per capita on the rate of subscription (Carvalho, 2006).[408] According to Carvalho (2006), the main determinant of the diffusion of mobile phones in Europe was the introduction of pre-paid cards. This is because the service became available to an important share of low-income people who otherwise could not have afforded the cost of the traditional mobile phone contracts. In the case of Portugal the diffusion of this service was faster and more important than in other European countries because the TMN, which used to be one of the two Portuguese communication operators, starting in 1995 introduced very competitive tariffs with "an innovative and competitive recharging system over the ATM operator".[409] Also, given the low expansion of telephone mainlines between 2000 and 2004 as shown in table 4.3 and the fact that Portugal remains one of the poorest countries in Western Europe as shown in table 2.1, it may be the case that new low-income suscribers have found more advantageous to buy a mobile phone contract rather than a mainline contract. In this regard, Waverman et al. (2005) have found that mobile phones in developing countries are playing the same role that mainline played in more advanced economies in the 1970s and 1980s mainly because they substitute for mainline telephony.[410]

Finally, a measure related to the potential that the three countries examined in this work have to exploit the ICT technologies is provided by means of the "New Economy Indicator" developed by van Ark and Piatkowski (2004) and derived from

[408] It is possible to notice that not only in advanced countries mobile telephony has been introduced but also in very poor countries the diffusion of mobile phones has been important. For instance, in Sub-Saharian Africa only 10 percent of the population had network coverage in 1999 whereas in 2007 more than 60 percent of the population does (The Economist, 2007, January 25th).
[409] Carvalho (2006, p.21).
[410] Waverman et al. (2005, p.1).

Piatkowski's (2002) previous study. The index is constructed by taking into account factors like spending on R&D, quality of human capital, trade openness, infrastructure, quality of regulations and contract enforcement, development of financial markets, labour and product market flexibility and macroeconomic stability. The variables chosen exhibit only positive or negative values. They are standardized and in case of negative correlation they are multiplied by -1 in order to keep the rule that the greater the value of the variable, the greater is its contribution in creating favourable conditions for the adoption of ICT.[411] The indicator is constructed by taking a weighted sum of the variables for each country and by giving double weight to the first five variables mentioned above as they are considered to be more important.[412] This indicator has been estimated for fifteen Western European countries and ten countries of Central and Eastern Europe. The former exhibit a greater "New Economy Indicator" than the latter. In the context of this chapter, the Netherlands perform better with respect to the other countries studied. They are rank 2, whereas Germany is 10, Portugal is 11 (the United States is 7).[413] The table 4.4 shows the value of this index and some of its components over the period 1995-2001.

Table 4.4. The New Economy Indicator for Germany, the Netherlands and Portugal, average 1995-2001

Country	Value 1995-2001	Human Capital	R&D spending	Infrastructure	Trade openness	Labour market flexibility	Product market flexibility
Germany	3.105	-0.416	0.928	0.526	-0.708	0.120	0.641
Netherlands	8.001	-0.195	0.513	0.765	0.975	1.099	0.641
Portugal	2.076	0.422	-0.860	-0.187	-0.347	0.902	0.342

Note: Human capital: public spending on education as percentage of GDP
R&D spending: R&D spending as percentage of GDP
Infrastructure: sum of total number of telephone lines and personal computers per 1,000 persons
Trade openness: share of trade in GDP (percentage)
Labour market flexibility: unemployment rate (percentage)
Product market flexibility: product market regulation indicator (Nicoletti et al., 2000)
Source: van Ark and Piatkwoski (2004)

[411] See van Ark and Piatkowski (2004) for a more detailed explanation of how the index has been constructed.
[412] Piatkowski (2002, p.9).
[413] van Ark and Piatokwski (2004, p.38). The indicator has been constructed for 21 European countries and the United States.

By looking at the decomposition of the index, it is very surprising to see that Portugal has a greater value of "human capital quality", as defined by van Ark and Piatkowski (2004), than the other two countries. However, if one looks at how this variable has been constructed, it is possible to understand why. From table 2.C in the appendix it is possible to observe that the ranking of the indicator reflects the level of public expenditure on education as a share of GDP over 1995-2000. As suggested in an earlier section,[414] this indicator does not seem to be accurate as there are countries that have increased the level of expenditure on education without achieving improvements in terms of quality.[415] The Netherlands exhibit the greater value related to the infrastructure, trade openness and labour market flexibility whereas Germany has the better indicator concerning spending on R&D and the same value for product market flexibility. On the other hand, Portugal is lagging behind with respect to these indicators. An indicator that is quite surprising is trade openness. There is no doubt concerning the level of openness of the Dutch small economy. However, it is rather unexpected that Germany exhibits a lower value than Portugal. There is no clear explanation for this in the literature. In the following paragraph, I present a brief summary of the stylized facts that show some features of the ICT adoption to which I will come back later and that motivate the analysis of the next sections.

The three European countries examined in this chapter have followed a different pattern of ICT adoption. When the absolute value of the investment in ICT is considered, differences look great over the period 1980-2004. However, when investment in ICT and its decomposition in IT, communication and software is considered with respect to the level of economic development of these countries, that is as a share of GDP, the pattern looks more similar. Following the ICT indicators developed by Timmer et al. (2003), it is possible to observe that in the three countries the growth rate of ICT adoption in IT and communication has been greater over 1995-2000 with respect to the overall period 1980-2004. On the other hand, the growth rate in software has followed a different evolution. In fact, it has been faster in Germany at an earlier date, 1980-90, whereas in Portugal and the Netherlands over the period 1990-95 and 1995-2000 respectively. Within each country the sector that

[414] Please refer to section 2.4.1.D for a discussion on the quality of schooling.
[415] The choice of this variable may be justified by the fact that the authors have included countries from Central and Eastern Europe for which data availability is probably more limited.

has experienced the greatest growth rate is the IT sector between 1995 and 2000. When the average growth rates of ICT and its components are compared across countries over the period 1980-2004, it is possible to observe that the greatest average growth rate in the IT sector has been experienced by Germany, in the area of software by the Netherlands and in the communication sector by Portugal. In Portugal this is a result of the reforms that were introduced between 1985 and 1995 under the influence of the EU policy to liberalize the sector; a merger took place between the three main operators and Portugal Telecom was partly privatized (Sousa, 1996). The overall picture depicted above seems to suggest that the ICT adoption of the three countries examined is related to their own pattern of economic development. This aspect will be further investigated later when it will be related to the pattern of introduction of the ICT-related degrees in general and vocational education. The stylized facts described have been summarized in table 4.5.

Table 4.5. Stylized facts related to ICT adoption in Germany, the Netherlands and Portugal, 1980-2004

		Germany	**Netherlands**	**Portugal**
Period during which the sector has experienced the greatest growth rate within the country	IT	1995-2000	1995-2000	1995-2000
	Communication	1995-2000	1995-2000	1995-2000
	Software	1980-1990	1995-2000	1990-1995
Sector and period that experienced the greatest growth rates within each country		IT 1995-2000	IT 1995-2000	IT 1995-2000
Country that has experienced the greatest growth rate according to the different ICT sectors over the period 1980-2004	IT	X		
	Communication			X
	Software		X	

Source: table derived from Timmer et al. (2003)

The analysis in the remaining of the paper will try to develop an understanding of what countries have done to create the environment favourable for the adoption of ICT in vocational education and training as well as in higher education. That is, what type of ICT-related degrees governments have introduced in the countries under study.

4.5) ICT skills shortages

According to the European Competitiveness Report (2001) of the European Commission, the demand for workers with skills in information and communication technology has increased rapidly in both the ICT sector itself and in the overall economy over the last twenty years.[416] In this regard, skills shortages in ICT have been identified by many international policy-oriented organizations (IDC (2000), EITO (2001), European Commission (2001) and WIFO (2001)). This excess demand for workers with ICT skills is largely due to "the length of time required to educate and train skilled workers"[417] (Forth and Mason, 2006).

However, it is important to acknowledge how difficult it is to provide a measure for the shortage of the ICT-related skills. As has exhaustively been explained by Leo (2001), there are three main difficulties associated with the estimation of the ICT skill gaps. First, it is difficult to measure the actual demand for ICT skills. This is because the estimate of the skills shortage is highly dependent on the choice of the variable. Different indicators like job vacancies and number of people with specific qualifications required can be used for the estimation and would lead to different results. Also, the size of the gap depends on the sectors of the economy examined. In addition to this, there are difficulties in comparing the supply of ICT-related skills. This is due to the fact that educational systems greatly differ across countries and it is very difficult to collect information related to the ICT-related degrees and programmes of training. Moreover, due to this great heterogeneity characterizing the education and training systems it is difficult to create common categories that would

[416] European Commission (2001, Annex III.1, p.50).
[417] Forth and Mason (2006, p.3).

allow for consistent comparisons across countries. In this regard, returns to ICT qualifications would be a good indicator of shortage of ICT-related skills. As previously suggested, Sloane and O'Leary (2004) found that by comparing various disciplines, the largest earnings premium was associated with Maths and Computing for men between 1994 and 2002. Similar results have been reported also by Blackbay et al. (1999). Thus, the important reward of this qualification provides evidence in support of the shortage of this type of skills.

In spite of these shortcomings, in the existing literature it is possible to find studies that have been undertaken both at national and international level to estimate the ICT skill-gaps. The majority of these studies cover a recent and short period of time. Country-specific studies related to the ICT skills shortages have been carried out in the countries of interest. However, it is important to notice that different methodologies make it difficult to derive a consistent cross-country comparison. In table 4.6, a summary of the stylized facts of the existing studies undertaken at national level for Germany, the Netherlands and Portugal is presented.

Table 4.6. Country level studies of the ICT skills shortages in Germany, the Netherlands and Portugal

Country	Source	Period	Demand	Shortage	Sector
Germany	IDC (2000) EITO (2001) D21 (2001) BMW1 (1999) ZEW	2003 2003 2001 1999-2002 2000-2002	 350,000 340,000	404,951 353,900 150,000	Total economy
Netherlands	IDC (2000) FENIT (2000) Dutch Ministry of Economic Affairs and Ministry of Education	2003 end of 2000 2002-2003	 14,500	118,882 24,000	Total economy Telecom sector Total economy
Portugal	IDC (2000)	2003		21,913	Total economy

Source: European Commission (2001)

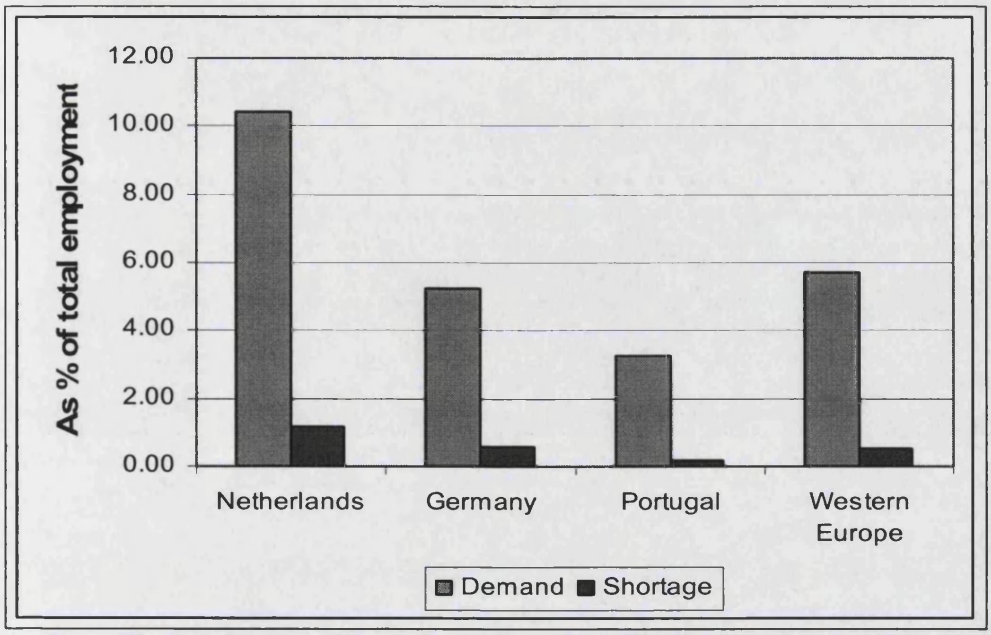
At international level there are two studies that represent the state-of the art literature.[418] These are the analyses of the International Data Corporation (IDC, 2000) and the European Information Technology Observatory (EITO, 2001). Different methodologies have been used for the construction of these datasets and have been acknowledged in Leo (2001). I have received part of the data of the IDC (2000) that have been used for the competitiveness report of the European Commission (2001) from Dr Guttman of the Austrian Institute of Economic Research (WIFO) and I will present these estimates in the remaining of this section.

In order to determine the "demand for ICT skills" the methodology adopted has been the following: more than 12,000 information system managers as well as representative of recruitment agencies were interviewed.[419] That is, information was collected to determine the size of the labour force with ICT skills in the different sectors of the economy across the three countries. On the other hand, in order to determine the size of the shortage, the "supply of ICT skills" was determined by drawing on many sources. Data and information related to the graduation rates and fields of study were collected from national sources. In addition to this, information related to the requirements for the training of experienced workers for jobs in the ICT sector or that require the skills to work with the information and communication technology were collected.[420]

In graph 4.3 the demand and the estimated skills shortage is presented for Germany, the Netherlands, Portugal and the average of Western Europe.

[418] These studies have been considered to be the best available from a number of scholars: Leo (2001), Forth and Mason (2006) and the European Commission (2001).
[419] IDC (2000), Leo (2001) and technical note of WIFO (2006).
[420] IDC (2000), Leo (2001) and technical note of WIFO (2006).

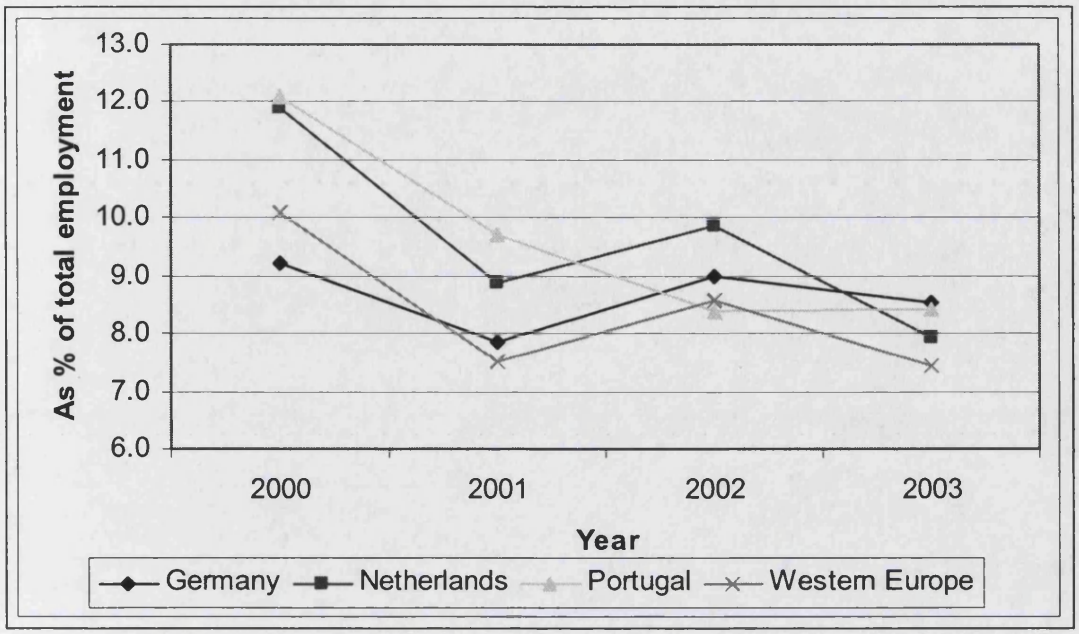
Figure 4.3 ICT Skills shortages as a percentage of total employment, Germany, the Netherlands and Portugal, 1999



Note: Western Europe refers to the average of 17 Western European countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom
Source: WIFO (2006) derived from IDC (2000)

It is possible to observe that the shortage is highly correlated to the demand of ICT skills. In this regard, the Netherlands have the greater demand for ICT skills, 10.43 percent of the total employment and the shortage reaches 1.17 percent, whereas Portugal has the lowest indicators, with 3.28 percent and 0.16 percent respectively. On the other hand, Germany is slightly below the European average. The growth in the demand for ICT skills has been particularly important in recent years but the average growth rate of demand has varied across countries as it can be observed from figure 4.4.

Figure 4.4 Average growth rates for the demand of ICT skills, Germany, the Netherlands and Portugal, 2000-2003



Source: WIFO (2006) derived from IDC (2000)

From the graph it is possible to observe that after 2002 the average demand for ICT skills measured as percentage of the total employment has been steady or has decreased in the case of the Netherlands. However, it is difficult to make forecasts for the evolution of the growth rate of the demand for ICT skills[421] as the use of the information and communication technology is expanding across the different sectors of the economy and at the same time institutions and social partners are addressing the shortage of skills through different policies. Policy changes in the education and training sector will be examined in the remaining of the paper.

In light of the increased demand for skilled labour related to the introduction of the information and communication technology in the economic activity, different strategies have been undertaken by governments to close the skill gaps. Among the highly regarded strategies outlined in the international reports,[422] key have been the outsourcing of high-tech production, the immigration of skilled workers as well as the investment and changes in education and training policies.

[421] See Leo (2001, p.6) for an insightful explanation.
[422] Among these reports, central appear to be European Commission (2001), de Ferranti et al. (2003) of the World Bank and Leo (2001) for WIFO.

In the framework of the analysis of this chapter the latter aspect appears to be central. This is because the interest of the analysis relies on the understanding of what have been the policy changes undertaken in the three countries under study in order to endow workers with the skills necessary to meet the requirements of the information and communication technology. Moreover, it is also interesting to examine this type of structural adjustment because it is likely to have long-term consequences on the competitiveness of these countries. In fact, human capital investment appears to be a key factor in determining the success of countries in the "knowledge-based society".[423] Therefore, the focus of the next section will be on the analysis of the changes in education and training policy by looking at the ICT-related degrees that have been introduced at different levels of education in Germany, the Netherlands and Portugal over the period 1980-2002.

4.6) Introduction of ICT-related degrees

In this section the response of the European education systems to the technological change will be examined by looking at what ICT-related qualifications have been introduced in vocational education and training and higher education in the three countries under study between 1980 and 2002. The analysis is based on the ICT-related programmes that were either "launched" or "updated".[424] In order to do this I will start by describing the dataset, after I will look at the timing of the introduction of these degrees and the level of education at which they have been introduced. Then, I will use an analytical tool in order to compare the timing of introduction of these degrees with respect to the pattern of ICT adoption. With the aim of providing a detailed analysis, I will divide the degrees according to the type of ICT technology that is relevant to the curriculum. That is, information technology, communication and software. So that, the pattern of ICT adoption and the institutional response in

[423] The Economist (2006, October 12th).

[424] This has been suggested by Professor Petersen, project leader of European Qualification Strategies in Information and Communications Technology in an email correspondence we had early this year. It is not possible to know in what proportion the programmes were updated and in what proportion they were completely new. According to Professor Petersen, in the 1990s, most of VET IT qualifications are new and most of VET communication qualifications are updated.

the education and training sectors will be considered at aggregate level and decomposed according to the different levels and areas of study.

The data I will use in this section come from two main sources. Data and information concerning the ICT-related degrees have been extracted from the European Qualification Strategies in Information and Communications Technology (EUQuaSIT) dataset. This is a dataset that has been compiled in the framework of the Leonardo da Vinci II programme funded by the European Commission. The purpose of this project was to investigate the supply of ICT-related skills in some European countries and to forecast the future requirements of the labour market. In order to do this, the research committee of the EUQuaSIT first analyzed the qualifications and the different programmes related to ICT in different European countries. The second part of the report investigates the labour market side. That is, the focus of the analysis is on the ICT business work, work processes and the implementation of vocational training strategies in the field of information and communication technology.[425] With the purpose of examining different sectors across the economy as well as specific case studies, interviews with ICT practitioners, representatives of training institutions as well as VET experts in different companies were undertaken. Finally, some recommendations with respect to the future homogenization of the qualifications across countries were drawn. The countries examined in the context of this project are Czech Republic, Germany, the Netherlands, Portugal and Romania. I complemented the data of this project by collecting the information related to the timing of introduction and the curriculum of the programmes that was missing from the Ministries of Education of Germany, the Netherlands and Portugal.

Before starting the analysis I would like to draw the attention on some aspects related to the construction of the dataset. This is because this will help understanding the setup of the remaining of the analysis. Data and information related to the ICT degrees and programmes of study have been collected from countries very different from each other with respect to the educational and training system. In order to make the information comparable across countries a common structure was imposed. However, as it is acknowledged in the final report of the EUQuaSIT project, this was "not easy to agree on due to the different existing VET systems in Europe".[426]

[425] EUQuaSIT (2004, p.5).
[426] EUQuaSIT (2004, p.11).

Therefore, some assumptions were made in order to adopt a common methodology. In fact, a distinction was made with respect to the continuing vocational education and training that provides a kind of retraining for experienced workers and programmes related to vocational education and training that refer to the initial level of qualification of an individual who enters into the labour market. The focus of the analysis in what follows will be on the programmes of VET and higher education because of the greater availability of data and information with respect to the programmes related to continuous vocational education and training.[427] Moreover, only courses longer than twelve months were considered as well as programmes of study that lasted more than three days per week. This was done in order to discriminate between the very short VET courses that exist in some countries.

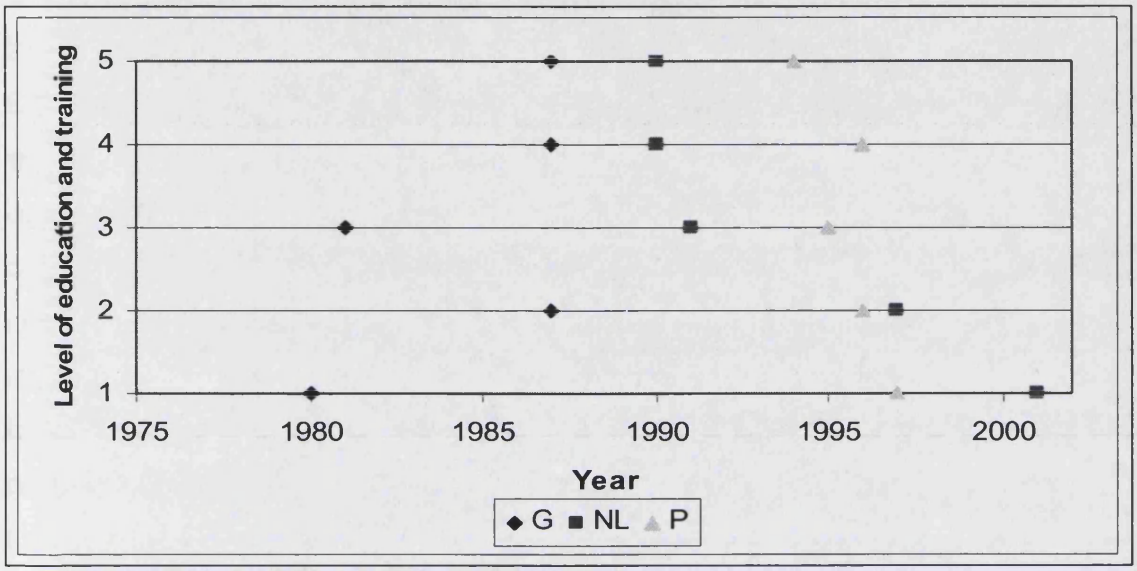
In order to make the different qualifications comparable across countries and across the different levels of education and training a different approach was used according to the level of education. For the higher education level the categories used were those established in the framework of the "Bologna Process structure".[428] That is, there is a first level which refers to the bachelor's degree and a second level that is related to the master's degree. With respect to vocational training, the approach used required a greater degree of discretion due to the great heterogeneity that characterizes the VET European systems as previously acknowledged. Therefore, a division of the degrees in five levels VET2, VET3, VET4, bachelor's (HEB) and master's (HEM) was agreed in accordance with the International Standard Classification of Education (ISCED). While choosing the categories related to the vocational education and training, researchers of the EUQuaSIT project tried to take into account country-specific characteristics and therefore to find a common rule as they have acknowledged in the final report. As a result, the three categories VET2, VET3 and VET4 correspond to the vocational education and training at secondary level and tertiary non university education respectively.

In order to show how countries have provided different responses over time in the provision of ICT-related degrees, some graphs will be presented. First, in order to have a general overview of the timing of the institutional response, figure 4.5 shows

[427] However, the increasing importance of this type of training is acknowledged as "continuous vocational training has expanded during the last twenty years" (Green et al., 1999, p.224).
[428] EUQuaSIT (2004, p.12).

when the first ICT-related degree was introduced in the three countries according to the different level of education and training that have been described in the previous paragraph.

Figure 4.5 Timing of introduction of the first ICT-related degree according to the level of education and training in Germany, the Netherlands and Portugal, 1975-2002[429]



Note: 1=VET2; 2=VET3; 3=VET4; 4=HEB; 5=HEM
Source: EUQuaSIT (2002) and Ministry of Education of Germany, the Netherlands and Portugal

From the graph it is possible to observe that Germany has introduced the first ICT programme at all levels before the Netherlands and Portugal. The introduction of ICT-related programmes in VET2 and VET4 occurred in Germany in the early 1980s whereas in the other two countries after 1990. On the other hand, the Netherlands have introduced the first programme at VET4 and at both undergraduate and postgraduate levels in advance with respect to Portugal. In this regard, it is interesting to notice that at lower levels of education Portugal has introduced ICT-related programmes before the Netherlands. Later, in this section the introduction of the ICT-related programmes of study will be analyzed with respect to the evolution of the ICT adoption in order to understand what is the correlation between the two: was an early (or late) response related to an early (or late) introduction of ICT

[429] It is acknowledged the fact that two degrees related to information technology were introduced in Germany in 1972-73 at higher education level. However, it has not been possible to collect accurate information related to these programmes.

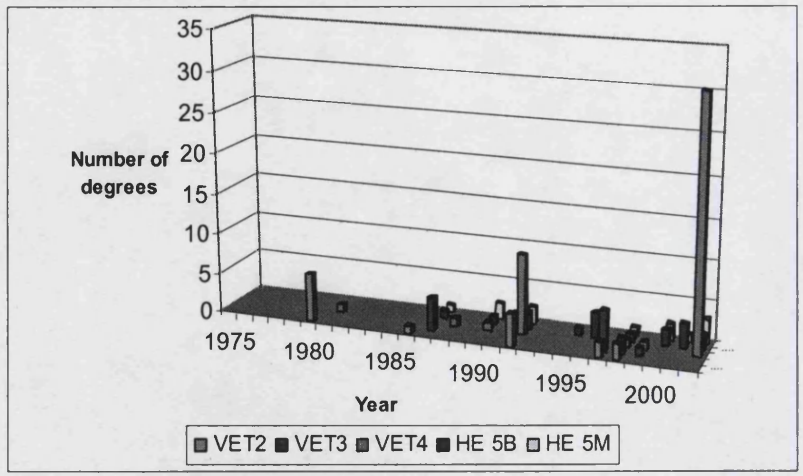
technologies in the economic activity or were there institutional factors, like good coordination between social partners, or on the contrary barriers that can explain it.

Figure 4.5 has the merit of providing a first intuition but in order to have a complete overview of the institutional response provided by countries at different levels of education and training it is necessary to examine the timing of introduction of every ICT-related programme that has been introduced in the country under study and to compare this with the pattern of adoption of the different types of ICT technologies. In order to do this, I had to divide the ICT-related programmes of study according to the different types of technology that characterize the curriculum. This is the reason why the programmes were divided in three categories: information technology, communication and software.[430] The pattern of introduction of the different categories of ICT degrees in vocational training and higher education is shown in the next page for the three countries under study. For each country, in the first graph, the total number of ICT-related degrees introduced between 1975 and 2002 is shown.[431] In the other graphs the timing of introduction of the degrees according to the level of education and training (VET2, VET3, VET4, HEB, HEM) and the type of technology that constitutes the core of the curriculum is shown.

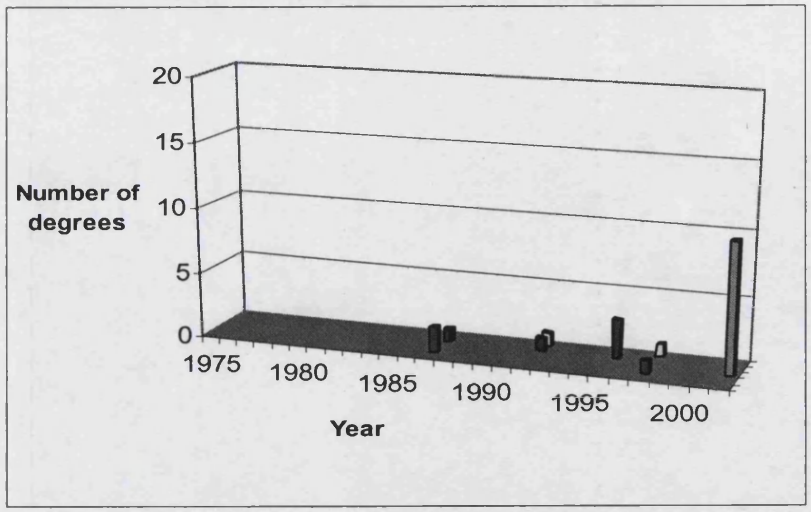
[430] A description of these types of technology has been provided in section 4.3.
[431] For the Netherlands and Portugal the time period shown in the graphs starts from 1990 because no ICT-related programme was introduced before then.

Figure 4.6 Introduction of ICT degrees in Germany, 1975-2002

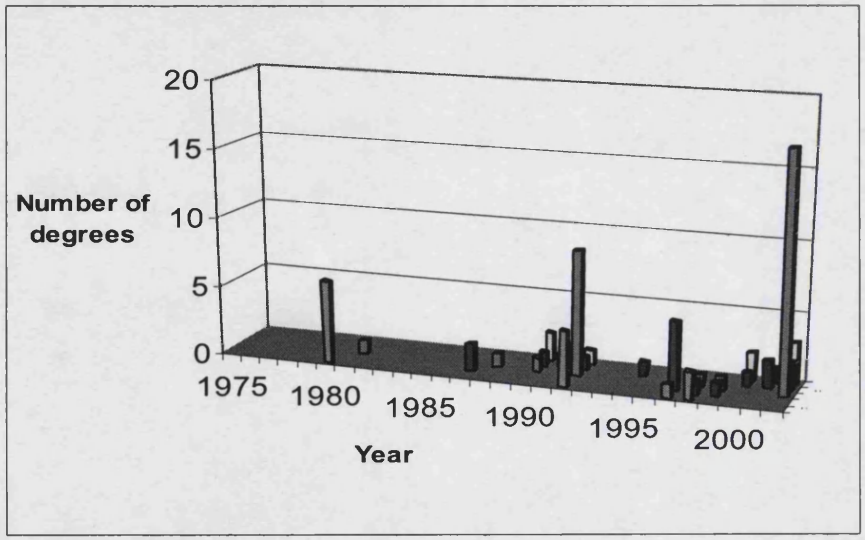
Introduction of ICT degrees in Germany, 1975-2002



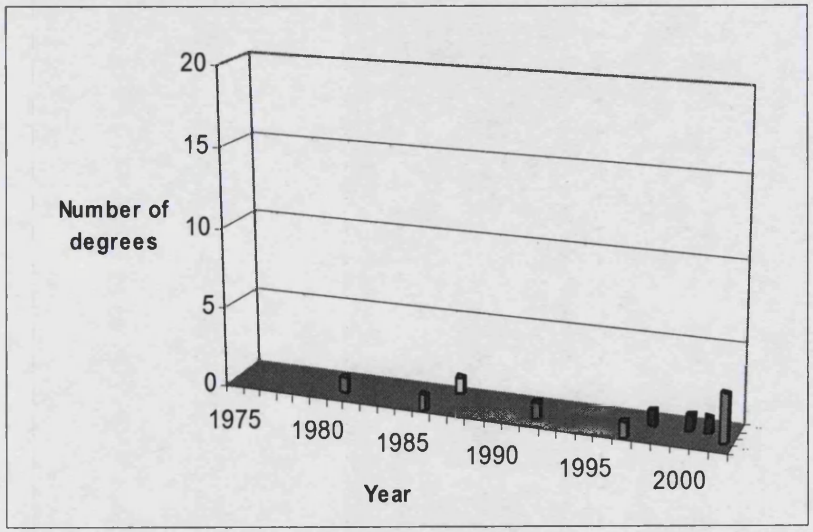
Introduction of Communication degrees in Germany, 1975-2002



Introduction of IT degrees in Germany, 1975-2002



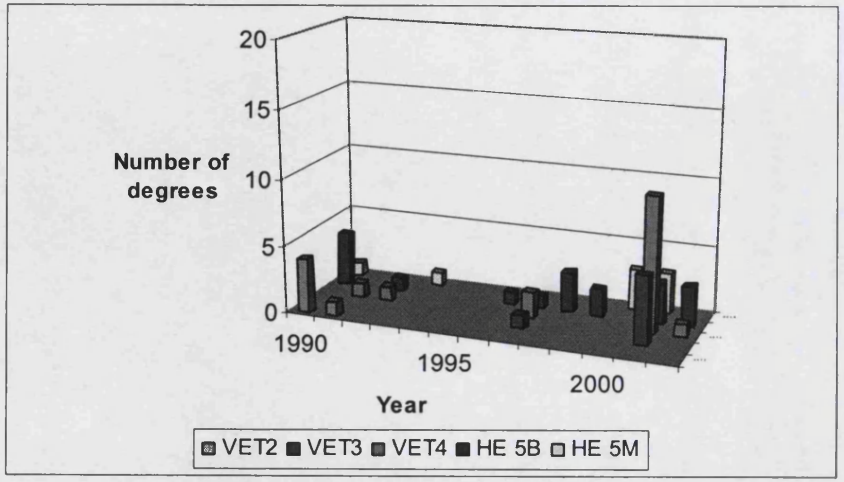
Introduction of Software degrees in Germany, 1975-2002



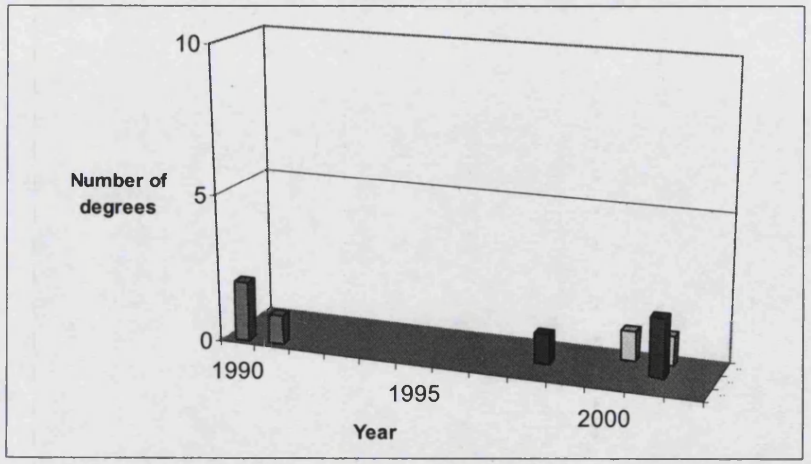
Source: EUQuaSIT (2002) and Ministry of Education of Germany

Figure 4.7 Introduction of ICT degrees in the Netherlands, 1990-2002

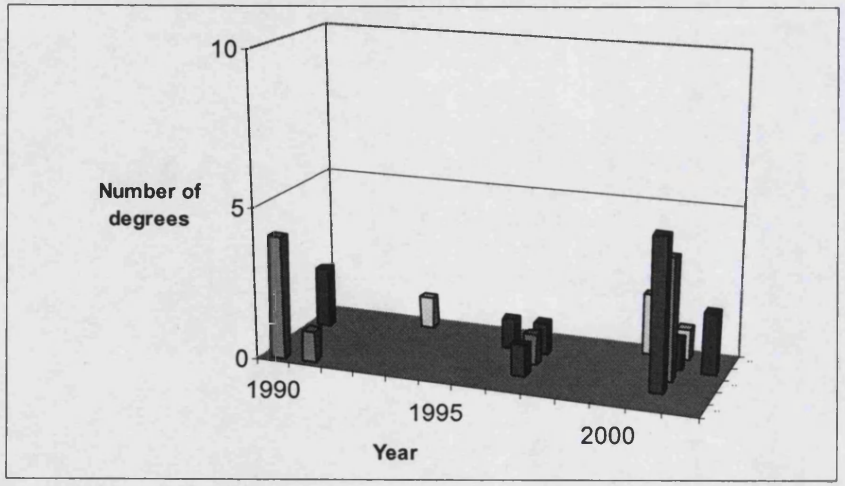
Introduction of ICT degrees in the Netherlands, 1990-2002



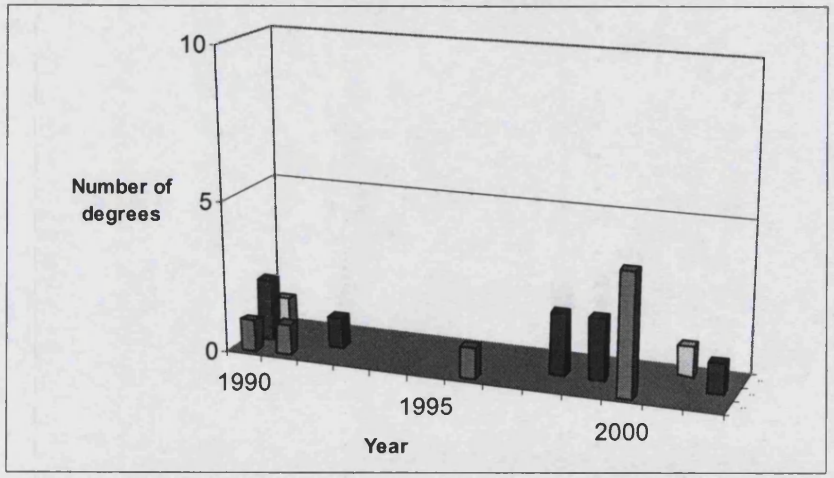
Introduction of Communication degrees in the Netherlands, 1990-2002



Introduction of IT degrees in the Netherlands, 1990-2002



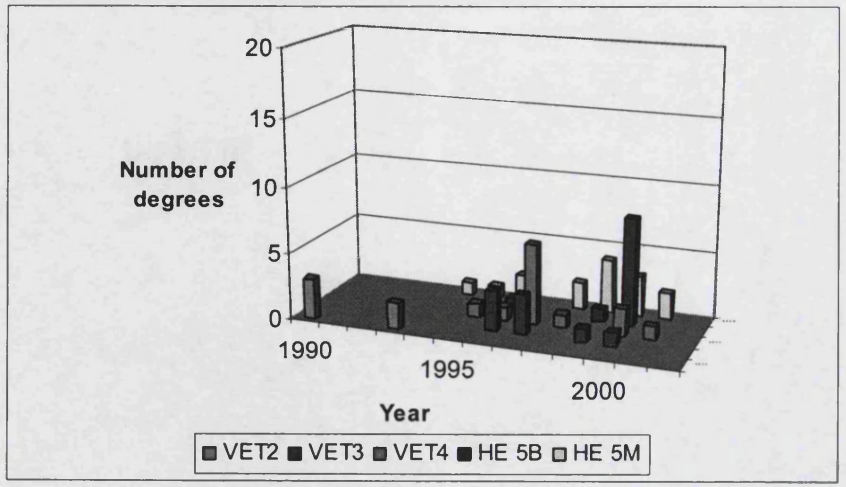
Introduction of Software degrees in the Netherlands, 1990-2002



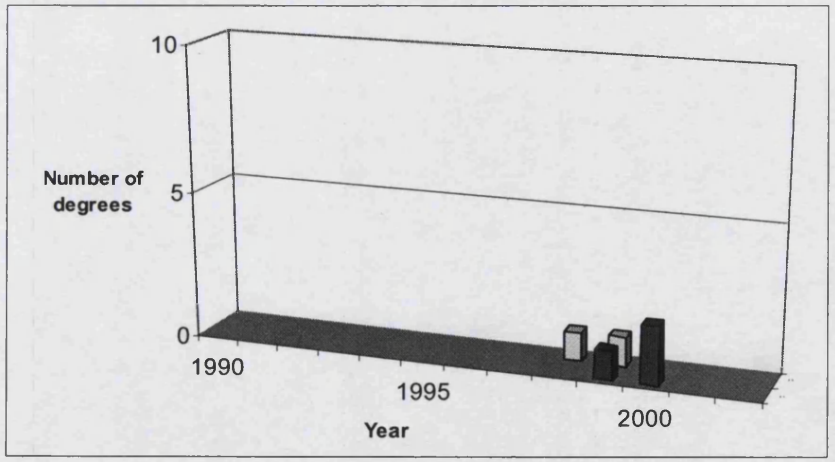
Source: EUQuaSIT (2002) and Ministry of Education of the Netherlands

Figure 4.8 Introduction of ICT degrees in Portugal, 1990-2002

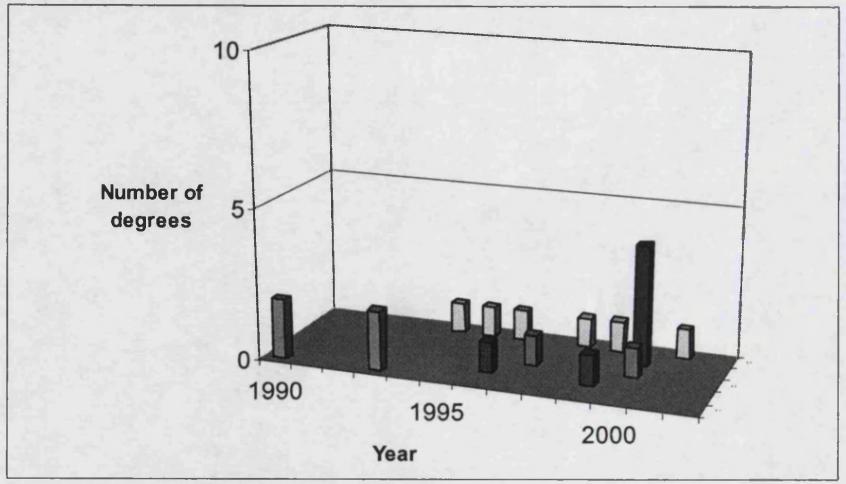
Introduction of ICT degrees in Portugal, 1990-2002



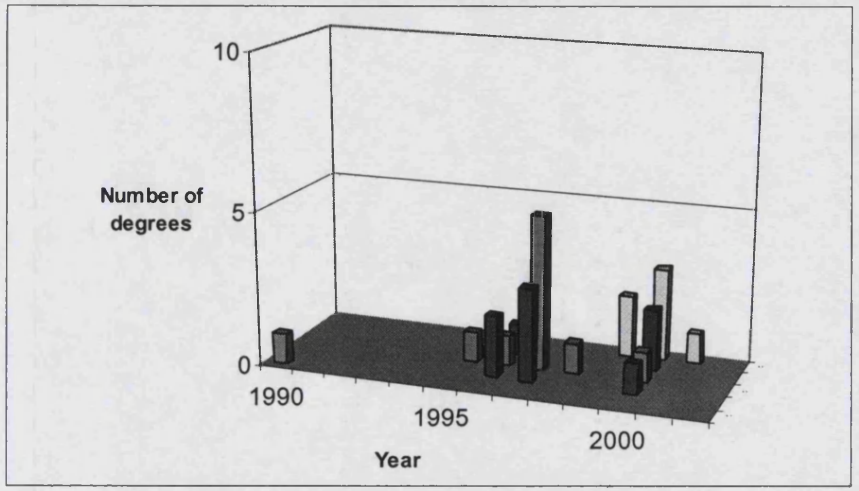
Introduction of Communication degrees in Portugal, 1990-2002



Introduction of IT degrees in Portugal, 1990-2002



Introduction of Software degrees in Portugal, 1990-2002



Source: EUQuaSIT (2002) and Ministry of Portugal

Figure 4.6 to figure 4.8 show that Germany had the earliest response in terms of introduction of the ICT-related programmes whereas the response in the Netherlands and Portugal was highly concentrated in the period 1995-2000. By looking at the pattern of growth in the ICT investment shown in table 4.2 it is possible to observe that this introduction of ICT-related degrees coincides with an increase in the investment in the new technologies across the three countries in IT and communication. Also, it is possible to observe that Germany is the country that has introduced by far the greatest number of ICT-related degrees between 1975 and 2002.

It seems important to look at what area and at what level of study these degrees have been introduced. For the three countries the majority of the degrees introduced are related to IT. Programmes of study like information technology officer, IT system support specialist in VET as well as informatics and information technologies at higher education level were introduced in the three countries. In Germany and the Netherlands, many degrees have been introduced in IT, a quite large number of software related-degrees have been introduced and few in communication. On the other hand in Portugal, more degrees have been introduced in IT, a small number in communication and very few in the area of software.[432] These differences may be explained by the strategy adopted in terms of investment in specific sectors of technology and the related labour market demand for certain types of skills but it is difficult to provide an exhaustive explanation for this. In fact, different agents are involved in the decision-making process for the introduction of new programmes of study and for the countries under study I could not find a specific "ICT-related programmes policy" in the sense of an agenda defining the plan for the introduction of the courses of study related to the new technologies.

By looking at the level of the institutional response it is possible to notice that differences exist across countries. In Germany, 15 programmes were introduced in VET2 and 13 at master's level. In the Netherlands, these figures correspond to 5 and 8 and in Portugal to 5 and 14 respectively. On the other hand, in Germany the creation of degrees in software and communication has occurred more heavily in VET whereas a large number of IT-related degrees have been created in higher

[432] Please refer to the appendix (tables 4.D, 4.E and 4.F) for the exact number of degrees that have been introduced in the three countries.

education. It is possible to notice a similar pattern for the Netherlands. In contrast, Portugal shows a more balanced pattern in IT and software whereas the introduction of communication degrees has been created at higher education level. These differences may be due to the organization of the educational system. As Steedman et al. (2003) have shown, given a similar labour market demand, the supply of skills can vary according to the type of education and training system. In particular, they look at the different supply of skills in Germany and Britain. They argue that in a country like Germany with a well established dual system of vocational training the profession is closely related to the type of studies achieved and skills produced in the vocational and training system are highly valued in the labour market. On the other hand, by interviewing 90 companies they show how in Britain what is more important is the level of the qualification acquired.[433] That is, companies in the ICT sector and also in other sectors that make an important use of new technologies value more higher education degrees with respect to technical qualifications.[434] This argument may help explaining the significant development of ICT-related programmes at vocational and training level that occurred in Germany and to a lesser extent in the Netherlands. In contrast, in Portugal the more recent expansion of the vocational and training system may have led to an increase in the labour market demand for graduates in ICT. That is, the structure of the educational system may have had an impact on the introduction of a smaller number of ICT-related degrees at vocational education and training level. Also, the greater participation of stakeholders and social partners in Germany may have been beneficial in leading to a faster introduction of the ICT-related degrees. This is because social partners may have been fast in perceiving the new type of skills needed in the labour market and may have created pressure on the state for the introduction of these new degrees.

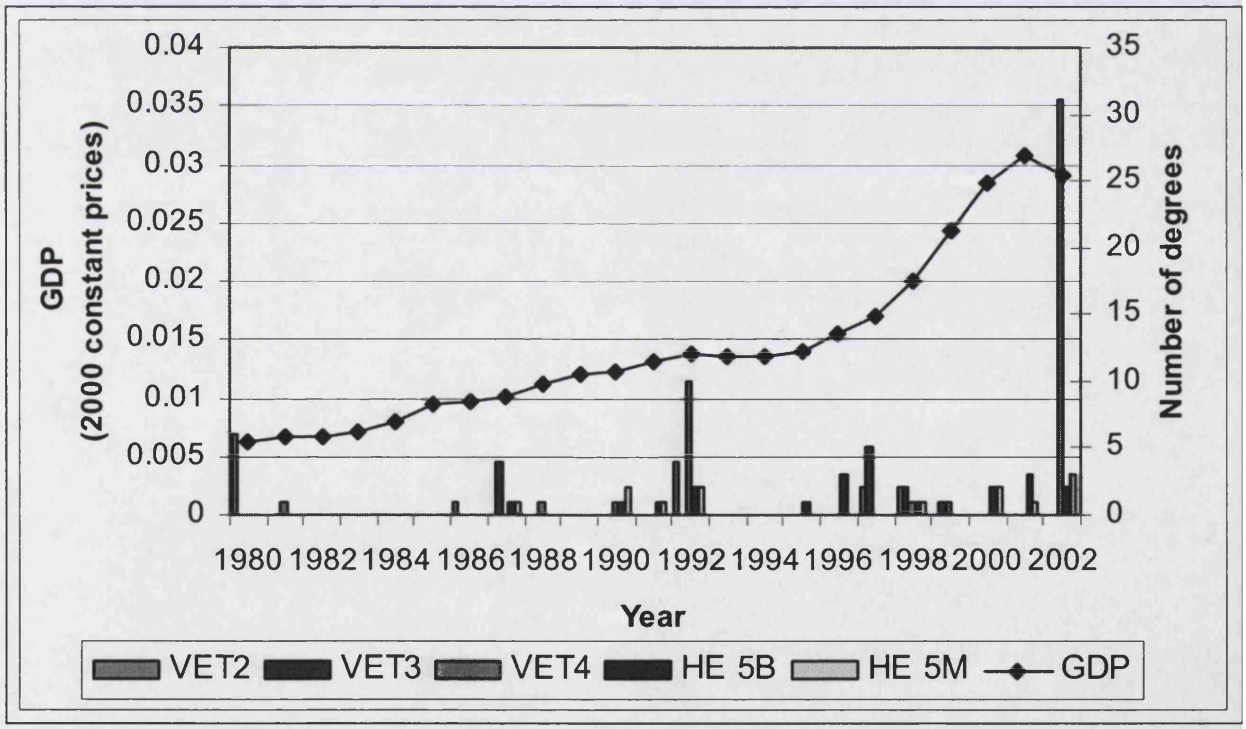
Following the overview of the introduction of the ICT-related degrees it seems interesting to relate it to the pattern of adoption of the new technologies in order to see whether the institutional response in the education and training system has followed the technological expansion or whether it has followed a different evolution. In order to do this the correlation between the pattern of ICT adoption and the timing of the introduction of the ICT-related degrees has been estimated for the different countries. By looking at the introduction of these degrees with respect to the

[433] Steedman (2003, p.3).
[434] Steedman et al. (2003, p.76).

pattern of adoption of ICT that has been presented in the previous section, it is possible to observe that apart from the positive correlation in IT for the three countries, it seems that in Portugal a large number of degrees has been introduced in software which is the sector where the country was lagging behind in terms of adoption of technology. On the contrary, in the Netherlands, it seems that a quite high correlation exists between the introduction of degrees and the adoption of technologies in the software sector. These initial thoughts are complemented by figure 4.9 which shows both the pattern of ICT adoption and the number of ICT-related degrees introduced between 1980 and 2002.

Figure 4.9 ICT adoption (expenditure as a percentage of GDP) and introduction of ICT degrees (number of degrees) in Germany, the Netherlands and Portugal, 1980-2002

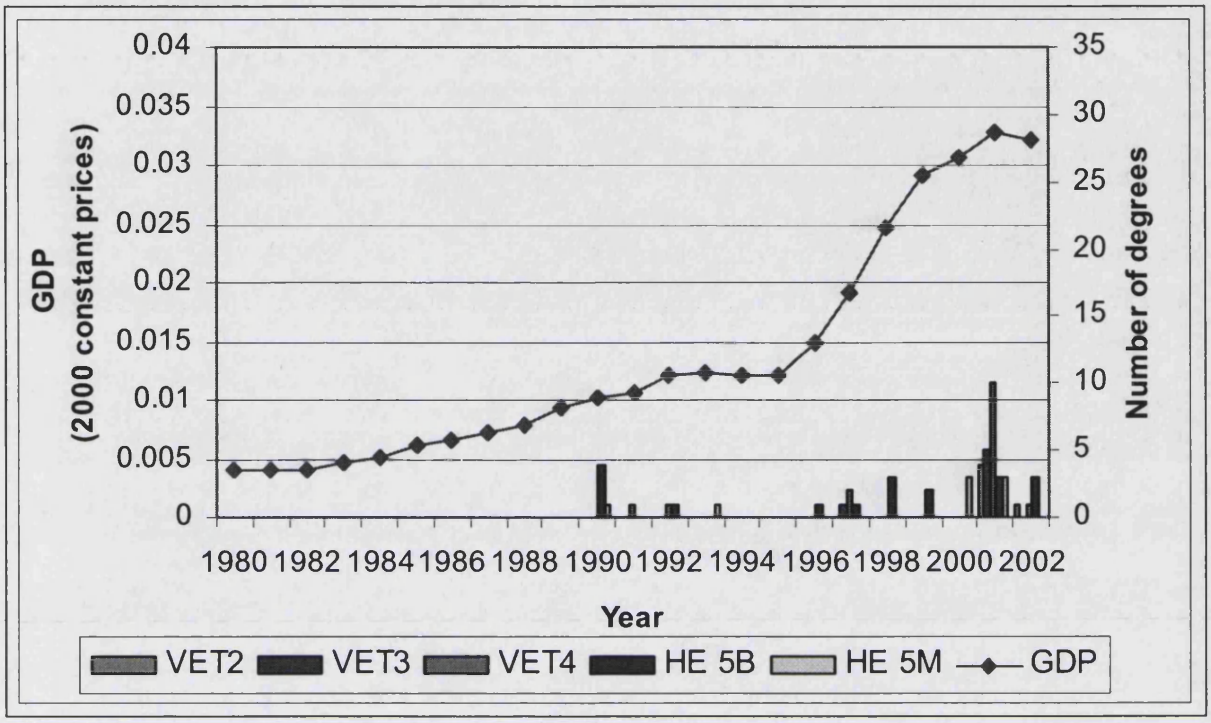
Germany



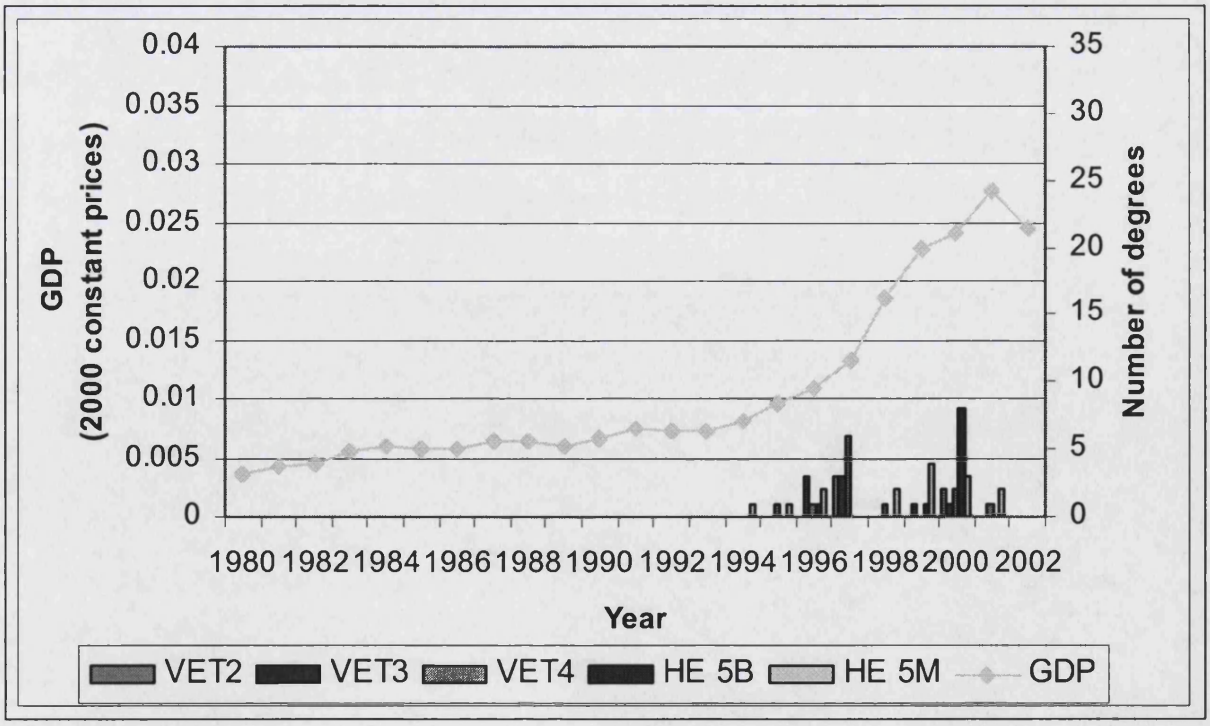
Source: Timmer et al. (2003), EUQuaSIT Database (2002), Ministry of Education of Germany, the Netherlands and Portugal

Figure 4.9. ICT adoption (expenditure as a percentage of GDP) and introduction of ICT degrees (number of degrees) in Germany, the Netherlands and Portugal, 1980-2002 (cont'd)

Netherlands



Portugal



Source: Timmer et al. (2003), EUQuaSIT Database (2002), Ministry of Education of Germany, the Netherlands and Portugal

From the graphs it is possible to observe that Germany has provided an earlier response in terms of introduction of ICT-related degrees whereas in the other two countries the response in the education and training sector has occurred later and has been highly concentrated between 1995 and 2001 when there has been an important increase in the rate of investment in ICT.

By comparing the programmes of study that have been introduced in the three countries, it is possible to see that there exist important differences in terms of curriculum at lower levels of education, especially at VET2 and VET3 levels.[435] In addition to this, it is possible to look at the level of the qualification profiles introduced in the different fields of education and compare the differences across the three countries considered. In Germany, apart from the field of computing, the introduction of ICT-related degrees has been homogeneous across the different levels in the fields of arts, business and administration as well as engineering and trades engineering. In the area of computing the greatest number of programmes has been introduced at level VET4 and a small number of degrees in higher education. In the Netherlands, the introduction of ICT-related degrees has been homogeneous across the different levels of study, only in arts and business administration ICT programmes have been introduced at higher education and VET4 levels but not at VET2 and VET3 levels. In Portugal, the framework is similar but in business administration where ICT programmes have been introduced only at higher education level.

The analysis provided so far has been mainly descriptive and has focused on the timing of the introduction of the ICT-related degrees. Due to data constraints it has not been possible to compare the quality of the degrees introduced as well as how they have been effective in creating the skills required by the new occupations that rely on the use of the ICT technologies. Moreover, it is not possible now to have complete information related to the pattern of participation of students in these newly created degrees. This is left for future work, what will be examined in the next section is the evolution of the enrolments in VET with respect to general education as well as the changes in participation and graduation rates in some ICT-related programmes. The rationale for doing this is the following: after having examined the

[435] The ICT qualification profiles considered in the analysis are presented in the appendix (tables 4.A, 4.B and 4.C); the content of these programmes is presented in the EUQuaSIT (2002) database.

institutional response in terms of creation of new degrees, it seems important to understand how the "allocation of talents"[436] has changed over time. That is, how people have perceived the relative returns from undertaking ICT-related studies with respect to the other fields. In this regard, a comparison of returns to education across different disciplines would be informative. The existing empirical evidence has been described in an earlier section and indicates that over 1994-2002 computer science degree exhibited the greatest returns to education with respect to the other disciplines examined by Sloane and O'Leary (2004).[437] The analysis of the participation rates in computer science is what underlies the analysis of the next section.

4.7) Evolution of the participation in general education and vocational education and training according to the field of study

4.7.1) Evolution of the enrolments in general education and vocational education and training

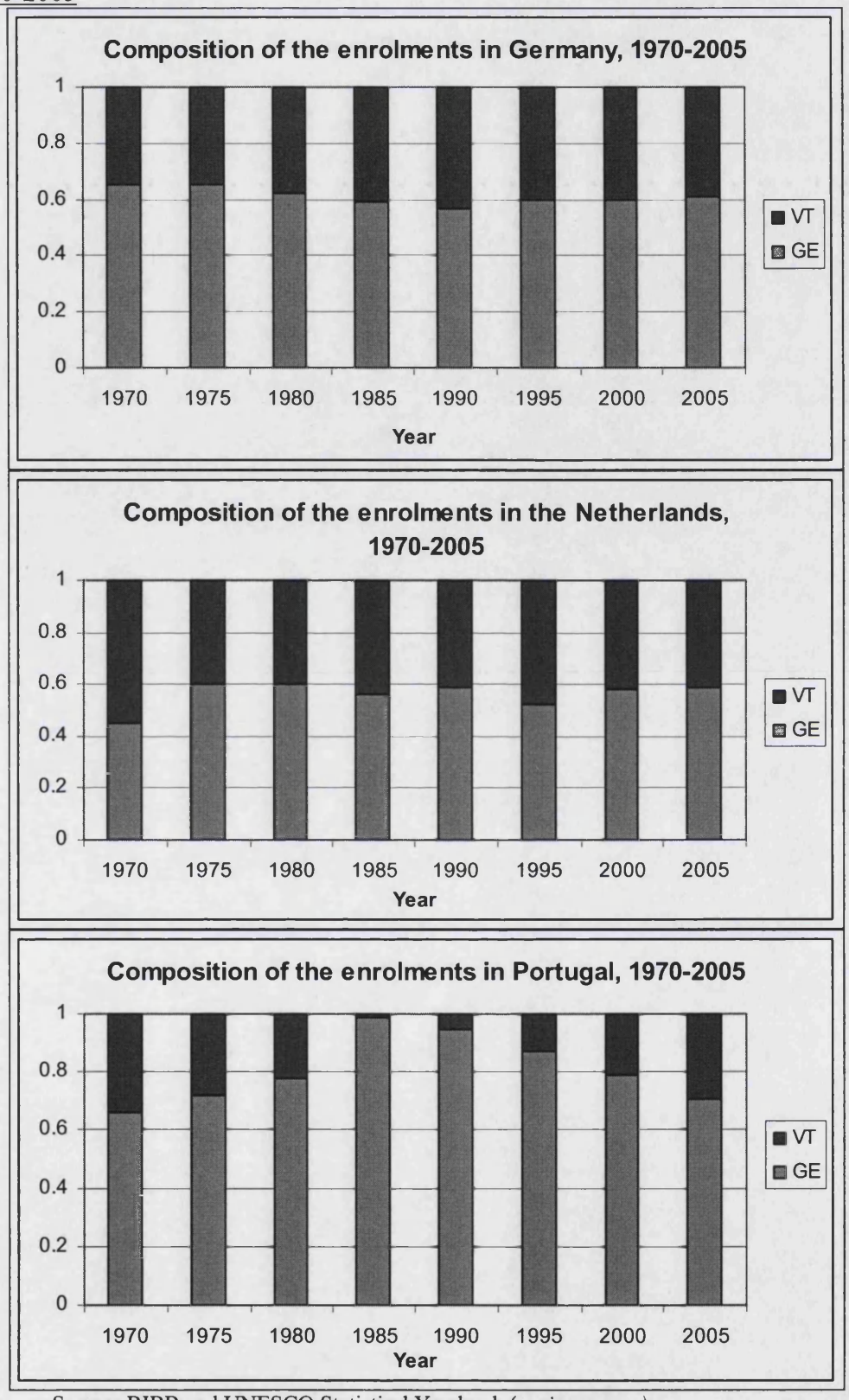
VET represents the type of education that an important proportion of the population in Germany and the Netherlands has received at secondary and tertiary level over the period 1970-2005. As can be observed from figure 4.10 the share of VET with respect to general education has been steady in Germany over the period considered at around 40 percent. Slightly larger fluctuations have occurred in the Netherlands, where from 1970 to 1975 there has been an increase of around 17 percent in the enrolments in VET and thereafter the proportion of enrolments has been quite steady again at around 40 percent. Portugal has experienced a quite different evolution. During the Salazar regime, VET was highly regarded by the regime but under the democratic regime established after the coup d'état in 1974, there was a progressive abolition of this educational system. From the 1980s onwards, the European Union has encouraged the country to reorganize the VET system as a mean of reducing the low levels of schooling among the Portuguese population and also with the aim of

[436] Murphy et al. (1991), talk about the implications for growth of allocating "talents" in productive activities like engineering as opposed to rent-seeking professions like law. Please refer to Baumol (1990) for an earlier discussion concerning "productive and unproductive entrepreneurs".
[437] This was for men whereas for women Maths and Computing had the second most important markup.

making the schooling system more effective in order to reduce the high levels of unemployment.[438]

[438] Data related to figure 4.10 are presented in the appendix, tables 4.G, 4.H and 4.J.

Figure 4.10 Evolution of the enrolments in Germany, the Netherlands and Portugal, 1970-2005



Source: BIBB and UNESCO Statistical Yearbook (*various years)*

4.7.2) Evolution of the enrolment and graduation rates in the ICT-related degrees

The expansion of the participation rates in higher education has been described in chapter two and the extraordinary growth in terms of enrolments has been illustrated in section 2.4.1. Here, the purpose of the analysis is to show the evolution of the participation and graduation rates in the ICT-related degrees. Due to the difficulty in collecting data related to the participation rates in the different ICT-related programmes and also because these degrees have been introduced quite recently, the focus of the analysis will be limited to the changes in computer science. This is because it seems a good example of ICT-related degree[439] and it has been introduced in every Western European country.[440] In the next page graphs showing the evolution of the enrolments in first year university degree and the evolution of the graduation rates in computer science are shown for Germany between 1980 and 2002 and for the Netherlands over the period 1994-2002.[441]

It was not possible to find these data for Portugal. I have consulted the publications of the Instituto Nacional de Estatística Portugal as well as the material available at the Instituto de Ciènciais Sociais de Universidade de Lisboa and I sought advice from some experts Dr Cardoso of the Institute for the Study of Labor (IZA), Professor Pereira of the University of Madeira who has studied the Portuguese educational and training system and Dr Trigo de Abreu, chief of cabinet of the Ministry of Science, Technology and Higher Education. The only data I could find are from a publication of the Ministry of Science, Technology and Higher Education[442] but they have the shortcoming of being aggregate and available only for some benchmark years.[443] Therefore, in order to give a rough idea of the evolution of the participation rates in this ICT-related degree for Portugal I will show the evolution of the composition of higher education according to the different fields of study. That is, I will look at how the enrolment rates in "other" (that includes

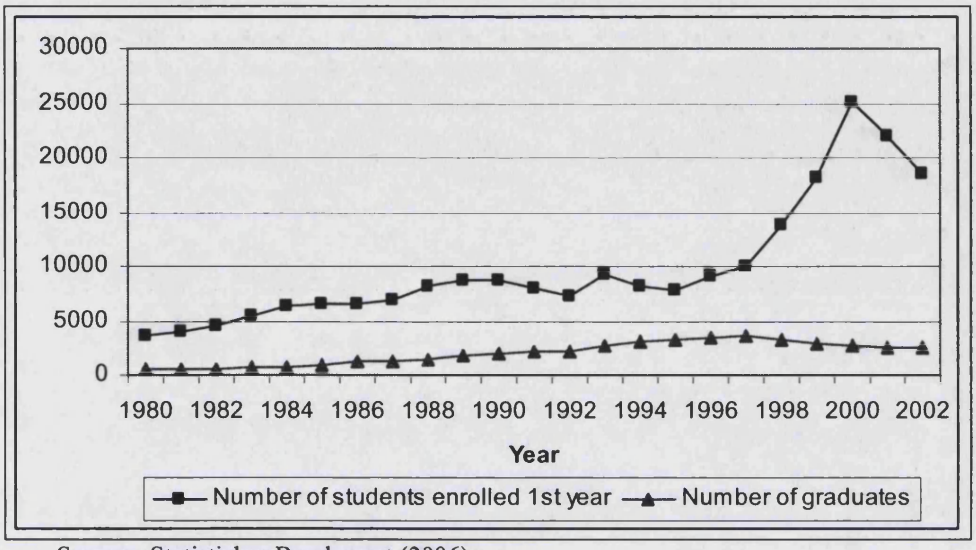
[439] It has been used by Steedman et al. (2003) in the context of their comparison in the labour market demand and skills supply for Britain and Germany.
[440] UNESCO Statistical Yearbook (*various years*).
[441] The shorter time series for the Netherlands is due to data availability. Among the datasets of the Central Bureau voor de Statistiek (CBS) I could not find earlier data. Other data related to the evolution of the enrolments and graduation rates in computer science at higher vocational education level can be found in the appendix, tables 4.M and 4.N.
[442] The publication of the Ministry of Science, Technology and Higher Education I am referring to is "Tertiary Education in Portugal. Background Report prepared to support the international assessment of the Portuguese system of tertiary education", 2006.
[443] Data related to the enrolments in computer science are presented in aggregate with science and mathematics and are available for the year 1997, table 3.13, p.127 and the year 2003, table 3.3, p.115.

computer science, mathematics and related degrees) have changed over time with respect to the other fields of study. In order to do this, I will use the data of the UNESCO Statistical Yearbook and not the ones of the Ministry of Science, Technology and Higher Education because the former are available from an earlier date.[444]

[444] Data related to figure 4.11 are presented in the appendix, tables 4.J, 4.K and those related to figure 4.12 are presented in table 4.L.

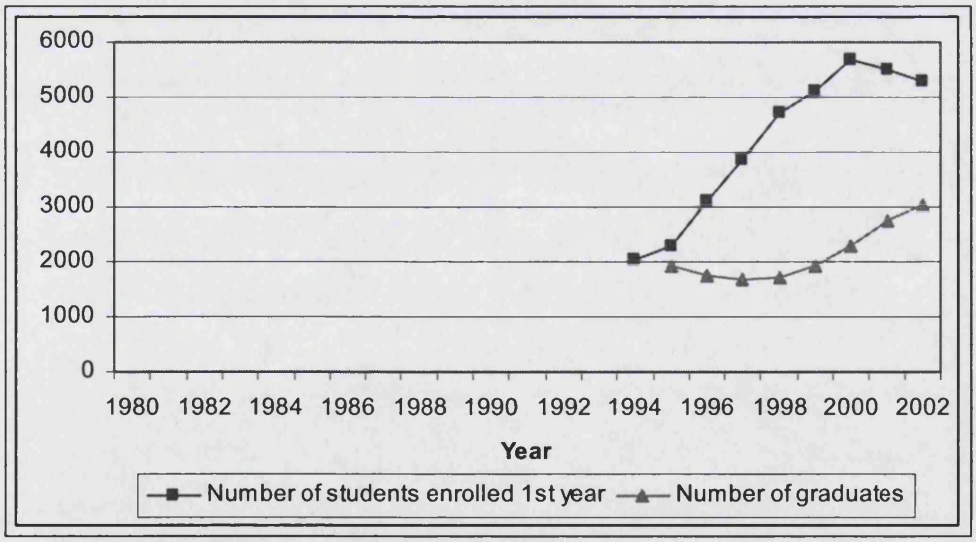
Figure 4.11 Number of first year students enrolled in computer science at university level and number of graduates in computer science, Germany and the Netherlands, 1980-2002

Germany



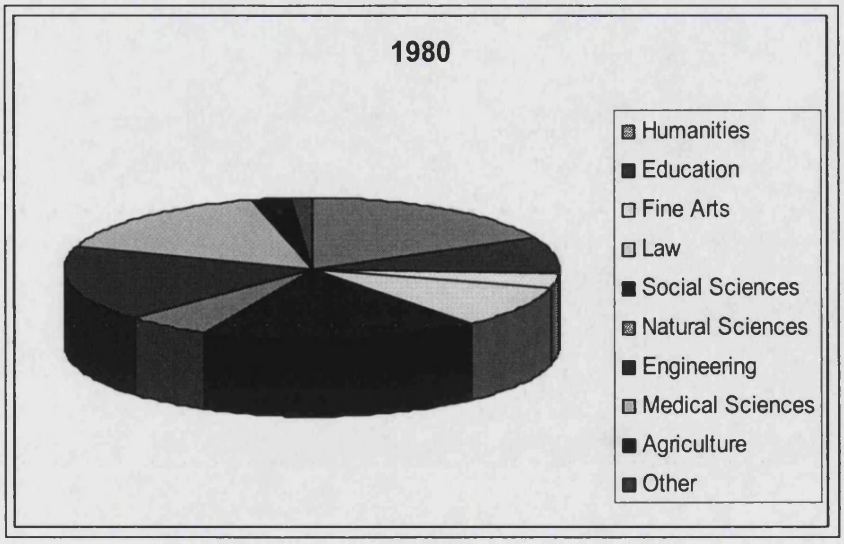
Source: Statistiches Bundesamt (2006)

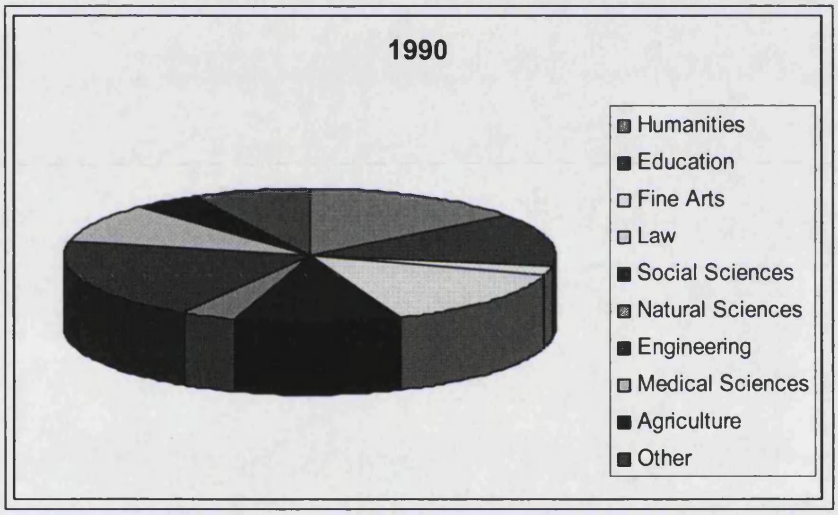
Netherlands

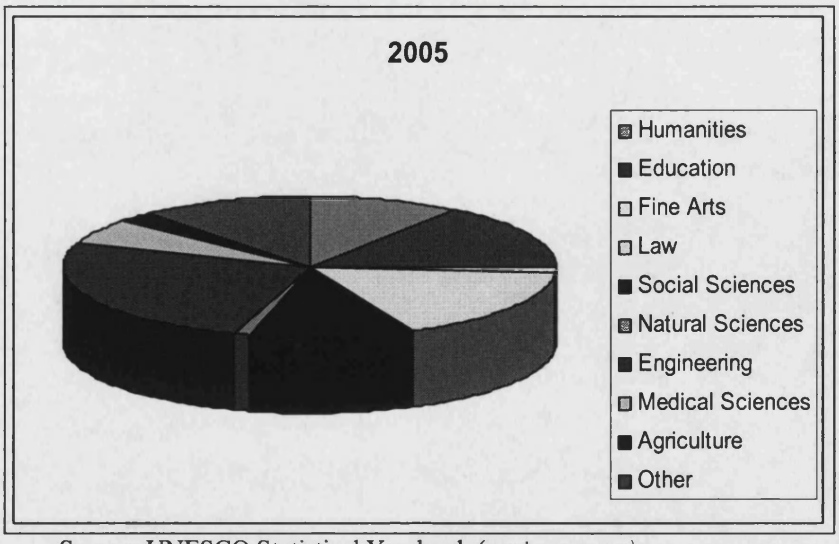


Source: Central Bureau voor de Statistiek (2006)

Figure 4.12 Higher education according to the field of study in Portugal 1980-2005







Source: UNESCO Statistical Yearbook (*various years)*

What can be observed from the graphs is that enrolment rates in computer science degrees have increased in Germany and the Netherlands between 1980 and 2001.[445] After 2001 they seem to have declined in both countries probably as a result of the ICT downturn (Eicher and Roehn, 2007). What is interesting to notice is the gap between the enrolment rates and the graduation rates in the two countries examined. This difference has been acknowledged in the case of Germany by Steedman et al. (2003, figure 2, p.6) who consider as an explanation for this divergence the length of the German bachelor's degrees and the high attrition rates.[446] They argue that these factors have contributed to the skill shortages in ICT and that drop out rates are greater for traditional than applied university courses. It is important to notice that the gap between enrolment and graduation reflects a particular problem with ICT courses (Steedman et al., 2003), which is similar to the trend of the engineering industry courses (Bruniaux et al., 2000; Steedman et al., 2003) but which does not reflect the general trend within higher education (Steedman et al., 2003, p.7).

In Portugal, enrolments in the category that includes computer science[447] have progressively increased over time and in particular from 2000 as can be inferred from the graphs and the publication of the Ministry of Science, Technology and Higher Education (2006).[448] However, it is not possible to draw definitive conclusions on the size of the expansion of computer science only due to the limited data available.

Tables showing the evolution of the participation and graduation rates in computer science at higher vocational level (that is tertiary education non university, VET4 according to the classification of the EUQuaSIT project) for Germany and the Netherlands are presented in the appendix.[449] In this case again, it is possible to observe that participation rate in the German *Fachhoschulen* and the Dutch *Hoger Beroepsonderwijs* has expanded even if at a slower pace with respect to the higher education bachelor degrees and important differences exist between first year enrolments and graduation rates for Germany.[450]

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[445] The period examined for the Netherlands is 1994-2002 due to data availability.
[446] Steedman et al. (2003, p.5).
[447] Enrolments in computer science are included in "other". Please refer to table 4.L in the appendix for details about the classification.
[448] pp.164-5. This is described in note 12 and table 3.39 that describe the areas of graduation of the new entrants in the labour market over the period 1994-97.
[449] These data are presented in tables 4.M and 4.N.
[450] Data related to graduation rates in computer science at HBO level are not available for the Netherlands from the Central Bureau voor de Statistiek (CBS) dataset.

What has been observed in this section is that apart from Portugal, the evolution of the participation rates between vocational and general education has been quite steady between 1970 and 2005. Enrolments in computer science have increased since the introduction of the degree programme and slightly declined since 2000 in Germany and the Netherlands. The difference between enrolments and graduation rates has highlighted the fact that there exists a lag between the introduction of the ICT-related degrees and the outcome in terms of labour force trained with ICT skills. The high levels of enrolments in Germany in 1999-2000 coincide with the height of the ICT boom and the important skill shortages that characterized these years (Steedman et al., 2003). On the other hand, it is possible to observe from figure 4.11 that after 2000 the enrolments in computer science have started decreasing in both Germany and the Netherlands. According to Forth and Mason (2006), after 2002 the ICT skill gap has declined in Europe and workers with ICT skills have experienced difficulties in finding an employment. The decline in the average growth rates for the demand of ICT skills, which has been particularly evident for Germany and the Netherlands since 2002, has been shown in figure 4.4. Leo (2001), by reviewing recent studies of the Information Technology Association of America (ITAA), argues that the forecast of the demand for ICT-skills has been overstated and this is due to the recession of the ICT industry.

This analysis has shown that it takes time for the adjustment to take place. That is, the number of students enrolled in computer science has grown relatively fast in Germany and the Netherlands in the 1990s whereas the increase in the number of graduates has taken place at a slower pace in these countries. This suggests that even if the institutional response is adequate in terms of creation of ICT qualifications, there may exist a significant lag between the ICT adoption, the institutional response and the ICT skills formation.

4.8) European policy and its impact: towards convergence?

4.8.1) The debate

In an earlier section Milward's discussion on the historical development of the process of European integration was described. However, Milward neither takes a theoretical position nor discusses the nature of the relationship between the nation-state and the supranational authority in areas like education and other welfare state services. In this regard, since the early stages of the European integration process the future of the governance of these policy areas, in terms of the relationship between states, state autonomy and international cooperation has been seen by theorists and policy-makers in a contrasting way. Two theories have dominated the 1960s and the early 1970s. On the one hand, supporters of the functionalist theory like David Mitrany and Paul Taylor formulated "the pooling of sovereignties"[451] at the European level. In this framework, Member States progressively delegate their decision-making power to the European authorities in the core areas. This would lead to a full synchronization of national politics and to a progressive "Europeanisation" of the institutions of the Member States. In this case, the impact of the EU policy in the areas of education and training would be great as policy guidelines would be set by the supranational authority and greater cooperation between the Member States would be pursued.

On the other hand, the federalists, including Karl Deutsch and Ernst Haas, advocated the transfer of decision-making power to the European level while leaving a limited number of areas to the national level.[452] Thus, the national institutions of the Member States would be re-organized under the federal model. In this setting, education and training policy would remain under the authority of the Member States without any supranational intervention.

As a result of the strengthening of the integration process since the mid-1980s once again theories related to the relationship between the European Union and its Member States have come to the fore. Even if the two theories previously described remain central to the debate, theorists have moved forward by trying to abandon the

[451] Wessels (1996, p.23).
[452] Wessels (1996, p.25).

dichotomy and have started considering all the possible evolutions of the European integration process. For example, Rosamond talks about "the range of possible 'Euro-futures' that may lie between 'Europe des Patries' and 'United States of Europe'".[453] In the context of the education and training policy, the tension between the different levels of decision-making power is central to the debate concerning EU policy. It has been central since the early stages of the integration process. In fact, the Social Democrat parties that were in power in the majority of the European countries joining the European Coal and Steel Community in the early 1950s were in favour of a European intervention with respect to the economic and social policies as well as in the issues related to defence.[454] As Kuhn (2002) has suggested in the report prepared for the European Commission, it is important to notice that "education policy has been for centuries one of the most national fields of practice and research areas".[455] On the other hand, from the 1970s there has been a great involvement of the European institutions in the education and training policy. In the context of this chapter, it seems important to understand what has been the European policy in the area of education and training with respect to the new technologies. That is, it appears key to develop an understanding on whether the need for a coordination of the national policies has been perceived at EU level and what has been its actual implementation. This is because in order to examine the response of the Western European countries in vocational education and training arising from the adoption of ICT in the economic activity it is key to understand the impact of the EU policy in this field.

In the following paragraphs the European legislation, the practical implementation as well as the policy response with respect to the ICT technologies in the areas of vocational and higher education are outlined.

[453] Rosamond (2000, p.106).
[454] Johnson (1990, p.130).
[455] Kuhn (2002, p.9).

4.8.2) Vocational education and training

Guidelines related to the vocational education and training policy were included at the very beginning of the process of European integration. Varsori (2002) suggested the High Authority of the ECSC as well as the national actors considered vocational education as a strategic policy in order to train workers in the coal and steel industries. In spite of the early introduction of guidelines related to vocational training in the Treaty establishing the ECSC, legislation remained very vague and countries went on following national policies. In the Treaty of Rome clearer instructions related to cooperation in the domain of vocational education and training were introduced.[456]

According to Mechi (2002), it was later at the end of the Golden Age when the economic slowdown and the subsequent technological transformation required a greater adaptation of workers to the new processes of production that vocational policy became a central issue in the European social policy debate. This is when the High Authority started seeing vocational training as "a strategic element that, while improving the possibility of workers adapting to technical change, would promote the attainment of higher productivity".[457] In this regard, many Member States started considering vocational policy as a strategic tool in order to help workers coping with the new technologies and those working in the unskilled sectors adapting to the new economic environment. The focus of the European policy relied on developing greater cooperation and transparency of the Member States practices related to vocational training. This led to the creation in 1975 of the Centre for the Development of Vocational Training (CEDEFOP). This organization had as primary objective to increase transparency in terms of qualifications and practices across the Member States. This allowed greater awareness of the practices of the other EU countries and led to a greater transparency in terms of qualifications existing in the other Member States. In addition to this, it is among the responsibilities of CEDEFOP to undertake studies related to the labour market, the skills required and

[456] According to Petrini (2002), this was a response in order to address social concerns related to some countries and also to face the issue of unemployment that was affecting some sectors of a certain number of European countries.
[457] Mechi (2002, p.13).

the transition from school to work.[458] Moreover, new programmes that allowed greater mobility were created.

Later, the Lisbon Process set the guidelines to transform Europe into the "most competitive and dynamic knowledge-based economy in the world by 2010".[459] In this framework, education and training were considered of great importance. After this Summit recommendations to increase cooperation and provide greater transparency in vocational education and training were strengthened by the Copenhagen Declaration of 2002 when plans to create a common system of qualifications were discussed.[460] In the context of ICT, the need of introducing these technologies in the vocational and training sector was emphasised in the Maastricht study of 2004 that suggested that "Member States should progressively ensure that, by 2010, ICT in vocational learning is embedded in work and business processes".[461] In addition to this, very recently, the European Commission has launched the eLearning initiative and the European Computer Driving Licence in order to provide better ICT training in the small and medium sized enterprises.[462]

By examining the achievements of the EU common policy it appears important to try to understand whether these have led to a convergence in the VET of the countries under study. In particular, on whether there is a similarity in the ICT-related degrees that have been introduced in the three countries examined. Following the Maastricht Communiqué, which assessed the progress made in the area of vocational education and training, there has been increased information about training practices among Member States, an increased cooperation and greater mobility across countries.[463] However, from what has been observed earlier, the introduction of ICT degrees in the VET systems of the countries that have been examined follows a different timing and also the type of degrees that have been introduced vary across countries. According to the findings of the EUQuaSIT Final Report (2004), this may be due to the intrinsic characteristics of vocational education and training. In fact, the organization of this type of instruction is highly dependent on the production system of each country. Moreover, as has been argued before, the conditions of the labour

[458] Versori (2002, p.90).
[459] Tessaring and Wannan (2004, p.10).
[460] Tessaring and Wannan (2004, p.11).
[461] Tessaring and Wannan (2004, p.49).
[462] European Commission (2001, p.54).
[463] Tessaring and Wannan (2004, p.11).

market play a key role in determining the structure of the system. Therefore, the role of EU policy seems to have been less effective than in other sectors in leading to convergence. One exception is represented by Portugal. In fact, the influence of the European policy has been great in leading the country to reintroduce the vocational and training system when the democratic regime was re-established in order to increase the level of education of the population and reduce the high rate of unemployment.

To summarize, it is not possible to talk about "convergence" of the three systems under study as vocational education and training appear to be highly dependent on the structure of the production system and the organization of the industrial relations of each country. As suggested by Leney and Deluca (2000), in the area of vocational and training "the basic structures were already in place in 1984 and only few major changes have taken place since then".[464] EU policy-guidelines in ICT in order to increase homogeneity in terms of qualifications and endow workers with the skills necessary for the effective use of the new technologies are only recent developments and by taking an historical perspective it is not possible to see convergence of these vocational education and training systems.

4.8.3) Higher education

Starting in the 1950s, the expansion of higher education in the majority of European countries attracted great attention and became a key policy issue in Europe. However, in the first Treaty marking the beginning of the process of the European integration there was no article related to the Community Policy in the area of higher education. This is because the initial focus of the Community was on the economic and to a certain extent on social issues whereas the competence in the domain of education was left to the Member States. Starting from 1971 the Education Ministries of the European countries started meeting on a regular basis but still in an informal way to discuss the main issues related to cooperation and mobility in higher education. According to De Witte (1993), this allowed European education policy to

[464] Leney and Deluca (2000, p.134).

remain highly "flexible"[465] with respect to the decision-making process in other social areas. Later, in the 1980s, economic slowdown imposed a budget constraint on European countries and delayed any project of reform. At the same time there was an acknowledgment of the importance of the cooperation in higher education given the importance of this strategic sector and the increasing technological gap with the United States. This acknowledgment and the formalisation of the non-formal education policy followed by the Ministers of the Member Countries were translated in 1986 into the articles of the Single European Act.[466] For the first time specific legislation was conceived with respect to higher education. The main focus was on developing technological research in order to "strengthen the scientific and technological basis of European industry" (De Witte, 1993). The legislation mainly provided the guidelines related to the further development of three areas: the recognition of degrees, the mobility and the financial incentives to undertake these programmes. Legislation concerning the recognition of qualifications received from other Member States was enacted as well as the recognition of the right of students to have their degree recognised when they move to another Member State. Moreover, equal opportunities were given to teachers to work and do research in another Member Country, the only requirement being to know the national language (Leitner, 1993).

In order to increase mobility, many programmes were created to foster the exchange of higher education students and researchers across Member States. Among these programmes there are ERASMUS, COMETT and LINGUA. Financial incentives to joint projects, exchanges and collaboration across Member States were planned. Very rapidly higher education became a key area within European Community policy. However, as De Witte (1993) has shown, many Member States were against a further surrender of sovereignty in tertiary education policy. For instance, some countries like Germany were not in favour of a surrender of decision making as they wanted to keep the autonomy in the context of the Federal state.[467]

Is it possible to talk about convergence of the higher education systems of the Member States? The state-of-the art literature does not provide a definitive

[465] De Witte (1993, p.194).
[466] The articles describing the development of the European higher education policy are 130F and 130G.
[467] Leitner (1993, p.205).

conclusion. According to Teichler (1993) there is no convergence as each country follows its own structural development. On the other hand, according to Green et al. (1999), EU Member States are moving in the same direction as they face similar constraints like changes in patterns of employment across sectors, internationalization, progressive ageing of the population and nore difficult transition from education to work.[468] However, these countries "do so at different speeds, at any given moment the process may be increasing some differences rather than decreasing them".[469] At a European level, "in the past years measures to combat the ICT shortage of skills topped the agenda"[470] and the institutional response to the ICT adoption has been provided in the framework of the eLearning initiative and the European Computer Driving Licence.[471] From the analysis carried out earlier, in the field of ICT it is possible to observe that the introduction of ICT degrees has followed a different pattern across countries. Certainly, cooperation has increased and greater information especially on technology may have had an impact on this development. By looking at the content of the programmes introduced in higher education it is possible to observe that there are more similarities between the ICT courses introduced with respect to the qualification profiles introduced in VET.[472] However, this similar pattern of educational change seems to be more the result of the technological change in terms of adoption of similar technologies and new economic conditions that have created the need for institutions to adjust the education system than as a result of the European Community Policy. The influence of the European policy has been greater for Portugal, that after having become a Member State has found it necessary to modernise its economy and social systems.[473] For the other two countries, given their willingness to expand the principle of subsidiarity in education policy, especially in the German case, it seems to be unlikely that they have been greatly influenced by the EU policy. In the framework of the EU legislation, the Bologna Process aims to create a European higher education area by harmonising academic degree standards and the quality of tertiary

[468] A cross-country analysis of the school-to-work transition has been carried out in Ryan (2001).
[469] Green et al. (1999, p.40).
[470] Leo (2001, p.18).
[471] Leo (2001, pp.18-9).
[472] See tables 4.A, 4.B and 4.C in the appendix.
[473] According to Marçal Grilo (1993), "education system has a key role to play" in this process (p.99). In fact, policy changes in education and other welfare state services were undertaken before the country could become a Member State. Also, after 1986 many reforms were on the agenda to modernize the education system.

education,[474] is a recent development of the EU policy which started in 1999. While trying to develop a common framework, the aims of the Bologna Declaration can be summarized as follows.[475] The first objective is to increase comparability in academic grades across Member States. This aspect is related to the project of creating a common system of higher education based on two cycles. The first would last three years and would provide students with the bachelor's degree whereas the more advanced cycle would last two years and award students with a master's degree.[476] In addition to this, the increase of mobility of students across Member States has been considered as a key point of the programme as well as the development of quality assurance and the cooperation in this area.

The importance of the Bologna Process has been subsequently emphasised in the Prague Communiqué (2001) and the Berlin Communiqué (2003) as this project fits into the broader Lisbon strategy.[477] According to the Bologna Declaration, the process of adjustment of the higher education systems of the Member States should have been achieved by the year 2005. However, "most countries do not currently fit the framework"[478] as they have maintained their traditional system of qualifications and policy changes required for the implementation of the common framework are moving at a slow pace. In the three countries studied in this chapter the process is underway. In Portugal and the Netherlands many reforms have been implemented to create the new higher education system whereas in Germany the process should be completed in some Länder in 2005 and in others by 2010 (Norwegian Ministry of Education and Research, 2005).

The influence of EU policy has been greater than in the VET sector and students' mobility as well as greater transparency in terms of degrees and qualifications are becoming a reality.[479] Nevertheless, the process is slow and so far it is possible to talk about increased similarities across the Member States but it is still difficult to talk about convergence and by taking an historical perspective, it is possible to observe that this is only a very recent development.

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[474] European Commission (2006, p.1).
[475] The objectives of the Bologna Process have been reviewed in the report of the EU Commission (2006, p.1).
[476] Wächter (2004, p.266).
[477] EU Commission (2005b, p.1).
[478] European Commission (2006, p.2).
[479] Green et al. (1999, p.217).

Following on from the analysis of the previous sections it appears that the EU policy has been particularly important for Portugal. This is because it has helped the country modernising the education and training system. Moreover, Portugal has experienced an important transformation as a result of the passage from the authoritarian regime to democracy. Consequently, the education and training systems have experienced major changes and the EU policy has been very influential.

4.9) Discussion

In an earlier section the institutional response in terms of adoption of ICT-related degrees in the period 1980-2002 in VET and higher education has been examined for Germany, the Netherlands and Portugal. The introduction of these degrees has varied across countries both in terms of curriculum and timing. Germany appears to have been an early adopter of ICT-related degrees whereas Portugal seems to have lagged behind. However, once the pattern of introduction of these degrees is compared to the pattern of ICT adoption the overall picture looks quite different. In fact, in this case the institutional response seems to have been closely related to the technological development of the countries examined. In this regard, it appears interesting to look at the achievements of the EU policy and to understand the rationale for intervention.

It is possible to observe that the EU policy has not led the countries examined to converge in terms of introduction of degrees related to the ICT. The EU policy has encouraged and most of the time made effective a greater transparency in terms of degrees and qualifications awarded in the Member States, greater standardization and greater mobility especially at higher education level. The launch of the degrees and qualification profiles related to ICT at the different levels of education and in the three sectors: IT, communication and software, has followed a pattern that is country specific and there is no clear sign of convergence. Was the institutional response given by Member States alone effective? By looking at the timing of the introduction with respect to the pattern of ICT adoption it seems that the response has been effective in Germany and the Netherlands whereas Portugal has needed a longer time to adapt the existing institutional setting. This point raises two key questions: How could EU policy have helped? is an EU response necessary? In addressing these

questions, it is possible to summarize the main conclusion reached from the previous analysis. In VET a European policy is likely to have a more limited impact because this type of education is highly dependent on the national systems of production. That is, this type of training endows workers with skills that allow them to perform specific tasks. This explains why the training is highly dependent on the national system of production. Therefore, a policy defined at country level may be appropriate in addressing the needs in this specific educational sector. Moreover, workers with vocational and training education also have among the lowest levels of mobility (it seems that there has been a quite effective response from countries with respect to the pattern of ICT adoption). In higher education countries have responded in an effective way in order to introduce degrees related to the new technologies. In addition to this, it has been noticed that skill shortages have coexisted with the introduction of the ICT degrees.[480] This is revealing of the length of time necessary to adjust the existing institutional settings when a technological change occurs as has been illustrated in the introductory chapter. In this regard, it seems that the absence of an EU policy concerning the introduction of ICT degrees has given to countries a greater flexibility to address the needs of the labour market. On the other hand, a EU intervention concerning a greater transparency in terms of qualifications and degrees as well as an improvement in the quality control are desirable but they are at the early stages.

From what has been observed so far: there is no clear pattern of convergence in the European countries with respect to the introduction of ICT degrees at vocational and higher education levels. That is, the institutional response to the technological change has not been coordinated by the EU policy. Following the analysis provided here, it seems that what is really necessary is to increase the quality standards and the transparency of degrees and qualifications. By taking a historical perspective it is not possible to see this kind of development but this is a recent and ongoing process.

[480] Please refer to sections 4.4 and 4.5.

4.10) Conclusion

The analysis undertaken in this chapter has been mainly descriptive but it has offered a tentative answer to the research questions: how have European institutions adjusted their education and training systems to deal with the introduction of ICT? Is there a convergence of these different models under the EU policy? The contributions of this work can be summarised as follows. First of all, a new series of data related to the timing of introduction of the ICT degrees in VET and higher education has been constructed by drawing on various national and international sources. After, the pattern of introduction of ICT degrees with respect to the ICT adoption in communication, IT and software has been examined. Finally, the paper has provided evidence of the heterogeneity of European countries in terms of ICT adoption as well as in the education policy with respect to ICT.

Among the findings are that the adoption of ICT has varied across the European countries that have been examined and that the education systems have been adjusted by creating new ICT-related programmes in both VET and higher education. As a general fact, VET is still "flourishing in Europe".[481] However, different institutional responses have been provided across the countries examined in the IT, communications and software sectors. Therefore, trying to model the European educational systems by arguing that there is a unique European model based on vocational education and training whereas the American one is oriented towards general education can reveal a too simplistic view of the European educational landscape and lead to misleading empirical results. That is, the analysis by Krueger and Kumar (2004) does not appear to be accurate and adequate as it does not consider European heterogeneity in terms of institutional response in the education system resulting from the adoption of the new technologies. However, I should acknowledge that I have been unable to provide an alternative model but I have presented what is available in terms of evidence.

The second major finding of the chapter is related to the effectiveness of the response of the different VET systems. The "demand-led" system, represented in this study by Germany has been very effective in providing an early response in terms of

[481] The quote refers to an article by Steedman (2005), "Apprenticeship in Europe: 'Fading' or 'Flourishing'?".

introduction of ICT-related degrees. This is due to the close interaction between government and the private sector that has allowed a faster response to the needs of the labour market. However, this model appears under pressure and is moving towards a greater provision of general skills and a greater participation of the state in the provision of training. That is, this system is to a certain extent becoming more similar to the "supply model". In this regard, the Netherlands have maintained nearly unchanged the core of the VET system and have successfully introduced the ICT degrees. The Portuguese case deserves a specific analysis even if it shares the main characteristics with the supply-led systems because vocational education and training has been abolished in 1974 and re-introduced in the 1980s. Moreover, Portugal has been among the most backward Western European countries over the period considered.

In spite of the influence of the European Union policy, [482] there is no convergence of the systems observed. In fact, important differences across countries remain and the main achievements of the European policy lie in the standardization of the length of the degrees and the increased mobility of university students across countries.[483] Moreover, there is no homogeneity in the ICT-related degrees that have been introduced. On the other hand, the organization of the vocational education and training remains nearly exclusively in the hands of the Member States and there is no convergence in the VET systems with respect to the introduction of the ICT degrees.[484] In fact, the guidelines of the Copenhagen Declaration are still far from being effectively implemented.

In conclusion, it is difficult to talk about an "European response to ICT" in the areas of VET and higher education as the "Old Continent" is characterized by different systems that have dealt with the adoption of the ICT technologies in dissimilar ways. Whether an European intervention is desirable and whether the EU policy by creating a greater homogeneity in the education systems would have led European Member States to respond more effectively and more rapidly to the adoption of new

[482] The European policy has been important especially for Portugal, the more backward country, in helping to establish an educational system mainly in two ways: by providing funding and creating the need for modernization.

[483] Green et al. (1999, p.217). They show that the number of Erasmus and Lingua-funded students was equal to 300 in 1987-88 and 61,000 in 1993-94. Moreover, the number of institutions receiving or sending students was equal to 400 in 1987-88 and 1,400 in 1993-94.

[484] It is important to notice that the EU policy has led to the homogenization in terms of the length of the undergraduate courses.

technologies still remains an open question. In fact, it seems that the introduction of ICT-related programmes has been closely related to the pattern of ICT adoption. That is the institutional response in the education and training systems has depended on the level of development of the new technologies.

Chapter Five

RETURNS TO EDUCATION ACROSS EUROPEAN COUNTRIES

5.1) Introduction

In this chapter returns to education will be estimated by using the changes in compulsory schooling laws as instrumental variable. Chapter five presents a slightly different analysis with respect to the previous ones and I will explain the motivation for this study. There are two elements that have been observed and represent the starting point of the analysis. First, the possible difference between private and social returns to education that can be an important justification for government intervention. As suggested in an earlier chapter, education can be considered as an investment undertaken by individuals to increase their productive capabilities. In addition to this, the existence of externalities may lead to the formation of social returns which would justify government interference. While reviewing the existing literature, Venniker (2000, pp.2-3) identifies three types of human capital externalities. First, "static human capital externalities" when investement in education increases the productivity of other factors of production. Second, "dinamyc human capital externalities" which are related to the positive effects that higher levels of education can have on the adoption of new technologies and on the process of learning-by-doing. The others, "non-pecuniary externalities", refer to the positive effects of education on factors like crime reduction, social cohesion and family health-care. The second element that has been observed is that the use of school-leaving age laws as an instrument allows examining the effects of the expansion of compulsory schooling on those affected by the schooling reform. That is, returns are estimated for those students who otherwise would have left school earlier. This aspect is related to the question of equity which has been described before as being one of the motivations underlying the thesis.

The research question that will be addressed in this chapter is: how do returns to education vary across European countries? Also, the analysis will focus on the gender issue to develop an understanding of the possible existence of a gender specific pattern.

The estimation of the returns will be carried out in a consistent manner over time and across European countries whereas most of the existing studies have only focussed on a short-time period or on single country analyses. Many scholars, including Autor et al. (1997) and Card (1999), suggest that this is an area that calls for further study. The study will cover seven Western European countries over the period 1985-2000. Another contribution will be methodological. The cross-country analysis will be carried out by

using minimum school-leaving age laws as instruments. These tools seem to be among the most accurate instruments available[485] and they have only been used for single country analyses or to compare the returns across a small number of countries but by using non comparable datasets. Therefore the use of a unique and comparable dataset across European countries as well as the compulsory schooling laws as an instrument can be considered as an innovative approach in the field. Moreover, this is an instrument but also provides a measure of returns before and after the reform.

In this chapter I will proceed as follows: in the next section I will review the existing literature related to the returns to education by highlighting how the difficulties in this type of estimation have been addressed and what are the most accurate findings that have been reached so far by scholars. After, I will describe both the methodology that I will use for the empirical analysis and the data sources. In section five I will derive some descriptive statistics to provide an initial overview of the changes over time of the main variables. Then, the empirical analysis will be described and comments on the results will be provided. A discussion will follow in order to provide an interpretation of the results and to position the findings in the existing literature. Section eight will provide a link between this chapter and the framework of the overall thesis whereas section nine will conclude the study.

[485] Authors like Card (1999) have suggested that this represents one of the most accurate techniques.

5.2) Literature review

The formulation of schooling participation as an investment has been one of the fundamental conceptualizations of the human capital theorists like Becker (1964) and later Mincer (1974).[486] The following review will focus on the specific literature related to the estimation of the returns to schooling, the empirical difficulties as well as the state-of-the art findings and one of the major gaps in the existing literature that I will try to fill with this work.

There has been an extensive amount of research done on calculating returns to formal education. The basic model from which all the empirical analysis has been derived owes its origins to Mincer (1974). According to this model, the individual logarithm of earnings is a linear function of the number of years of schooling, experience (measured as "potential experience", that is the difference between the individual's age and the age at which he left school) and an error term. The crucial assumptions of this model are: linearity and homogeneity of the returns to education as well as exogeneity of the schooling decision. That is, there are no variables that affect both the schooling decision and the level of earnings that are not included in the model. The empirical analyses that have made use of this model have estimated the returns to an additional year of schooling to vary from 6 to 10 percent.[487] In spite of the powerful simplicity of this model, the underlying assumptions are quite strong. The possible sources of bias arising from the estimation will be reviewed in detail in section 5.6. Among these, the ability bias remains the main difficulty in the estimation of the returns to schooling, that is the endogeneity of the education decision. Some unobservable characteristics of the individuals are correlated both with the education decision but also wages, which, it is generally assumed, bias the estimates upwards.

One strategy that has been employed is to rely on so called natural experiments to identify the effect on earnings of exogenous changes in education. Such experiments consist of changes in the schooling participation of some individuals that are independent of their own characteristics. Institutional and policy changes can be seen as natural experiments where some cohorts of individuals see their education opportunity

[486] A discussion of the concept of human capital has been presented in section 1.3.
[487] Please refer to Psacharopoulos (1994), Card (1999) and Psacharopoulos and Patrinos (2004) for an overview of the estimates and the studies in the existing literature.

changed independently of their own abilities and motivation. From an empirical perspective, the estimation of this type of model requires the use of the instrumental variable (IV) technique and thus, the choice of the instrument and the control of its validity are extremely important.

Various instruments have been used in the literature in order to find variables positively correlated with schooling but not with personal capacities. Examples include quarter of birth and school leaving rules used by Angrist and Krueger (1991), college proximity employed by Kane and Rouse (1993) for the United States as well as by Flabbi (1999) to estimate the returns to schooling for Italian workers. Instruments related to the family background have been used in a number of studies. These include father and mother's level of schooling, spouse's education but there are serious doubts concerning their validity. Also, twins and siblings have been considered as valuable natural experiments. The underlying rationale that has led scholars like Ashenfelter and Krueger (1994) and later Ashenfelter and Rouse (1998) to use this kind of instrument is that it is possible to use the individual's twin in order to generate a counter-factual variation in the level of schooling. In fact, it is possible to estimate the returns to different levels of schooling without introducing any bias given the similarity of the individuals. This approach holds under the assumption that these are individuals who share similar characteristics with respect to the intellectual abilities and social skills but differ for the level of schooling experience. In addition to this, scholars have also used less conventional instruments in order to capture the exogenous variation in schooling attendance. Other examples of more innovative instrumental variables used in the literature include the Vietnam draft and the massive schooling construction programme that took place in Indonesia between 1973 and 1978.

However, some of the above instruments do not seem to perform well under the Bound et al.'s (1995) validity checks. This is because variables like the ones related to the family background have proved not to be completely exogenous and the different schooling choice can be determined by dissimilar abilities as Card (1999) has pointed out.[488] On the other hand, instruments like the lottery numbers considered by Angrist and Krueger (1992) for the period 1970-73 as well as the schooling investment used by Duflo (2001) seem to be quite impractical and not easily applicable for cross-country comparisons.

[488] Card (1999, p.64).

In light of the great variety of instruments that have been used, some of which of dubious validity, changes in the school-leaving age legislation seem to be appropriate. As Card (1999) suggested, in his insightful review, the use of these tools is "one of the most important directions of research in the recent literature on schooling".[489] In the existing literature this type of instrumental variable has been used for the estimation of the returns to education for many European countries. Among the existing studies, starting from Angrist and Krueger's (1991) pioneering analysis, returns to schooling have been estimated for Portugal by Vieira (1999), for Italy by Flabbi (1999) and for Ireland by Callan and Harmon (1999). For the United Kingdom, Harmon and Walker (1995, 1999) have improved the quality of the estimation in their second study by controlling for the changes in schooling participation and returns independent of the increase in the level of minimum compulsory schooling of 1947 and 1973. Later, Oosterbeek and Webbink (2007) have used the same technique to estimate the returns to schooling for the Netherlands, Grenet (2004) for France, Pischke and von Watcher (2006) for Germany as well as Meghir and Palme (2005) for Sweden. Finally, Oreopoulos (2003) has estimated separately the earnings from schooling for Canada, the United Kingdom and the United States. Table 5.1 summarises the main methodology, the data sources and the results of these studies.

[489] Card (1999, p.44).

Table 5.1. Summary of the studies that make use of changes in the school-leaving age (SLA) as IV

Study	Country	Sample	OLS[490]	IV[491]	Instruments
Single country					
Angrist and Krueger (1991)	US	US Census 1980; Males born between 1930 and 1939	0.0711 (0.0003)	0.0891 (0.0161)	Season of birth and school attendance laws
Harmon and Walker (1995)	UK	UK FES 1978-1986; Males 16-64	0.061 (0.001)	0.152 (0.015)	SLA changes
Harmon and Walker (1999)		UK GHS 1992; Males 16-64	0.049 (0.000)	0.140 (0.005)	SLA changes
Callan and Harmon (1999)	Ireland	Survey of Income Distribution, Poverty and Usage of State Services 1987; Male Employees 18-64	0.074 (0.005)	0.101 (0.013)	SLA changes
Vieira (1999)	Portugal	Quadros de Pessoal 1986-92; Males 14-65	0.0779 (160)	0.0150 (1.16)	SLA changes
Flabbi (1999)	Italy	Bank of Italy Survey 1991; Employees born between1945 and 1962	0.017* (0.002) 0.023** (0.002)	0.053* (0.012) 0.030** (0.012)	SLA changes and geographical proximity
Aakvik, Salvanes and Vaage (2003)	Norway	Statistics Norway; 10 male cohorts born between 1948 and 1957	0.0749 (0.0005)	0.1026 (0.0024)	Reform of the comprehensive school system and SLA changes
Grenet (2004)	France	Enquete Emploi; Workers 25-60	0.066 (0.0004)	0.018 (0.041)	SLA changes
Meghir and Palme (2005)	Sweden	Individual Statistics (IS) project 1948-1953; Males	0.028 (0.007)	0.036 (0.021)	Swedish curriculum reforms
Pischke and von Watcher (2006)	Germany	Qualification and Career Survey; Micro Census; IAB Employee Sample; Workers 15-65	0.083 (0.0004)	0.005 (0.006)	SLA changes

Note: * Male employees
** Female employees
Sources: studies reviewed in the table and Harmon et al. (2003)

[490] Coefficient of the rate of return to education obtained by using the ordinary least squares technique (OLS).
[491] Coefficient of the rate of return to education obtained by using the instrumental variable technique (IV).

Table 5.1. Summary of the studies that make use of changes in the school-leaving age as IV (cont'd)

Study	Country	Sample	OLS	IV	Instruments
Single country					
Oosterbeek and Webbink (2007)	Netherlands	Wage Structure Survey (LSO) 1995; Workforce 16-65		-0.018^ (0.019)	SLA changes in vocational programme
Cross-country					
Oreopoulos (2003)	Canada, UK and US	Canada: Census 1971, 1981-2001 Birth cohorts 25-64^^	0.088 (0.0008)	0.084 (0.0103)	SLA changes
		UK: GHHS 1983-98; Northern Ireland Continuous Household Surveys 1985-98 Birth cohorts 32-64^^	0.147 (0.0058)	0.158 (0.0491)	
		US: Census microdata 1950-2000; Birth cohorts 25-64^^	0.079 (0.0005)	0.133 (0.0118)	
Trostel et al. (2002)	28 worldwide countries	ISSP 1985-95; Employed individuals 21-59	0.048 (0.001) pooled	0.064 (0.005) spouse 0.072 (0.054) father	Spouse's education and parents' schooling

Note: ^ Difference in Difference approach
^^ Males 25-64 (for the UK: 32-64) and females who were aged 14 in the years that the school-leaaving ages were available
Sources: studies reviewed in the table and Harmon et al. (2003)

In spite of the positive returns that have been found in various studies shown in table 5.1 there are some shortcomings in these analyses. For instance, Harmon and Walker (1995) have not controlled for cohort fixed effects as suggested by Card (1999) whereas Oosterbeek and Webbink (2007) have used samples that change in composition over time. Moreover, there are some unexpected findings: in Germany and France the authors have estimated zero returns to schooling after an increase in compulsory

schooling.[492] Most of the national studies presented in table 5.1 show higher returns to education for the IV estimates than OLS. Possible explanations for this will be provided in section 5.6. In spite of the positive returns found in the literature, the greatest limitation consists of the fact that these analyses are single country studies, using different and non-comparable datasets.

What is necessary is a cross-country analysis in order to understand the evolution and the main differences across countries. Oreopoulos does compare three countries: Canada, the United Kingdom and the United States. However, he uses three different datasets: the Census for Canada, the General Household Surveys and the Northern Ireland Continuous Survey for the United Kingdom and the Census microdata for the United States. The only study using a unique dataset is by Trostel et al. (2002). However, the authors use spouse's education and parents' schooling level as instrumental variables and these instruments do not seem to be appropriate in this type of empirical analysis as they appear to be correlated with the unobserved characteristics that affect both the schooling experience and earning level of the individual.[493] Therefore what is missing from the existing literature is a consistent cross-country, cross-time comparison of the returns to schooling by using changes in minimum compulsory schooling laws as instrumental variables and by using a common and consistent dataset for the countries included in the study. This is where I would like to make my contribution to the literature with this work.

The purpose of this paper, like Lleras-Muney (2002) or Oreopoulos (2003) Pischke and von Wachter (2006) is to follow the Harmon and Walker (1995) identification strategies and rely on change in school leaving age to identify exogenous changes in education. The next section describes the methodology that will be used in order to fill this major gap that has not been addressed so far in the existing literature.

[492] Also Oosterbeek and Webbink (2007) have estimated zero and negative returns from an increase in the length of a basic programme of vocational training.
[493] Please refer to Card (1999) for a technical analysis of the problems with using family background as instrumental variable.

5.3) Methodology

The analysis carried out in this chapter is based on a sample of seven Western European countries over the period 1985-2000 taken from the International Social Survey Programme (ISSP) dataset.[494] These countries are: France, Ireland, Italy, the Netherlands, Portugal, Spain and the United Kingdom.[495] The number of countries has been reduced with respect to the initial ISSP sample. This is because these are the Western European countries included in the survey for which data related to compulsory schooling laws are available but for which there has been no regional variation in the implementation of the school-leaving age laws.[496]

First, descriptive statistics will be presented with respect to the main variables that will be used in the study. These are: school-leaving age laws, schooling participation, earnings and control variables. The purpose of the exercise is to show how these variables have changed over time for the cohorts of interest in aggregate and at country level and to provide some initial thoughts on the analysis that will be carried out subsequently. The empirical analysis will employ both Ordinary Least Squares (OLS) and two-stage least squares (2SLS) techniques, applied to a standard Mincerian wage equation. The basic earning function will be estimated by using years of education as the measure of schooling. The first regression will be run by using the OLS technique for the seven countries included in the study over the entire period for which the data are available, that is 1985-2000. After, the same analysis will be carried out using the instrumental variable technique (IV). The second estimation will be run at country level and will be an attempt to replicate Trostel et al.'s (2002) work in order to check for the robustness of the results. Therefore, country OLS regressions will be run for both the male and female population between 1985 and 1995 for twenty-eight countries. After, the IV analysis will be carried out on the same sample by using spouse's education as instrumental variable as Trostel et al. (2002) did in their paper. A critical analysis will be provided in order to show what are the limitations of this instrument and of the other tools used in this paper. Then, changes in school-leaving age laws will be used as instrumental variable on this sample to estimate the returns to education for the male

[494] Section 5.4 provides a description of the dataset. The participation of these countries varies across the different waves of the survey.
[495] Some of the countries examined in chapters three and four have been excluded from the analysis of this chapter. Section 5.4 provides an explanation for this.
[496] Other sample of countries will be used mainly to provide robustness checks.

and female population separately for the countries for which the data are available. Finally, OLS estimates related to the returns to education before and after the first change in compulsory schooling laws will be provided.

A further check for robustness has been taken on by replicating the analysis with the data used by Trostel et al. (2002) in their paper. These data have been kindly provided by Professor Walker. The reason for doing this is that the coding of the microdata of the international social survey that will be used has changed over time. This is because different methods of coding have been adopted to identify the variables across the different waves. Therefore, it seems important to provide a further check on the accuracy with which the data have been combined. Consequently, following the technique described by Bound et al. (1995) a check to control for the validity of the instrument will be carried out. In addition to this, the empirical findings will also be compared with the results reached by other scholars.

This chapter attempts to understand how returns to education vary across the different European systems, whether the changes in compulsory schooling laws have had a more persistent effect in some countries than in others with respect to the evolution of participation rates and earnings. Although the choice of countries has been dictated by data availability, the countries in the sample are representative of the main European models as they belong to the different social models described in chapter two. Following Green et al.'s (1999) argument, Ireland and the United Kingdom belong to the Anglo-Saxon system whereas France shares many characteristics with the other continental countries. On the other hand, the Netherlands share common features with countries that belong to the liberal market model and have developed a "quasi-market system of education".[497] In addition to this, Italy, Portugal and Spain symbolize the Southern European countries.

One of the originalities of the paper relies on the use of a unique and comparable dataset for the seven European countries under study. The other consists of the use of the school-leaving age laws as instrumental variable to determine the impact on earnings of an exogenous change in schooling attendance. As previously mentioned this institutional change has been used only for single country studies or across three countries by using datasets that are not readily comparable; here the cohort analysis is

[497] Green et al. (1999, p.97).

undertaken for seven European countries over the period 1985-2000. Another aspect that will be analysed is the gender issue, as returns are estimated for both males and females. This seems to be important as "many studies have investigated male and female earnings but the number that reports separate schooling coefficients is much smaller".[498] Following the findings of the majority of the existing studies, surveyed by Altonji and Blank (1999) as well as by Blau and Khan (2000), returns to education for women are expected to be greater than for men. Explanations put forward in the literature refer to the quality of educational attainment, job characteristics and occupational choice as well as the endogeneity of schooling and work experience. Dougherty (2005) has shown how important is the "discrimination, taste and circumstances hypothesis".[499] By examining the National Longitudinal Survey of Youth 1979, he shows that education not only increases women's skills and productivity but also reduces factors like discrimination that are important at lower levels of education. In addition to this, preferences concerning certain type of low-paid occupations or professions that give women more time to take care of children may change according to the level of schooling.

5.4) Data

Two types of data will be used for the analysis: data related to the changes in the school-leaving age laws that will be used as instrumental variables and data related to schooling, earnings and other control variables that represent the basis to carry out the empirical study. Data related to changes in the minimum levels of compulsory schooling have already been presented in chapter three, table 3.1. A discussion concerning the historical evolution of compulsory education in Europe, the sources of these data and summary statistics has been provided in sections 3.2 and 3.4.1 respectively.

The other data have been extracted from the ISSP. This is a unique dataset that contains data that are comparable over time and across a large number of countries. The ISSP is

[498] Dougherty (2005, p.971).
[499] Dougherty (2005, p.970). The author does not find supporting evidence for the other hypotheses.

an annual survey that has been carried out in a varying number of participating countries since 1985. Each cross section is identical across countries and includes all the variables necessary for this type of study. This has been demonstrated by Trostel et al. (2002). The programme was founded by four countries: Australia, the United Kingdom, the United States and West Germany; it has expanded over time and in the last editions it included thirty-nine participating countries. According to many researchers, the ISSP "has proved to be an important development in the area of cross-national research"[500] as it covers both dimensions: cross-time and cross-section. The questionnaire that is administered in the member countries covers the fields of sociology, social policy and politics. The questions addressed to the individuals are related to their age, sex, social background, marital status, level of education, occupation, political and religious orientation as well as union participation and many others. The main advantage in the use of this international source is represented by the fact that data are derived from a common questionnaire,[501] homogenous methods for data collection are used and also the same technique for the construction of the dataset is followed. However, the coding of the variables often changes from one wave to another (especially so during the first years of the survey, after 1996 the nomenclature becomes much more homogenous and readily comparable) and this has required a lot of work in terms of recoding and controlling for the classification compatibility.

Data are available in a consistent way for the United States also. However, it will not be possible to estimate the returns to education for the United States as there is no information related to the state of residence of the individuals interviewed and the changes in school-leaving age laws have been implemented at different times across the American states. Consequently, the empirical results that will be obtained for the other European countries will be compared to those found for the United States by other scholars like Trostel et al. (2002) and Oreopoulos (2003). Germany has been excluded from the analysis even though it has been studied in the previous chapter mainly for two reasons. First, Germany was divided into two countries after the Second World War and schooling laws have changed at different points in time across the German Länder; (see Pischke and von Watcher (2006), table 1, for the timing of introduction of the ninth grade in basic track of secondary school across the German states). Moreover, as a result of the important migration that has occurred after reunification, it is not easy to

[500] Ghiolla Phádraig (2003, p.1).
[501] This advantage has been also highlighted by Harmon et al. (2003, p.121).

reconstruct the entire schooling and working experience of the individuals interviewed. Other countries that have been studied in chapter three have been excluded from the analyis of the chapter either because of data availability or because the law has been implemented gradually across regions or municipalities.

For the empirical analysis it is possible to go further back in time as data related to the age of the population is available and this allows undertaking the cohort analysis. The participation varies over time and across countries but on average for each wave in each country, 3,000 individuals have answered to the questionnaire. The sample size related to each country that will be used for the analysis can be observed in table 5.2. As it will be clarified later only working individuals and employees have been kept. Therefore for the majority of the countries in the sample the number of observations used is less than 3,000. The ISSP has been administered by the same national institutions over the period considered. Data are available for the United Kingdom for the entire period, for Italy for fourteen years, for Ireland and the Netherlands for eleven years. In Spain the survey has been administered during eight years whereas in France and Portugal for four years. The fact that for some countries data are not available for the entire period considered does not seem to cause any problem. This is because what matters here is the cohort analysis. Therefore, even by considering a small number of waves of the survey it is possible to compare returns to education between cohorts who have experienced the reform and those who have not. The time series element of the data will not be used and additional waves of the survey are only used to increase the population observed. Having an unbalanced sample for this type of analysis is acceptable.

5.5) Descriptive statistics

In what follows some preliminary and partial observations are provided for the variables that will be of interest for the empirical analysis. Table 5.2 provides summary statistics for years of education, age and hours worked for the sample of seven Western European countries studied in this chapter.

Table 5.2. Summary statistics of the ISSP waves for years of education, age and hours worked*

Country		Males			Females			
	number of waves	sample size	mean educyrs	*standard deviation*	sample size	mean educyrs	*standard deviation*	t-test
France	4	1469	13.95	3.97	1241	14.22	3.69	1.82
Ireland	11	1820	12.42	3.13	1441	12.99	2.80	5.41
Italy	14	2141	11.52	3.95	1304	12.04	3.90	3.77
Netherlands	11	2114	13.65	4.19	1241	13.76	3.67	0.77
Portugal	4	740	8.55	4.55	746	8.58	4.73	0.12
Spain	8	717	11.49	4.52	433	11.53	4.63	0.14
United Kingdom	16	3635	11.68	1.94	3666	11.70	1.91	0.44
	number of waves	sample size	mean age	*standard deviation*	sample size	mean age	*standard deviation*	t-test
France	4	1469	40.85	9.37	1241	38.43	9.35	6.71
Ireland	11	1820	38.47	10.61	1441	36.35	10.43	5.71
Italy	14	2141	41.15	10.40	1304	38.44	9.95	7.54
Netherlands	11	2114	38.30	9.19	1241	35.68	9.13	7.99
Portugal	4	740	39.90	10.69	746	37.78	10.03	3.94
Spain	8	717	38.30	10.22	433	35.93	10.13	3.82
United Kingdom	16	3635	40.11	11.05	3666	39.99	10.59	0.47
	number of waves	sample size	mean hours worked**	*standard deviation*	sample size	mean hours worked	*standard deviation*	t-test
France	4	1443	42.10	8.64	1201	35.09	10.10	19.23
Ireland	11	1790	42.47	10.12	1420	33.37	12.30	22.99
Italy	14	2131	33.49	25.53	1302	30.71	40.18	2.50
Netherlands	11	2082	39.61	7.17	1228	29.60	9.16	34.92
Portugal	4	739	43.73	10.06	746	38.51	9.84	10.11
Spain	8	675	41.28	9.53	412	35.89	13.92	7.57
United Kingdom	16	3579	44.23	9.95	3607	32.05	30.24	22.90

Note: *these data are related to the post-education working age population (age between 22 and 65), working individuals and employees only
** hours worked per week
Source: statistics derived from the ISSP dataset

It is important to notice that for the previous table and the remaining of the empirical analysis some observations of the original sample of the ISSP Dataset have been excluded. In fact, only observations related to the active population (people of age between 22 and 65), working individuals and employees have been kept (students and people who are retired have been excluded from the analysis as they do not work). These correspond to standard assumptions used in the literature. Also, unemployed have been excluded as the interest of the analysis is to estimate returns to education. That is,

unemployed do not work, they earn a minimum wage that does not depend on the market but is set by institutions. This would introduce some selection in terms of underestimating the returns to education. However, given the small share of unemployed in the majority of the countries examined, it seems that this assumption will not create a major bias in the estimation. This is shown in table 5.A in the appendix.[502] Moreover, self-employed have been kept out because data related to wages for this category of workers are very often poorly reported. In this regard, Klepper and Nagin (1989) acknowledge the difficulty of controlling for the unreported self-employment income.

What can be observed from table 5.2 is that average years of education differ across countries. In Ireland and Italy women exhibit higher levels of education than men whereas for the other countries the difference is not significant. Portugal and Spain exhibit the lowest levels[503] whereas France and the Netherlands show the highest levels of average education. The variable related to age is quite homogenous across countries. The male population that has been interviewed in the framework of the survey is on average older than the female population with the exception of the United Kingdom where the difference is not significant. On the other hand, hours worked vary across countries. On average women have worked fewer hours per week than men between 1985 and 2000 for the countries observed.[504] Among the male population English have worked on average 44.23 hours their Italian counterparts has worked only 33.49 hours. This is consistent with the pattern illustrated by Blanchard (2006b).

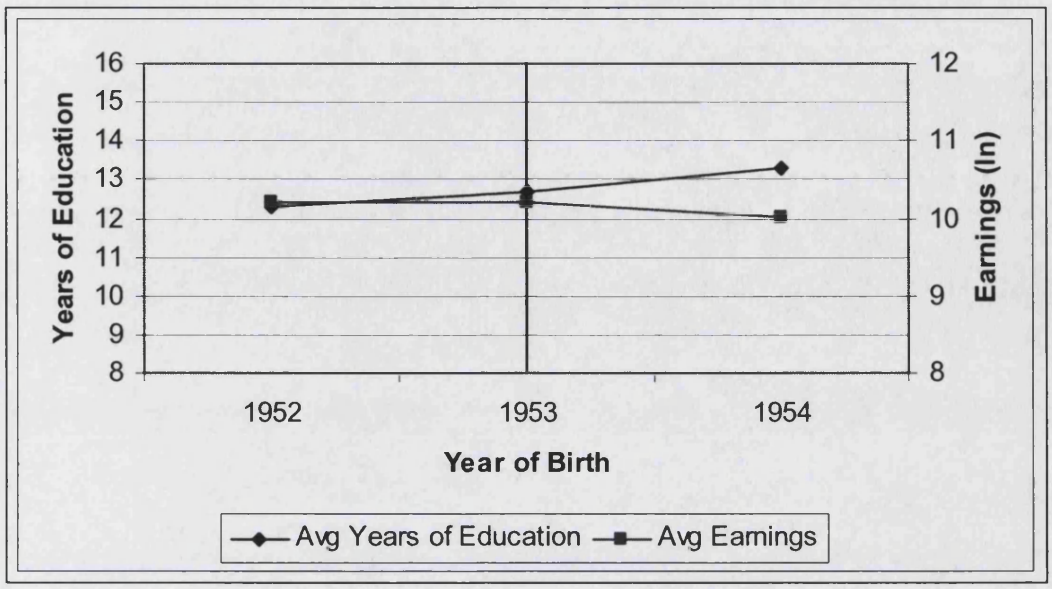
Before estimating the returns to education and examining the impact of the exogenous change in schooling participation caused by the changes in compulsory schooling laws, it would be interesting to provide some descriptive evidence concerning the variables of interest: average years of education and average earnings.[505] These statistics will be displayed for the population of the seven Western European countries according to the year of birth. This is because the interest is to look at how these variables have changed across the different cohorts. Therefore, in the figures that follow the evolution of

[502] At 11 years of education unemployment varies between 3.94 percent in Ireland and 14.71 in Spain. On the other hand, at 14 years, the share of unemployment varies between 4.60 in the United Kingdom and 14.16 in Spain. It is interesting to notice that unemployement rates are lower for individuals with higher levels of education in the majority of the countries examined but there are exceptions.
[503] This pattern has been described in chapter 3, section 3.4.2.
[504] The high standard deviation for Italy is unexpected and may be related to some problems in the survey.
[505] Earnings are annual data, have been converted into a common currency, the US dollar and deflated with the price index of every single country. In the graphs they are presented in logarithmic scale.

average years of education and average earnings will be presented for the cohorts of the countries included in the study. The lines drawn in the graphs correspond to the changes in compulsory schooling laws considered here with respect to the cohort they have affected. For example, in the case of France, (figure 5.1) individuals born in 1953 were the first to be affected by the schooling reform of 1967. This is because these individuals turned fourteen in the year when the Berthoin reform was implemented and consequently had to stay in school two years longer.[506] In the same graph, average earnings are shown according to the different cohorts. Each point of the line represents the average logarithm of the annual income of the individuals born in a given year over the period 1985-2000.[507] The same methodology has been used for average years of education.[508] That is, the interest is to observe the variables for the cohorts that have been affected by the reform and for those who have not. These can be defined as pre-reform and post-reform cohorts. In the graphs presented in the following pages earnings and years of education are shown for the cohorts immediately before and after the first reform. For those countries that experienced multiple passages of the law the graphs related to the subsequent policy changes are shown in the appendix. This analysis will provide an initial insight on what may have been the effect of an increase in the school-leaving age on the returns to education. In the next section the empirical estimation will be carried out.

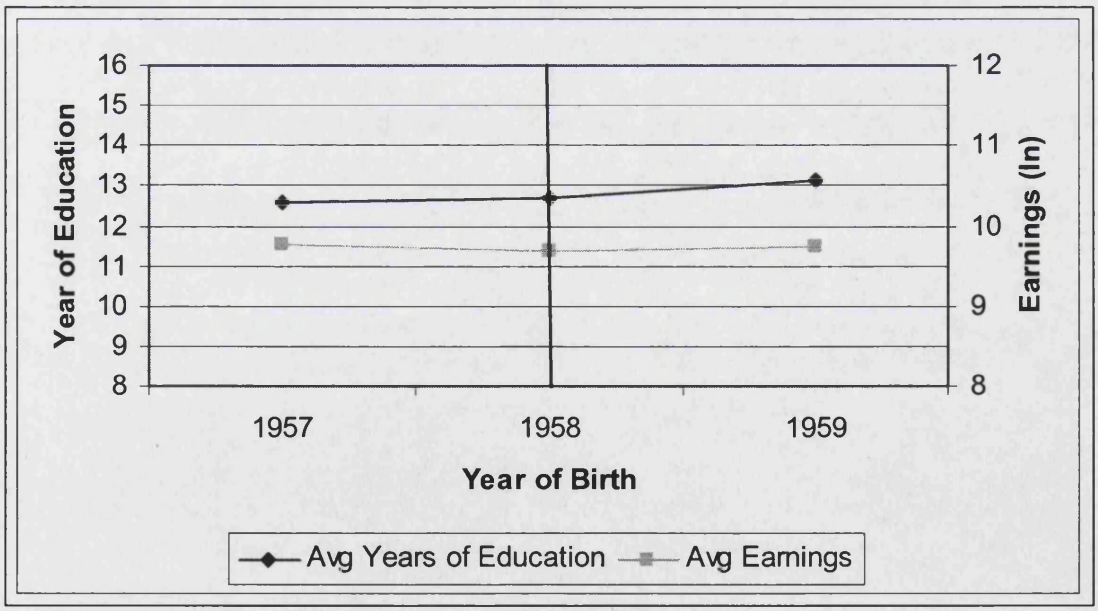
[506] The timing of the implementation of these reforms has been shown in table 3.1.
[507] This type of graphs has been presented for France by Grenet (2004) by using data of the Enquete Emploi.
[508] A different scale has been used for the two variables. Average years of education goes from 8 to 16 whereas average earnings from 8 to 12. This is because average earnings exhibit less variation as they are measured in logs.

Figure 5.1 Distribution of average years of education and average earnings for individuals born between 1952 and 1954 in France



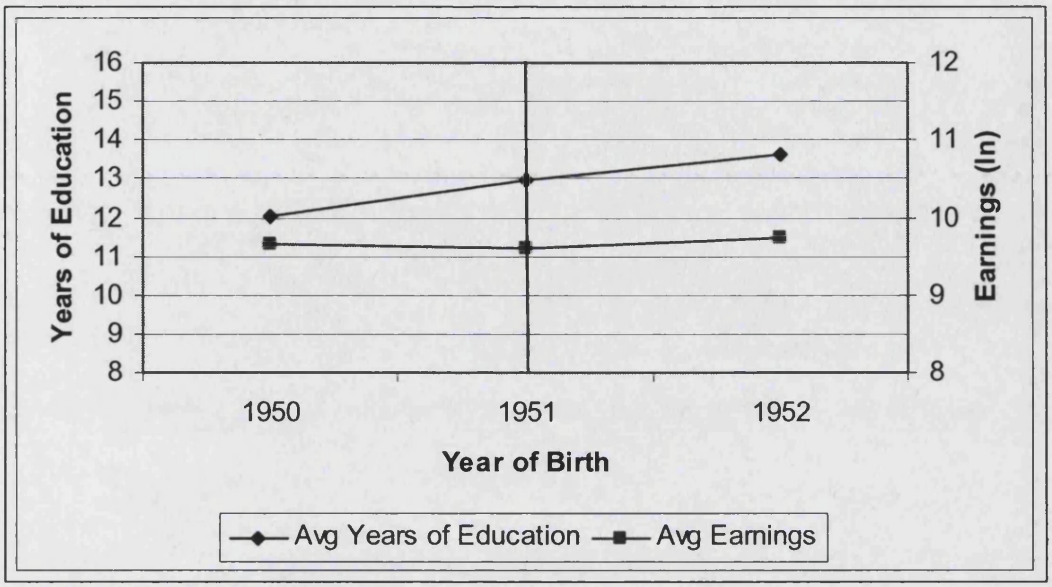
Source: derived from ISSP Dataset used for the empirical analysis

Figure 5.2 Distribution of average years of education and average earnings for individuals born between 1957 and 1959 in Ireland



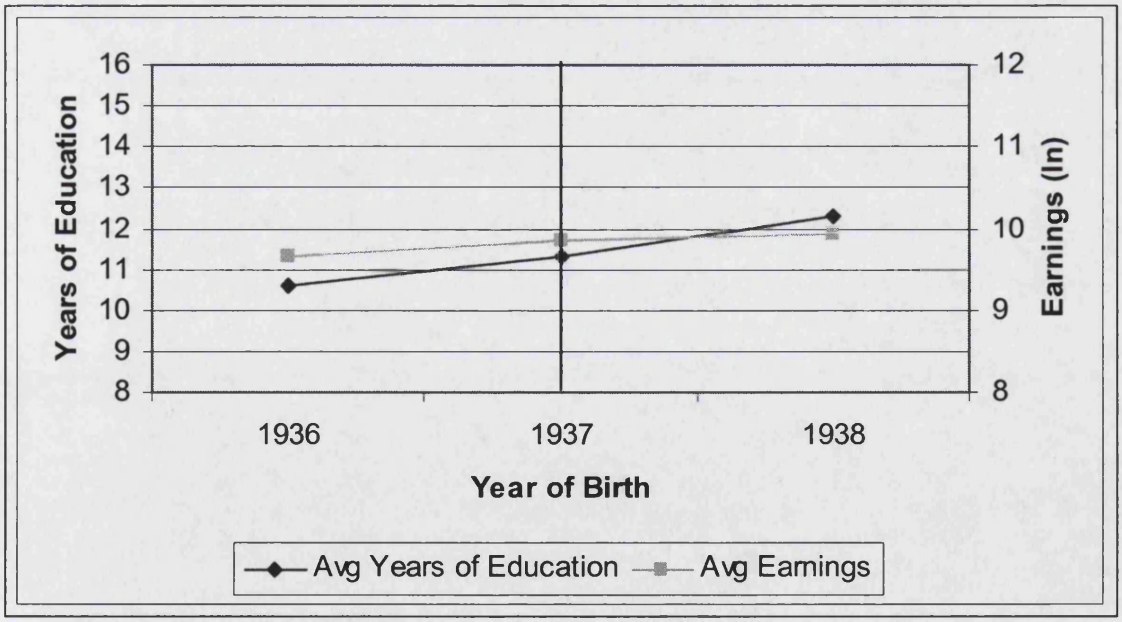
Source: derived from ISSP Dataset used for the empirical analysis

Figure 5.3 Distribution of average years of education and average earnings for individuals born between 1950 and 1952 in Italy



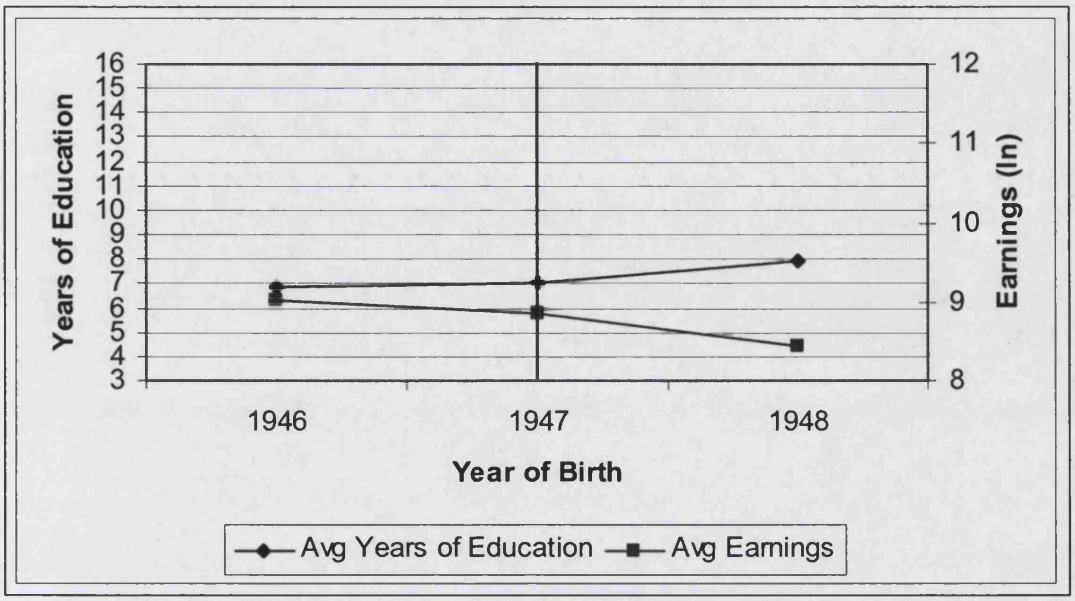
Source: derived from ISSP Dataset used for the empirical analysis

Figure 5.4 Distribution of average years of education and average earnings for individuals born between 1936 and 1938 in the Netherlands



Source: derived from ISSP Dataset used for the empirical analysis

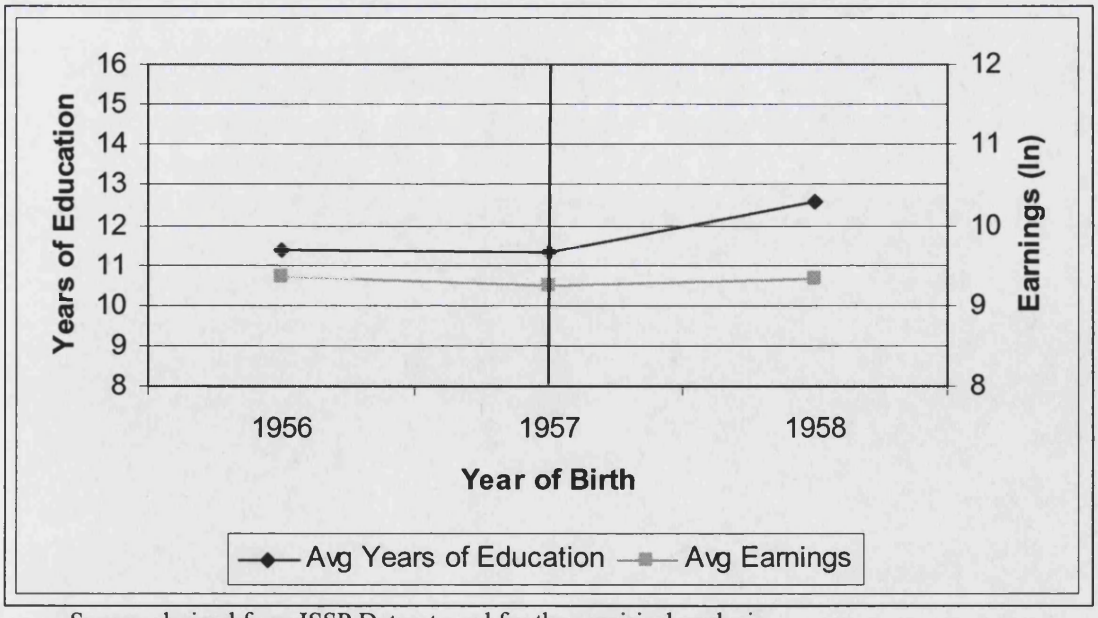
Figure 5.5 Distribution of average years of education and average earnings for individuals born between 1946 and 1948 in Portugal*



Note:* The first schooling-law change for Portugal applied to men only. The implementation of the equivalent change in legislation for women occurred in 1960. The two subsequent changes applied to the entire population

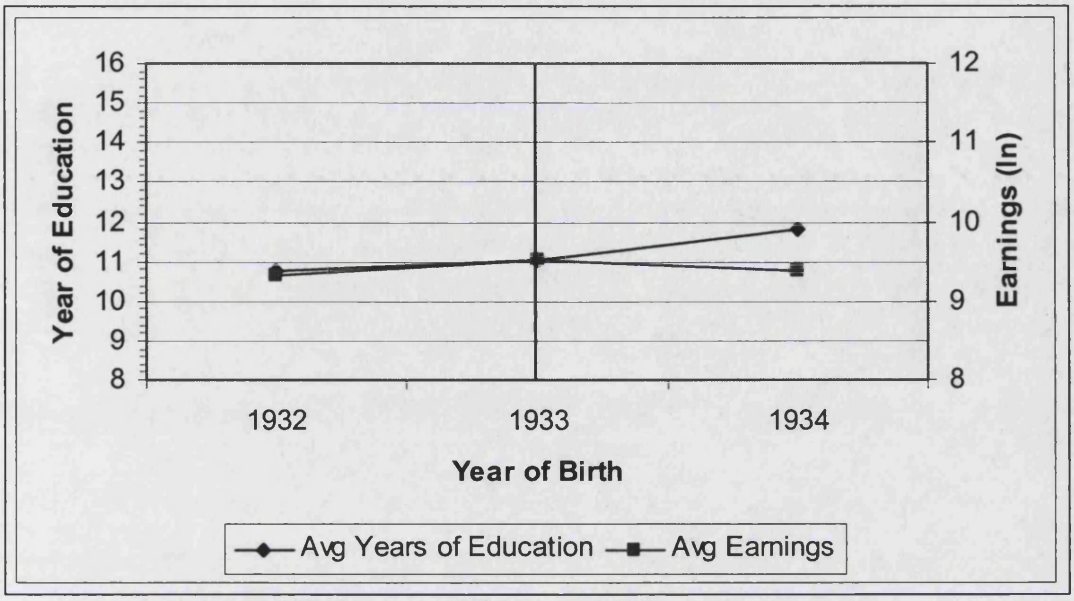
Source: derived from ISSP Dataset used for the empirical analysis

Figure 5.6 Distribution of average years of education and average earnings for individuals born between 1956 and 1958 in Spain



Source: derived from ISSP Dataset used for the empirical analysis

Figure 5.7 Distribution of average years of education and average earnings for individuals born between 1932 and 1934 in the United Kingdom



Source: derived from ISSP Dataset used for the empirical analysis

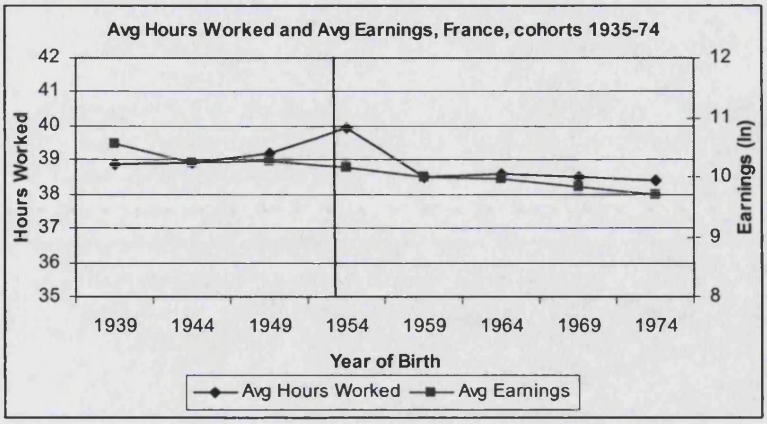
Average years of education are expected to increase after an increase in the number of years of compulsory schooling. By looking at the graphs it seems that for the majority of the countries examined, average years of education have increased after the reforms with the exception of Spain after the second schooling reform (see appendix, figure 5.6b). This anomaly can be explained by the fact that after the second change in compulsory schooling law only 24 observations remain (see table 5.3). Moreover, the waves of the survey are recent and cover the period 1993-2000. Therefore, there is a selection problem as the sample only includes people who have left school early enough to have been observed. Also, it is possible to observe that the early cohorts in Portugal and Spain presented much lower levels of average education with respect to the other countries in the sample.

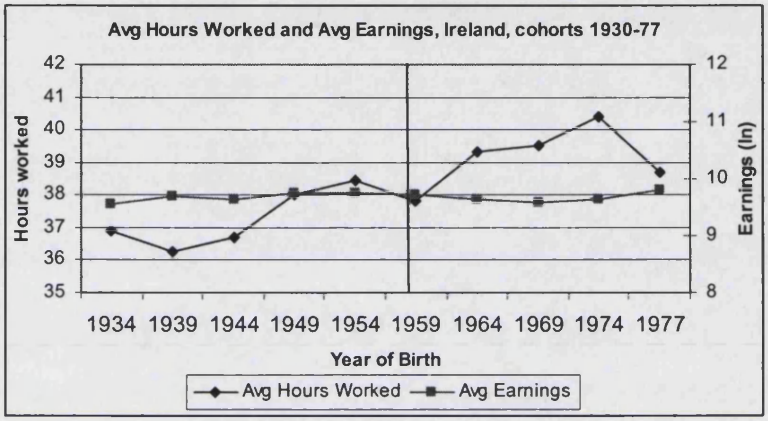
According to the standard human capital model, older workers should, *ceteris paribus*, earn more. That is, wages are expected to increase with age up to a certain point. In this case the graphs show the reversed situation as wages go from the older to the younger workers. So that earnings are expected to exhibit a decreasing pattern. On the other hand, more skilled workers, who are those with higher levels of education, should earn more. That is, an increase in school-leaving age should result in higher earnings. In the previous graphs, the level of education has increased over time and younger workers are

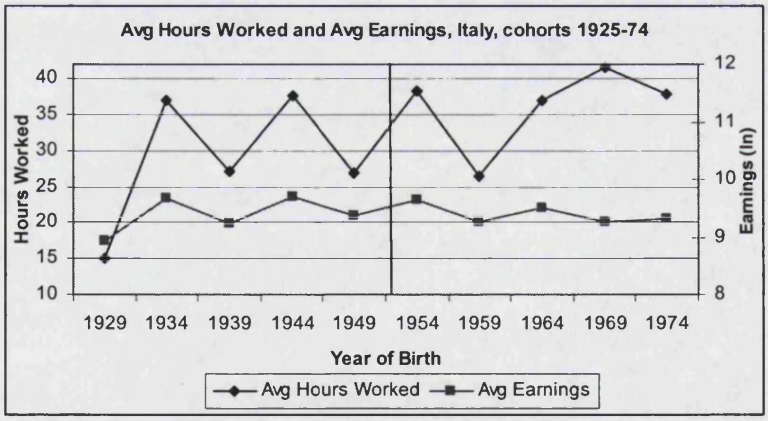
on average more educated than the older ones. Earnings look quite steady for the cohorts considered as they have been measured in logs but report a slight decrease in France, Portugal and Spain and a slight increase in the United Kingdom. In the next section for the estimation of the returns to education I will control for age and age squared in order to control for these effects. In figures 5.8 and 5.9 the evolution of the distribution of earnings and hours worked per cohort is shown for the seven countries observed.[509]

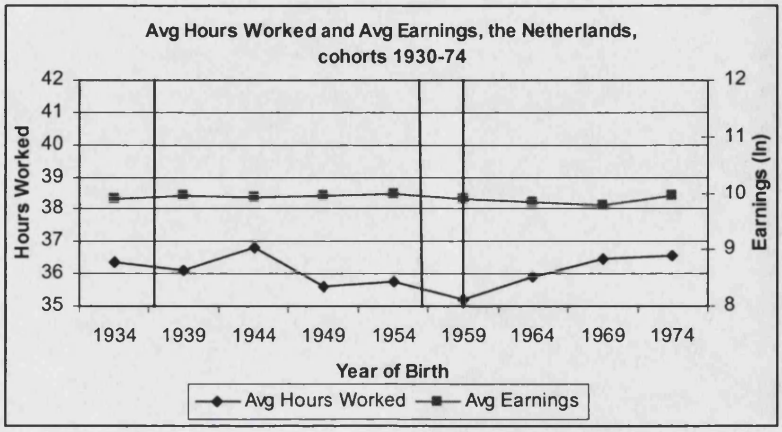
[509] Each point corresponds to the 5 years average. For example, average years of education and earnings in 1944 correspond to the average of these variables for the individuals born between 1939 and 1944.
The first school-leaving age law change for Portugal applied to men only. The implementation of the equivalent change in legislation for women occurred in 1960. The two subsequent changes applied to the entire population.

Figure 5.8 Distribution of average earnings and average hours worked per cohort in France, Ireland, Italy and the Netherlands



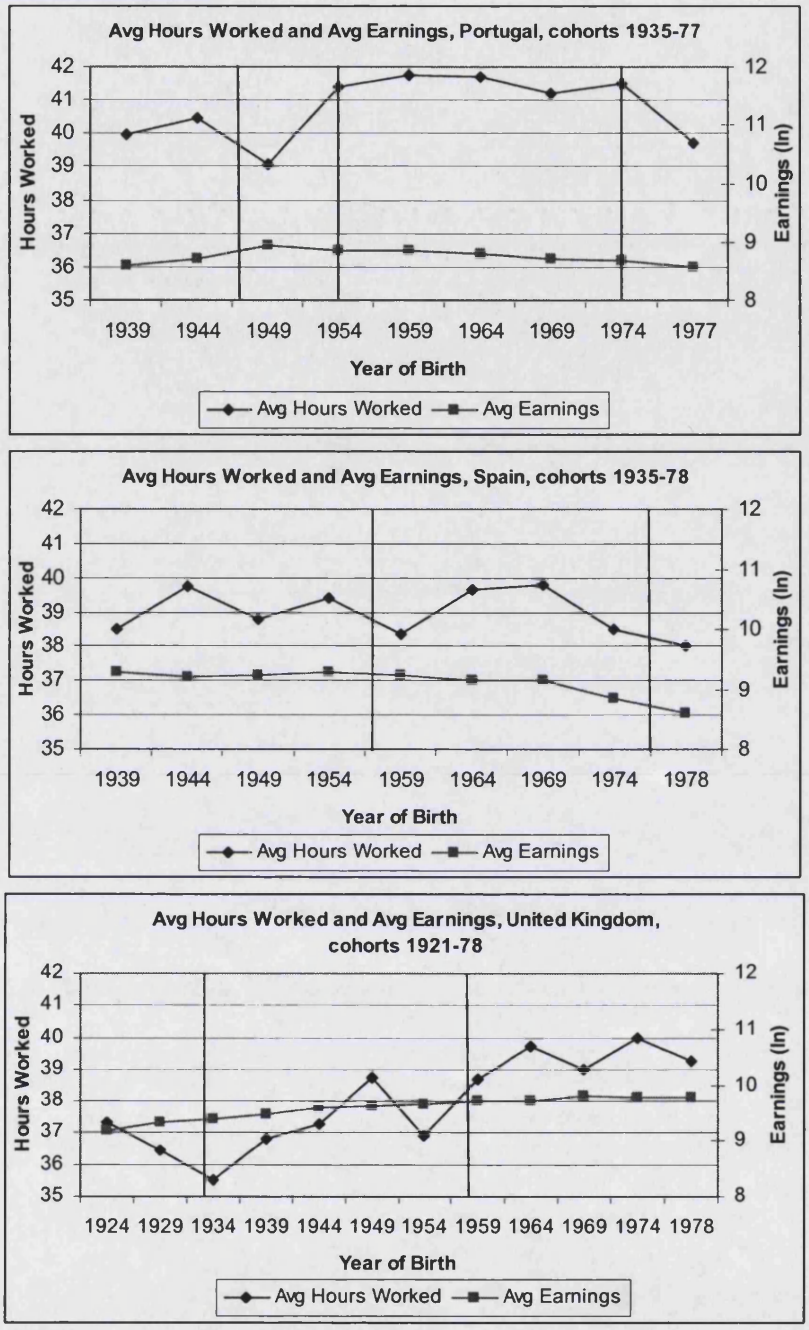






Source: derived from ISSP Dataset used for the empirical analysis

Figure 5.9 Distribution of average earnings and average hours worked per cohort in Portugal, Spain and the United Kingdom



Source: derived from ISSP Dataset used for the empirical analysis

There is no clear theory about how hours worked should be expected to change per age. According to Ngai and Pissarides (2006), at the very early stage of industrialization hours worked increase and after decline. However, "in later stages of modern growth trends become less clear-cut, with no systematic overall dynamic pattern".[510] It is possible to observe that Ireland and the United Kingdom exhibit a similar evolution of the average hours worked. Another similar pattern can be noticed by looking at Portugal and Spain. This variable has increased over time but for the cohorts of around 1970 it started decreasing. Nevertheless, what is surprising is the high number of hours worked reported by these Southern European countries. In this regard, Italy shows a different pattern with an important variation across the cohorts. There is no explanation for this pattern in the existing literature. This may be due to some measurement error or some characteristics of the labour market and remains a topic that requires further investigation.

In order to check whether there is a statistically significant difference between the three variables observed in the previous graphs before and after the schooling reforms, the t-test has been performed and the results are shown in table 5.3.

[510] Ngai and Pissarides (2006, p.2).

Table 5.3. Descriptive statistics for avg years of education, avg earnings and avg hours worked

Variables	Countries	Reform	Pre-Reform			Post-Reform			
			Mean	StdDev	Obs*	Mean	StdDev	Obs	t-test
Avg years of education	France	14-16	13.54	*4.18*	854	14.32	*3.65*	1856	4.93
	Ireland	14-15	12.14	*3.24*	1706	13.26	*2.60*	1555	10.82
	Italy	11-14	11.08	*4.16*	1763	12.38	*3.58*	1682	9.81
	Netherlands	13-15	11.95	*4.44*	121	13.21	*4.39*	1591	3.04
		15-16	13.21	*4.39*	1591	14.50	*4.12*	353	5.05
		16-17	14.50	*4.12*	353	14.22	*3.23*	1290	1.35
	Portugal**	9-10 m	6.05	*3.84*	121	8.01	*4.58*	134	3.68
		9-10 w	6.05	*4.17*	147	7.09	*4.69*	47	1.44
		10-12	7.77	*4.61*	181	9.17	*4.59*	922	9.64
		12-15	9.17	*4.59*	922	10.83	*3.84*	115	14.92
	Spain	13-14	10.00	*4.57*	421	12.96	*4.25*	705	10.99
		14-16	12.96	*4.25*	705	13.08	*3.91*	24	0.14
	United Kingdom	14-15	10.66	*1.26*	480	11.39	*1.79*	4252	8.69
		15-16	11.39	*1.79*	4252	12.37	*2.03*	2569	20.82
Avg earnings	France	14-16	10.25	*0.60*	854	9.91	*0.53*	1856	14.87
	Ireland	14-15	9.72	*0.76*	1706	9.64	*0.59*	1555	3.33
	Italy	11-14	9.43	*0.61*	1763	9.40	*0.59*	1682	1.47
	Netherlands	13-15	9.88	*0.74*	121	9.95	*0.68*	1591	1.08
		15-16	9.95	*0.68*	1591	9.93	*0.58*	353	0.51
		16-17	9.93	*0.58*	353	9.83	*0.57*	1290	2.91
	Portugal	9-10 m	8.93	*0.53*	121	9.03	*0.59*	134	1.42
		9-10 w	8.59	*0.73*	147	8.65	*0.66*	47	0.50
		10-12	8.93	*0.63*	181	8.77	*0.58*	922	3.34
		12-15	8.77	*0.58*	922	8.53	*0.53*	115	4.22
	Spain	13-14	9.25	*0.69*	421	9.06	*0.67*	705	4.55
		14-16	9.06	*0.67*	705	8.51	*0.81*	24	3.93
	United Kingdom	14-15	9.32	*0.75*	480	9.62	*0.87*	4252	7.26
		15-16	9.62	*0.87*	4252	9.78	*0.72*	2569	7.84
Avg hours worked	France	14-16	39.54	*10.46*	823	38.64	*9.71*	1821	2.15
	Ireland	14-15	37.53	*12.54*	1686	39.45	*11.34*	1524	4.53
	Italy	11-14	30.00	*27.45*	1756	34.98	*35.82*	1677	4.58
	Netherlands	13-15	36.66	*10.38*	119	35.81	*9.99*	1565	0.89
		15-16	35.81	*9.99*	1565	35.24	*9.65*	350	0.97
		16-17	35.24	*9.65*	350	36.11	*8.20*	1276	1.69
	Portugal	9-10 m	42.88	*10.87*	120	42.90	*8.84*	134	0.02
		9-10 w	36.02	*12.04*	147	40.04	*12.07*	47	1.99
		10-12	42.16	*9.83*	181	41.62	*9.91*	922	0.67
		12-15	41.62	*9.91*	922	40.00	*8.55*	115	1.68
	Spain	13-14	39.22	*10.52*	405	39.11	*12.16*	659	0.15
		14-16	39.11	*12.16*	659	43.26	*16.36*	23	1.59
	United Kingdom	14-15	35.67	*11.51*	466	37.73	*24.91*	4178	1.76
		15-16	37.73	*24.91*	4178	39.19	*22.26*	2542	2.42

Note: * Obs: number of observations.

** For the first reform the variables are examined by gender as the schooling law was implemented in different years for men (m) and women (w). For the other reforms the whole population is considered.

Source: statistics derived from the ISSP dataset

The statistics reported above show that, with few exceptions, in every country in the sample the average years of education after the schooling reforms are significantly greater than before the implementation of the school-leaving age law. This does not hold true in Spain for the reform of 1990; in the Netherlands for the third change in school-leaving age law and in Portugal for the extension of mandatory schooling of one year for women in 1960.

For France, Ireland, the Netherlands for the third change in legislation, Portugal apart from the first reform and Spain, average earnings were greater before the increase in the level of compulsory schooling whereas the United Kingdom exhibits greater earnings after both changes in the level of compulsory schooling. A decrease in earnings would be justified by the increased supply of educated employees whereas an increase in wages in spite of the expansion of education would reveal an increase in the demand for more educated workers. An estimation of the trend in the returns to education will be provided later in the analysis.

What happens to hours worked is mixed as for some countries like Ireland, Italy and the United Kingdom after the second reform the level is greater whereas for France it is lower after the Berthoin schooling reform. For the other countries the difference is not significant. However, to draw any conclusion it is necessary to undertake the empirical analysis by controlling for other factors like age, other control variables like union status and marital status as well as for country and year fixed effects. This is the purpose of the next section.

5.6) Empirical analysis and results

The first model that will be estimated has been derived from a simple Mincerian equation:[511]

$$\ln W_{icy} = \alpha + \beta S_{icy} + \gamma age_{icy} + \delta age_{icy}^2 + \rho\,(year, country) + e_{icy}$$
(5.1)

Where:

$\ln W_{icy}$: logarithm of earnings of individual i in US dollars, living in country c, in year y

βS_{icy}: number of years of schooling of individual i, living in country c, in year y

age_{icy}: age of individual i, living in country c, in year y

age_{icy}^2: age squared of individual i (measured as age squared), in country c, in year y

ρ (year, country): country dummy variables for year of survey and for country as well as all the interactions to capture country and year fixed effects as well as country effect specific to a given year[512]

e_{icy}: error term

α: constant

β, γ, δ: coefficients to be estimated

There are three main assumptions underlying the Mincer's (1974) model. The specification implies that the logarithm of earnings is a linear function of schooling. Moreover, that returns to education are homogenous across individuals. I adopt this parsimonious specification as additional exogenous variables may be considered.

Estimating this reduced form has important limitations for the OLS estimates. As reviewed by Card (1999) in the case of positive correlation between the individual's ability with schooling and earnings, the OLS estimator would be biased. This is because if unobserved characteristics of the individual have an impact on both the level of schooling and the level of earnings, it would not be possible to have an unbiased

[511] This model has been derived from Mincer (1974). An extension of this model has been briefly described in section 1.4.3 when the validity of some empirical tools used for the estimation of the returns to education at aggregate level has been discussed. In this chapter the cross-country comparison will be carried out by using microdata.

[512] This specification differs from Trostel et al. (2002) who do not include the interaction between year of survey and country.

estimate of the returns to schooling. Also, measurement issues concerning the quality of schooling exist and they are related to the errors that lead to a difference between estimated and actual schooling level.[513] This could bias the estimates downward. A different technique has been developed in order to address these issues and to provide a better estimator. By using this technique, it is possible to measure the returns to education related to a variation in the level of schooling which is independent of the individual's attributes. This is called the instrumental variable (IV) technique because a variable, an instrument that is correlated with schooling but not with earnings is used.

The estimation of this model is run in two steps and the two-stages least squares specification that will be used in this chapter is:

$$1)\ S^*_{icy} = \theta sla_{ic} + \gamma age_{icy} + \delta age_{icy}^2 + \rho\ (year, country) + u_{icy} \qquad (5.2)$$

$$2)\ \ln W^*_{icy} = \alpha + \beta S^*_{icy} + \gamma age_{icy} + \delta age_{icy}^2 + \rho\ (year, country) + e_{icy} \qquad (5.3)$$

Where:[514]

θsla_{ic}: school-leaving age faced by individual i

u_{icy}: error term

That is, the interest in this framework is to consider the variation in the individual's schooling level caused by the increase in the school-leaving age and to look at the impact of this change on the individual's earnings. This is considered as a natural experiment because it allows measuring the impact of an extension of the schooling level on earnings where the change in schooling participation does not depend on the individual's choice and on unobserved characteristics like ability and intelligence. It is important to notice that by using this approach returns to education will be estimated for those affected by the policy change, the treatment group. This is the local average treatment effect (LATE) as defined by Imbens and Angrist (1994, p.467). That is, "the average treatment effect for individuals whose treatment status is influenced by changing an exogenous regressor that satisfies an exclusion restriction".[515] Card (1999)

[513] For a critical review of the difficulties in measuring human capital and the various proxies that are used in the literature to measure formal education please refer to section 1.5.1.
[514] The other variables are the same that have been specified in the previous equation.
[515] Imbens and Angrist (1994, p.467).

provides a discussion and an exhaustive review of the existing studies showing how the use of different instruments leads to the measurement of different effects. In this regard, he provides an explanation on the reason why returns to education are greater by using the instrumental variable technique rather than the OLS approach. According to Card (1999) IV results could occur because returns are estimated for a subgroup of the population. That is, in this case, the subgroup affected by the policy change is the one composed of more disadvantaged children, the ones who would have left school earlier if school-leaving age had not been raised. These students could be more credit constrained or have a greater distaste for schooling than the overall student population (Oreopoulos, 2001, p.2). Consequently, these students would exhibit relatively high marginal discount rates (Card, 1999, p.1842; Harmon et al., 2003, p.145). Thus, for this specific group, returns to education could be greater than the average of the whole population making IV estimates to be higher than the OLS ones. Another factor that can explain why other national studies have found higher IV estimates than OLS, particularly when using school-leaving age instruments, is the possibility of measurement error.[516]

Another concern arises in the case of non-linearities in returns to education. In this case, the IV approach would present some limitations. In fact, in the context of non-linearity what is needed is a valid instrument for the entire range of education outcomes (Trostel, 2005, p.198) whereas, as previously suggested, in the case of instrumental variable estimation the instrument only captures the causal effect of education over a small range of education outcomes. In this regard, Harmon and Walker (1999, p.886) have shown that in the case of non-linarities in the returns to education there is a great sensitivity to the instrument that has been used as different instruments select different subgroups of the population. This is one of the reasons why, according to Trostel (2005, p.200), using "natural experiments as instruments to identify the causal effect of education is particularly problematic" in the case of non-linear returns to education.

In the following tables the results of the estimation of the returns to education by using the OLS and the IV techniques for the seven countries under analysis over the period 1985-2000 are shown.[517]

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[516] However, Harmon et al. (2003, p.145) acknowledge that this is a relatively minor problem in this type of studies.

[517] Data have not been pooled for the analysis because of the variation in coefficients across countries. It is important to notice that there may be a problem of aggregation as the pooled regression is different

Table 5.4. OLS estimates - Returns to education by gender, 7 countries, 1985-2000

Country	Males		Females	
	coefficient	*robust SE*	*coefficient*	*robust SE*
Anglo-Saxon countries				
Ireland	0.071	*0.004*	0.108	*0.008*
United Kingdom	0.081	*0.005*	0.146	*0.008*
Southern European countries				
Italy	0.031	*0.002*	0.040	*0.003*
Portugal	0.059	*0.004*	0.090	*0.004*
Spain	0.033	*0.004*	0.066	*0.007*
Other countries				
Netherlands	0.019	*0.003*	0.024	*0.006*
France	0.043	*0.003*	0.047	*0.005*

Note: The coefficients presented in this table are significant at 1 percent level
The regressions have been estimated by including year dummies, country dummies and country-year dummies

Table 5.5. IV estimates (SLA) - Returns to education by gender, 7 countries, 1985-2000

Country	Males			Females		
	coefficient	*robust SE*	*First Stage F-test*	*coefficient*	*robust SE*	*First Stage F-test*
Anglo-Saxon countries						
Ireland	0.046**	*0.021*	*0.06*	0.135***	*0.041*	*3.71*
United Kingdom	0.064**	*0.031*	*24.11*	0.033	*0.052*	*50.68*
Southern European countries						
Italy	0.028**	*0.011*	*1.99*	0.021*	*0.012*	*4.70*
Portugal	0.059**	*0.023*	*0.02*	0.099***	*0.023*	*28.16*
Spain	0.039**	*0.015*	*10.12*	0.041*	*0.022*	*7.55*
Other countries						
Netherlands	0.020	*0.018*	*2.05*	0.068***	*0.023*	*81.88*
France	0.055***	*0.020*	*43.94*	0.049*	*0.026*	*13.61*

Note: *** p<0.01, ** p<0.05, * p<0.1; (robust standard errors in parentheses)
The regressions have been estimated by including year dummies, country dummies and country-year dummies

from the single countries average. This is because in the pool estimate, the control category mixes individuals who have not been affected by the reform and individuals whose country has reformed the education system earlier. For example, the second Dutch reform identifies the effect of increasing education from 15 to 16. However, in the pooled sample, the population of individuals who left school at 15 also includes individuals who have faced an increase in their minimum school leaving age such as the United Kingdom.

The results of the OLS estimation can be compared to the findings of other studies. They appear to be quite close to the results reviewed in table 5.1 and lower than those of the single country estimations presented in table 5.D in the appendix. However, it should be acknowledged that the studies reviewed in Harmon et al. (2001) often refer to single year estimation and make use of country-specific datasets. The exception is the United Kingdom for which the results reported above are greater than the ones presented in Harmon et al. (2001). These results are for women quite close to those found by Trostel et al. (2002): 14.6 percent against 13 percent estimated by the authors. Then again, returns for men are equal to 12.7 according to the authors' estimation and 8.1 percent in table 5.4.

On the other hand, according to the IV regression, it is possible to observe that returns to an additional year of schooling vary across countries when the change in school-leaving age laws is used as instrumental variable. For France, Ireland, Italy, Portugal and Spain both coefficients are significant whereas for males in the Netherlands and females in the United Kingdom coefficients are not significant.[518] With the exception of France, the estimated returns are in both cases greater for women than for men as the findings of the existing literature previously mentioned would suggest.[519] For the female population returns vary between 9.9 percent in the case of Portugal[520] to 4.9 percent for France. When the male population is considered returns are equal to 6.4 percent in the United Kingdom, 5.5 percent in France and 3.9 percent in Spain. For Italy and the United Kingdom returns to an additional year of schooling are positive but lower than what the studies presented in table 5.1 would suggest. As previously suggested, these results show the returns to education of a subgroup of the population which includes children who otherwise would have dropped out of school as soon as possible whereas OLS returns have been estimated for the whole population. As Card (1999) suggested these children may face higher discount rates and this would explain the difference between IV and OLS estimates. For the Netherlands it is not possible to compare the findings of table 5.5 to the ones obtained by Oosterbeek and Webbink (2007) as the authors have estimated the impact on earnings of an extension of a vocational education

[518] In the case of Ireland, Italy, the Netherlands and Portugal the instrument used in the regression is weak when returns to education for men are estimated. This is because the first stage F-test is less than 10. On the other hand, when returns to schooling are estimated for women, the instrument is weak in the case of Ireland, Italy and Spain. In the discussion that follows the results of the estimations for which the instrument is weak have been excluded because the estimates could be biased.

[519] France is an exception as returns are equal in the OLS estimation and greater for men in the IV regression.

[520] This is close to the result found by Callan and Harmon (1999) and reviewed in table 5.1.

programme only whereas here what has been measured is the extension of mandatory schooling. As highlighted by Green et al. (1999), there exists a variety of criteria that can be used to classify the education systems; among these, the regional cluster appears to be important. This is because there are national education and training systems that share common characteristics and can be grouped according to regional lines.[521] This is the approach that has been used here to group the estimation results. However, it has not been possible to group the countries in the regression and identify them with a dummy related to the different models. This is because the identification comes from country specific policy change. Therefore, only a descriptive analysis can be provided. From the OLS estimates, it is possible to observe that the Anglo-Saxon countries exhibit returns to schooling greater than the three Southern European countries in the sample for men and women. This also holds true for men when the IV estimates are considered. In this case, returns for men are greater in Ireland and the United Kingdom with respect to Italy and Spain. It is not possible to identify other patterns in the returns with respect to the different models of education systems.

What is interesting to notice is that in this case a sample of countries is considered. In the dataset there are countries like France, Ireland, Italy, the Netherlands,[522] Portugal and the United Kingdom for which returns to education have been estimated by using a similar technique on country specific datasets. On the other hand, there is a country like Spain for which no estimation by using the change in compulsory schooling laws as instrumental variable has been provided so far.

Therefore, even if the statistical consistency of the analysis has been supported by the regression diagnostics and the fact that other studies have found similar results is reassuring, it is nevertheless important to provide further checks for the robustness of these results. In fact, as previously suggested, putting the data in the right format has required a great effort due to the changes in the methodology used for coding the variables across the different waves of the survey. Moreover, the scarcity of information for some of the earlier editions of the survey has not helped in this task. In order to verify this possibility, further checks will be carried out in what follows.

[521] Green et al. (1999, p.26).

[522] As previously suggested the study by Oosterbeek and Webbink (2007) makes use of the change in schooling legislation in a vocational training programme and does not include changes in legislation related to general education.

In order to check for the robustness of these results, I will expand the empirical investigation by replicating Trostel et al.'s (2002) analysis. That is, I will do the OLS estimates and the IV analysis by using spouse's education as instrumental variable. After, I will do the IV estimation with compulsory schooling laws as instrumental variable by limiting the analysis to the sample that Trostel et al. (2002) have used in their work. This would provide a further check on the validity of the instrument and possibly the analysis at country level will provide results more similar to those available in the existing literature. In order to replicate Trostel et al.'s (2002) study I have run the OLS regression for the twenty-eight countries that have been selected by the authors from the original ISSP dataset. The estimation has been carried out for both males and females over the period 1985-95. The results are displayed in the appendix, table 5.B. By comparing these results to those reached by Trostel et al. (2002) and presented in the appendix,[523] it is possible to observe that they are not exactly the same but they are very close for the majority of the countries examined. A further check has been carried out by comparing these estimates to those that are available in country specific studies. Again, as it can be observed from table 5.D in the appendix, the results appear to be consistent with what has been found in many country-specific studies. By pooling the countries I find the returns to an additional year of schooling to be equal to 0.068 for men whereas the authors' estimate is only slightly below and equal to 0.048. As I have suggested before Trostel et al. (2002) have used a different specification with respect to the country and year fixed effects. Therefore, there is no reason to believe that my data suffer from major miscoding.

This implies that there are no major mistakes made during the initial task of merging the different waves of the survey. The last part of the replication analysis consists of the estimation of the returns to education by using spouse's education as an instrument. However, there is something that should be acknowledged. Spouse's education is coded in categories for Czechoslovakia, Germany and Italy but it is not possible to find the appropriate code from the codebook of the ISSP. Therefore, these countries have been excluded from my analysis whereas have been included in Trostel et al.'s (2002) sample. The results are reported in table 5.E in the appendix.

[523] These results can be found in Trostel et al. (2002, p.5) and are presented in the appendix, table 5.C.

When compared to Trostel et al. (2002)[524] estimates', these results appear to be very similar. In fact, there are minor differences for some countries that can be simply due to data approximation. The difference in the pooled estimation is obviously due to the fact that the authors have a larger sample as I had to exclude those countries for which I could not find complete information concerning the spouse's education categories. In fact, due to this lack of information I have been unable to transform these data into years of schooling.

In spite of the validity of the empirical results of the previous estimation, the instrument does not seem to be appropriate from a theoretical perspective. In fact, as previously noted, spouse's education does not appear to be independent of the unobserved characteristics that affect both the schooling and earning level of the individual. That is, this instrument does not seem to be orthogonal to the unobserved factor of the wage equation. This is the reason why even if the use of this instrument leads to valid empirical results it cannot be accepted when economic theory is considered. This is because, even if the importance of educational sorting in marriage has been acknowledged in the existing literature by Mare (1991) as well as Lewis and Oppenheimer (2000) it has also been shown that "for social reasons similarity between husband and wife is favoured".[525] That is, there are some unobserved characteristics of the spouse that are correlated with the unobserved characteristics of the husband that affect both his schooling and earning levels.

The other instruments used in this work, mother and father's education are not even considered here as their correlation with children's level of schooling and other characteristics like ability, motivation and intelligence appears to be very strong. In fact, it is plausible to think that parents' education is correlated with their ability, which is also correlated with their children's ability. Therefore, the assumption of exogeneity of the instrument is violated. A vast amount of research has been devoted to the analysis of the impact of family background on children schooling performance over time and across countries. The influence of parents has been found to be important for students' schooling experience in various ways. Another line of research has focussed on characteristics of the family that may affect children's schooling experience. See Scott-

[524] Trostel et al. (2002) estimates' using spouse's education as instrumental variable are presented in the appendix, table 5.F.
[525] Vandenberg (1972, p.128).

Jones (1984) for a review of the existing studies. Other scholars, for example Bloom (1981), have looked at the impact of parents' motivation on students' achievements and found it to be important. A related stream of the literature that has recently expanded as a result of the development of international studies related to students' performance has examined the effect of family background on pupils' schooling performance at various levels. Woessmann (2003) has found it to be significant over time and across countries. Finally, another area of research has looked at the family influence on university attendance plans. Stages and Hossler (1989) acknowledge the importance of the role played by the family in determining students' participation in higher education. Therefore, following on from the findings of the existing literature, it appears that there exists a correlation between parents' and children unobserved characteristics that are likely to have an impact on schooling achievement and wages. The analysis of the previous paragraphs has highlighted the reasons why the instrumental variables used in Trostel et al. (2002) do not seem to be appropriate in spite of the valid empirical results achieved.

Also, the trend of the returns to education that have been derived from the OLS estimates for some countries that have been studied in this section by following Walker's specification. This variable has been constructed first by generating a time trend (i.e., year-1985). After, the time trend has been interacted with the years of schooling variable. Consequently, this "trend" variable has been included in the model previously specified. However, the trend of the rate of returns is only significant for the Netherlands and the United Kingdom when the female population is considered. Moreover, the trend in these cases is close to zero, (-0.004) for the United Kingdom and (-0.007) for the Netherlands.

A further estimation has been carried out in order to see whether returns are different before and after the first change in the level of compulsory schooling. Obviously, by doing this the control group changes and after the reform it is composed by more educated workers. Therefore, according to the general equilibrium effect, young and more educated workers would affect the wage profile of the old workers. As suggested in the descriptive statistics, a decrease in the returns to education would be the consequence of an increased supply of educated workers. On the other hand, if returns estimated in the second period are greater this would be a consequence of the increased

demand for skilled labour arising from the use of more advanced technologies in the economy. The results of the OLS estimation are reported in table 5.6.

Table 5.6. OLS estimates - Returns to education by gender before and after the first change in compulsory schooling law, 7 countries, 1985-2000

Country	**Males**				**Females**			
	Slalaw=0		Slalaw≥1		Slalaw=0		Slalaw≥1	
	coefficient	*robust SE*	*coefficient*	*robust SE*	*coefficient*	*robust SE*	*coefficient*	*robust SE*
Anglo-Saxon countries								
Ireland	0.080***	*0.004*	0.048***	*0.008*	0.115***	*0.011*	0.099***	*0.009*
United Kingdom	0.118***	*0.023*	0.079***	*0.005*	0.183***	*0.039*	0.144***	*0.007*
Southern European countries								
Italy	0.037***	*0.003*	0.031***	*0.002*	0.038***	*0.004*	0.040***	*0.003*
Portugal	0.070***	*0.011*	0.057***	*0.004*	0.112***	*0.011*	0.089***	*0.004*
Spain	0.039***	*0.006*	0.029***	*0.005*	0.054***	*0.015*	0.073***	*0.009*
Other countries								
Netherlands	0.019***	*0.003*	0.018***	*0.003*	0.030***	*0.007*	0.024***	*0.005*
France	0.053***	*0.005*	0.039***	*0.004*	0.039***	*0.009*	0.049***	*0.005*

Note: *** p<0.01, ** p<0.05, * p<0.1; (robust standard errors in parentheses)
The regressions have been estimated by including year dummies, country dummies, and country-year dummies

It is possible to observe that for men returns are greater before the first schooling reform in every country. Also, returns are greater in the Anglo-Saxon countries as previously estimated. For the female population the evidence is mixed. In Ireland, the Netherlands, Portugal and the United Kingdom returns are greater before the first change in compulsory schooling law whereas for France, Italy and Spain returns are greater after.

5.7) Interpretation

After having checked for the validity of the instrument used and the robustness of the empirical results it seems important to provide an explanation for them. This is because they differ to a certain extent from the findings of the majority of the existing studies that have been reviewed in table 5.1. In fact, in most of the estimates where changes in compulsory schooling laws are used as instrumental variables, the returns to education vary between ten and fifteen percent. By using compulsory schooling laws as instrumental variable the results found in this chapter for the country level analysis vary between 9.9 percent in the case of the Portuguese female population and 3.9 percent in the case of the Spanish male population. Apart from France where estimated returns are greater than in Grenet (2004), for the other countries the returns to education that have been estimated appear to be a bit lower than the existing studies. In this chapter returns estimated for France are equal to 5.5 for men and 4.9 for women. Therefore, these results are on average lower than those found in the mainstream literature.

In the following paragraphs some of the possible explanations for the results obtained in this chapter will be discussed. The methodology used for the analysis in the chapter is similar to the one used in the other studies. Therefore, differences in the estimates must have another explanation. Also, data are comparable, they do not present inconsistencies and the accuracy of the merging procedure has been previously tested in a number of ways. It is important to notice that the countries that have been studied present important differences with respect to their schooling system as has been suggested in chapters 2 and 4 and any explanation should fit these different educational and training models.

It could be the case that in these countries skills are produced earlier and, as previously suggested for Germany, increases in the level of compulsory schooling at a late stage of the tracking system do not increase the level of human capital in a significant way and therefore the market value of this increase is close to zero. In order to explore this possibility, I have compared the International Test Scores in Mathematics and Sciences for which I have collected the data from the earlier to the more recent waves for the countries in the sample with respect to the other countries. These standardized scores are presented in table 2.15. However, it is not possible to see a clear pattern of these countries with respect to the other ones. It is possible to observe that the majority of

these countries perform better than the United States in 1963 and 1981; thereafter the performance is reversed. Moreover, some countries like Italy and Portugal have a late tracking system whereas the Netherlands are more similar to the German system (Hanushek and Woessman, 2006). Therefore, this explanation does not seem to be satisfactory.

On the other hand, the fact that the market may value more workers' qualification levels than the number of years spent in school can apply in this context. Starting with Spence's (1973) pioneering work on the signalling value of education, a large strand of literature has examined the market value of qualifications and information costs. The basic idea of the model is that employers would hire workers with higher qualification levels because they have a higher probability of finding high ability workers. That is, as a result of the asymmetric information between the employer and the potential employee and the costs of collecting information related to worker's abilities, the qualification acts as a "signal" given to the market that conveys information related to the potential worker's characteristics. In this regard, by looking at the sample used in this chapter, it can be observed that what happened is mixed: in some of these countries the increase in the number of years of compulsory schooling has been associated with the award of a higher level qualification and in others it has not.[526] For instance, in Spain, the General Organic Act of the Education System (LOGSE) of 1990[527] increased the level of compulsory schooling from the age of 14 to the age of 16 leading to the award of the Graduado in Educación Secundaria certificate. Another example is the United Kingdom where the Education Act II of 1973 increased the level of compulsory schooling by one year and led some individuals to obtain the General Certificate of Secondary Education (GCSE). As suggested by Grenet (2004), the increase in the level of compulsory schooling that took place in 1973 also improved the level of qualifications and had a positive effect on the returns to education as shown by Harmon and Walker (1995). On the other hand, not every reform led to the award of an additional qualification in Portugal. The results of the country-level estimations of this chapter show positive returns for the United Kingdom and Spain for men and women respectively. However, for the United Kingdom returns for men are greater than the other countries in the sample but lower than the ones estimated in the studies reviewed

[526] Country-specific information have been collected from various national sources and from the EURYDICE Database (2000) and Harmon et al. (2001).
[527] Harmon et al. (2001, p.236).

in table 5.1. This difference remains to be explained. For other countries examined it may have been the case that an increase in the number of years of compulsory schooling has led to a minor increase in wages because there was no additional qualification awarded to students. Among the tentative explanations provided, the latter seems to be the more likely. However, further research is required in order to establish how the skills are formed and how the market values the qualification profiles with respect to the number of years of schooling in these countries.

5.8) Conclusion

In this chapter returns to education for different samples of European countries over the period 1985-2000 have been estimated. It has not been possible to test the impact of ICT on returns directly. This is because data do not allow this. Moreover, by looking at national statistics, it is possible to infer that only a small share of the individuals in the sample was working in the ICT sector over the period considered. Therefore, the impact of this general purpose technology on the returns to education was examined in two stages. First, by looking at the impact of technology on the changes in school-leaving age, in chapter 3.[528] After by looking at the impact of compulsory schooling reforms on returns to education, in this chapter. Specifically, the analysis here has focused on three aspects: the general returns to education, the impact of changes in the level of compulsory schooling on earnings and gender differences.

This work has tried to fill one of the major gaps in the existing literature. That is, the cross-country comparison of the returns to education by using compulsory schooling laws as instrumental variables. These tools satisfy the check of validity described by Bound et al. (1995) and seem to be among the best instruments currently available. Among the existing analyses, Oreopoulos (2003) has compared three countries but has made use of different datasets whereas Trostel et al. (2002) have used a comparable dataset but inappropriate instruments. On the other hand, the other studies in this line of research are country specific. In this regard, this paper is original in many ways. First, a dataset comparable across countries and over time has been used. Returns to education have been estimated for seven Western European countries between 1985 and 2000. Moreover, the analysis has been extended to countries that have not been studied before.

Among the findings, the OLS estimates are in line with the existing studies whereas the returns to education estimated with the instrumental variable technique are on average lower than the majority of the findings in the literature. I believe that the estimates presented in this chapter are more accurate than the ones of other studies. The use of the instrumental variable technique has allowed the estimation of returns to education for the disadvantaged students as opposed to the OLS technique which has identified the

[528] However, it is important to notice that the changes in compulsory schooling laws are concentrated in the twenty-five years that follow the end of the Second World War and the investment on ICT starts becoming very important towards the end of the 1970s as shown in section 2.3.2.

average returns for the whole population. Thus, allowing to understand the impact that the schooling reforms may have on inequality. Country level estimates have shown that returns vary across countries: returns for women vary between 4.9 percent in the case of France and 9.9 for Portugal. Then again, returns for the male population vary between 3.9 percent for Spain and 6.4 percent for the United Kingdom. On the other hand, Oreopoulos (2003) finds returns for the United States to be greater and equal to 13.3 for a sample of men and women. These results suggest how an institutional intervention could have an impact on the returns to education of those at the lower end of the income distribution.

In this chapter, the gender issue has been investigated. Estimates show that returns to education are greater for females over 1985-2000 as women at lower levels of education earn less than men. These results seem to be coherent with the findings in the existing literature. Moreover, women may have benefited more from an increase in the level of compulsory schooling as a greater share of them would have otherwise left school earlier. However, it is not possible to draw definitive conclusions on whether women's returns are higher after the first change in legislation. This aspect raises many other interesting issues that are left for future research.

Many checks for robustness have been used and tentative explanations have been provided. The one that appears to be the most likely is related to the qualification structure of the countries examined. It has been shown that the increase in the number of years of compulsory schooling in some of the countries studied corresponded to the award of an additional qualification and in others it did not. In this case, it can be argued that the market has valued more the qualification profile of the individual rather than the number of years spent in school. Therefore, an additional year of schooling that does not lead to the award of any further qualification may have a limited impact on the returns to education.[529] However, more research is needed in order to see whether these findings can apply to other countries and to draw any definitive conclusion.

[529] This is the same argument that has been put forward by Grenet (2004) in the case of France and Oosterbeek and Webbink (2007) in the case of the Netherlands.

Chapter Six

CONCLUDING COMMENTS

The first chapter introduced the theoretical framework and laid down the motivation for the thesis. Three elements have been observed and represent the starting point of the analysis. First, after the Second World War there are two moments when the technological gap of Western Europe with respect to the United States has experienced an important widening. This was after 1945 when the lag in labour productivity greatly increased in many sectors of the economy as a result of war destruction and the interruption of technological development and also towards the mid-1990s when the labour productivity gap became especially pronounced in the service sector. The latter was largely due to the end of the slowdown of American productivity resulting from the introduction of the information and communication technologies in the early 1980s. The second element is the highly skilled European labour force. In fact, the techniques of production that have been used in Europe since the early stages of industrialization have relied on average on a more skilled labour force and a greater quality of human capital with respect to the United States. As the choice of techniques of production along with technological development depend on factor endowments, the early choice of modes of production determine a sort of lock-in (Broadberry, 1997). That is, European countries chose at an early stage a strategy of production that relied on "high quality human capital" and intermediate level skills in manufacturing. Having taken this direction in the development of the techniques of production it is likely that European countries will adjust to technological advance by following this line of development. Thus, it seems reasonable to believe that European countries have followed their own technological development and their own pattern to modernity by relying on a high quality provision of human capital. Third, the process of adjustment. The interruption of the process of technological development during the war as well as the introduction of new technologies later created the need for adjusting the existing institutions to take advantage of the technological opportunity.

Therefore, the research question addressed in this dissertation is: "what have been the structural adjustments undertaken by Western European countries in human capital policy since the end of the Second World War in order to close the technological gap with the United States? Have these changes been sustained by the technological development?". That is, the interest of the thesis relies on understanding the role of institutions in shaping the education and training systems. Having examined the theories that are central to the debate on human capital and

growth, it is possible to notice that the main limitation of the existing theoretical framework is that it does not consider the process of adjustment when major changes occurr in the economy. That is, the existing theories do consider as automatic the process of adjustment of human capital to the different technological contexts. This is hardly credible in light of the historical development of the Western World. In this regard, as Abramovitz (1986) has shown in a deservedely famous paper, what matters for the implementation of technologies to be effective are social capability and technological congruence. In this context, it is possible to think that the widening of the existing technological gap with respect to the United States involved a European response and it is also very likely that human capital policy played a role in this response. Therefore, the interest of the thesis consists of examining some aspects of the policy changes undertaken by European institutions in order to close the gap with the United States by following their pattern to modernity.

The focus of the three substantive chapters has been on Europe only as it does not seem that the United States can be considered as a model for Europe in terms of human capital development and European countries have followed a different pattern of development.

Chapter two provided an overview of the historical background of growth, technology and human capital. The remarkable catch-up of the majority of Western European countries as well as the slowdown that followed the Golden Age were acknowledged. The nature of technology in the post-war period, the introduction of the information and communication technologies were examined and measures of labour productivity were discussed. In addition to this, the evolution of the education and vocational training policies were reviewed and the main differences between Western Europe and the United States highlighted.

In this broad context three aspects were studied in the remaining of the thesis in order to address the research question. These aspects have been chosen because they appear to be of great importance but have been largely neglected in the existing literature. Apart from the originality, the rationale for the choice of these topics has been dictated by the need of covering every level of the education system. The choice of techniques and measures used for the analysis may be not entirely ideal but has appeared to be the best available.

In chapter three the analysis has focused on compulsory schooling, that is primary and lower secondary levels. The aim of this chapter has been to understand the factors that led Western European countries to increase the level of compulsory schooling having observed that this phenomenon has been highly concentrated in the twenty-five years following the end of the Second World War. The empirical evidence has been in favour of the modernization theory after the Golden Age: that is, the greater the technological gap and the lower the school-leaving age, the greater has been the likelihood for governments of increasing the number of years of compulsory schooling. Also, it was observed that the development of the different levels of education varied according to the level of economic development. Moreover, according to the results, economic growth and state capacity played an important role in the expansion of formal education of the more advanced countries in the sample. These results are consistent with the findings of the existing literature and they have the advantage of providing empirical evidence for this.

The analysis of the subsequent chapter has focused on the institutional change at secondary and higher education levels. What has been examined in this framework is the institutional response with respect to the introduction of degrees related to the information and communication technologies. The focus of the analysis has been on three countries that illustrate well the European heterogeneity in terms of vocational education and training systems. There has been an institutional response in the three countries and when compared with the pattern of technological adoption in the field of information and communications, it seems that the response has been adequate. Consequently, what this analysis points out is that the response has been highly dependent on the pattern of technological development of the countries examined. In fact, those that have adopted the new technologies at an earlier stage have also provided a faster educational response to provide training for the labour force in these new fields. On the other hand, except for poorer countries like Portugal, it does not appear so far that the institutions of the European Union have played a role in leading the educational systems to converge as it appears that Member States have followed their own pattern of development.

In chapter five, returns to education have been estimated for seven European countries over the period 1985-2000. The innovation here relies on the comparable dataset and the technique that have been used. The estimation has been carried out

by using the changes in school-leaving age laws as instrumental variable. This tool addresses some of the difficulties in the estimation as it introduces a variation in the level of schooling that is independent of the unobserved characteristics of the individual that may affect both the level of schooling and wages. The results clearly show that in spite of the greater participation rates, returns to education have not fallen. Estimated returns for women have varied between 4.9 percent in France and 9.9 percent in Portugal whereas for men they are equal to 3.9 percent in Spain and 6.4 percent in the United Kingdom. When compared to the studies in the existing literature, some of these results appear to be a bit lower but consistent with the findings of the studies that have used the same specification of the model and control variables. This, among other things, shows that governments have increased the level of compulsory schooling and this expansion has been sustained by the technological development as suggested by Abramovitz (1986). The IV estimates have also shown the positive impact that these institutional interventions have had for children who otherwise would have left school as soon as possible.

What the overall thesis has shown is that there has been a Western European response in human capital policy in order to close the technological gap with the United States. The aim of the thesis has been to provide a technocratic analysis; any political judgment goes beyond the modest purpose of this work. In this regard, Western European countries have expanded compulsory schooling since the end of the Second World War and have quite effectively introduced degrees and programmes of study related to the new technologies. However, there has not been convergence in the development of the education systems as countries appear to have followed their own pattern of development and provided the appropriate institutional response according to the stage of development.[530]

Therefore, my findings are in support of Blanchard and Wolfers's (2000) view: the current pattern of economic development of European countries is highly dependent on the interaction between "shocks" and "institutions" and this can explain the existing heterogeneity in terms of economic performance. It is possible to notice that structural adjustments have been undertaken in Europe to close the gap with the United States. Following the findings of this dissertation, significant changes in human capital policy have taken place. However, as has been noted throughout the

[530] This is consistent with Gerschenkron's (1962) idea of "appropriate institutions".

analysis, education systems change very slowly and path-dependence is important. It may be the case that it takes time and the right conditions must exist in many areas for the effective adoption of technologies and to foster productivity and growth. In Abramovitz's words: "the combination of technological gap and social capability defines a country's potentiality for productivity advance by way of catch-up. [...] The pace at which the potentiality is realized depends on still another set of causes that are largely independent of those governing the potentiality itself".[531]

[531] Abramovitz (1986, p.389).

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APPENDIX Chapter 2

Tables reported in the following pages refer to the section 2.4.1, "Education"

Table 2.A: Enrolments in primary, secondary and higher education

Number of students in primary education as % of 5-14 age group

Year	Austria	Belgium	Denmark	Finland	France	Germany*
1950	80	72	61	69	79	81
1955	66	67	70	73	81	64
1960	61	67	71	59	74	74
1965	105	109	100	109	134	131
1970	104	103	96	82	117	93
1975	102	102	104	102	109	93
1980	99	104	96	96	111	99
1985	100	99	99	102	109	98
1990	102	100	98	99	108	101
1995	101	103	101	99	106	102
2000	103	105	102	102	105	103

Year	Greece	Ireland	Italy	Netherlands	Norway	Portugal
1950	66 (*1951*)	102	54	71	71	40
1955	64 (*1956*)	98	54	62	82	51
1960	62	89	50	72	71	53
1965	62 (*1963*)	105	109	104	97	52
1970	107	106	110	102	102	98
1975	104	106	106	99	99	113
1980	103	100	100	100	100	123
1985	104	100	96	99	97	129
1990	98	103	97	102	100	123
1995	94	104	101	107	99	128
2000	97	104	101	108	101	121

Year	Spain	Sweden	Switzerland	United Kingdom°	*Average 16*	United States
1950	54	68	67 (*1951*)	...	69	88
1955	67	77	70 (*1956*)	72	70	88
1960	73	70	68 (*1959*)	74	68	83
1965	67	100	64 (*1967*)	62	94	81
1970	123	94	65 (*1972*)	111	101	101
1975	111	101	67 (*1977*)	104	101	101
1980	109	97	...	105	103	100
1985	110	98	95	103	102	101
1990	109	100	102	104	103	105
1995	109	106	...	105	104	102
2000	107	110	107	101	105	100

Note: * For Germany data refer to the Federal Republic of Germany until 1985, after data refer to the reunited State
° For the United Kingdom, data before 1970 refer to England and Wales
The gross enrolment ratio corresponds to the total enrolment, regardless of age, divided by the population of tl age group which corresponds to the specific level of education

Source: Data for the period 1950-2000 are taken from UNESCO Statistical Yearbook of various years (1965, 1983, 1995, 1999, 2005 Online Database)

Table 2.A: Enrolments in primary, secondary and higher education (cont'd)

Number of students in secondary education as % of 15-19 age group

Year	Austria	Belgium	Denmark	Finland	France	Germany*
1950	35	59	72	40	35	77
1955	53	83	75	52	46	99
1960	55	116	72	95	83	77
1965	69	75	66	57	62	69
1970	72	81	78	102	74	92
1975	74	84	80	89	82	94
1980	93	91	105	100	85	94
1985	99	102	105	106	90	98
1990	104	103	109	127	99	98
1995	104	146	121	116	111	104
2000	99	154	133	126	108	99

Year	Greece	Ireland	Italy	Netherlands	Norway	Portugal
1950	35	34	29	62	40	11
1955	39	38	38	78	43	17
1960	44	45	52	107	78	30
1965	47	45	47	59	70	39
1970	63	74	61	75	75	57
1975	78	88	70	89	89	53
1980	81	90	72	93	94	37
1985	90	98	73	117	97	57
1990	93	101	79	120	103	67
1995	95	116	94	137	116	111
2000	96	104	96	124	115	114

Year	Spain	Sweden	Switzerland"	United Kingdom	*Average 16*	United States
1950	17	57	30 (1951)	70	44	60
1955	20	61	36 (1956)	83	54	64
1960	26	67	39 (1959)	107	68	76
1965	31	85	...	68	56	86
1970	56	86	...	73	71	86
1975	73	78	...	83	76	88
1980	87	88	...	83	86	91
1985	98	91	88	84	93	98
1990	104	90	90	85	98	92
1995	122	137	...	133	118	97
2000	114	149	100	157	118	94

Note: * Data for Germany refer to the Federal Republic until 1985
Source: Data for the period 1950-2000 have been taken from UNESCO Statistical Yearbook of various
years (1965, 1983, 1995, 1999)

Table 2.A: Enrolments in primary, secondary and higher education (cont'd)

Number of students in higher education as % of 20-24 age group

Year	Austria	Belgium	Denmark	Finland	France	Germany*
1950	*4.0 (1952)*	*4.5 (1953)*	*4.7*	*4.4*	*9.8*	*4.1*
1955	*6.0 (1957)*	*6.6 (1958)*	*4.6*	*5.6*	*12.8*	*4.8*
1960	*8.2*	*7.3*	*6.1*	*7.4*	*18.1*	*5.6*
1965	*9.3*	*13.2*	*9.4*	*10.8*	*18.4*	*7.7*
1970	11.8	17.5	18.4	13.3	19.5	*11.5*
1975	18.9	21.3	29.4	27.2	24.4	*17.4*
1980	21.9	*26.0*	28.3	32.2	25.3	25.6
1985	26.4	32.2	29.1	34.1	29.8	29.2
1990	35.2	40.2	36.5	49.0	39.6	33.9
1995	47.0	56.0	48.0	70.0	51.0	46.0
2000	57.0	58.0	59.0	85.0	54.0	49.0

Year	Greece	Ireland	Italy	Netherlands	Norway	Portugal
1950	...	*3.5*	*3.5*	*5.8*	*3.1*	...
1955	...	*4.4*	*3.6*	*6.1*	*2.8*	...
1960	...	*6.9*	*4.9*	*7.9*	*4.3*	...
1965	...	*9.1*	*8.6*	*9.9*	*7.5*	...
1970	13.5	13.6	16.7	19.5	19.5	8.0
1975	18.4	19.3	25.1	25.5	25.5	10.5
1980	17.0	18.1	27.0	29.3	25.5	11.0
1985	...	22.3	25.5	31.8	29.6	12.0
1990	...	29.3	30.8	39.8	42.3	23.0
1995	...	40.0	42.0	48.0	59.0	39.0
2000	61.0	47.0	50.0	55.0	70.0	50.0

Year	Spain	Sweden	Switzerland	United Kingdom°	*Average 16*	United States
1950	...	*3.2 (1949)*	*4.0*	*2.3*	4.4	32.1
1955	...	*4.6 (1954)*	*3.9*	*2.8*	5.3	36.7
1960	...	*7.0 (1959)*	*4.3*	*3.6*	7.0	41.3
1965	...	*10.3 (1964)*	*5.5*	*5.5*	9.6	45.9
1970	9.0	21.4	10.0	14.1	14.8	49.4
1975	20.0	28.8	13.0	18.9	21.5	58.2
1980	23.0	30.8	18.3	19.1	23.7	55.6
1985	29.0	30.0	21.0	21.7	27.9	60.7
1990	37.0	32.0	25.7	26.5	34.7	74.1
1995	48.0	47.0	33.0	50.0	48.3	81.0
2000	57.0	70.0	42.0	59.0	57.7	71.0

Note: * Data for Germany refer to the Federal Republic until 1985
° Data for the United Kingdom until 1970 refer to England and Wales
Source: Data for the period 1950-2000 are taken from UNESCO Statistical Yearbook of various years
(1965, 1983, 1995, 1999, 2005 Online Database)

Table 2.B: Institutional development of the European educational systems

Country	Introduction of compulsory education	Students in general secondary and higher education in % of total population[1]	Subsequent legislation
Austria	1774 Principle of compulsory education introduced by Joseph II (6 years)	1841: 0.2%	1869: extension to 8 years of compulsory education 1897: Part-time instruction compulsory at industrial schools
Belgium	1914 Introduction of 6 years of compulsory education realized only after WWI	1910: 0.9% and 1919: 0.9%	1919: extension to 8 years of compulsory schooling
Denmark	1814 Introduction of 7 years of compulsory education 3 days a week	...	
Finland	1921 Introduction of 6 years of compulsory schooling	1920: 1.1% and 1930: 1.6%	
France	1879 Introduction of 7 years of compulsory education	1875: 0.2% and 1890: 0.3%	1936: extension to 8 years of compulsory schooling
Germany*	1763 Introduction of 7-8 years of compulsory education	...	1871: extension to 8 years with the exception of Wurtenberg and Bavaria
Greece	1834 Introduction of 4 years of compulsory school, adoption of the Bavarian Plan	...	
Ireland	1926 Introduction of 8 years of compulsory education in towns	1891: 0.6%	
Italy+	1859 Introduction of 2-4 years of compulsory education	1880: 0.3%	1904: extension to 5 years of compulsory schooling

Note: [1] a better indicator would have been the age cohort, however it is not available

* Compulsory education was introduced in Prussia in 1763, after changes in law that occurred in 1871 took place in the German Empire

\+ The law of 1859 refers to the Kingdom of Sardinia and it was extended to all regions of united Italy in 1877

Source: Data and information have been taken from Flora et al. (1987), Eurydice Database and World Education Encyclopaedia (2002)

Table 2.B: Institutional development of the European educational systems (cont'd)

Country	Introduction of compulsory education	Students in general secondary and higher education in % of total population[1]	Subsequent legislation
Netherlands	1900 Introduction of 6 years of compulsory education	1890: 0.3% and 1910: 0.5%	
Norway	1848 Introduction of compulsory education from the age of 7 to confirmation	...	1889: extension to 7 years of compulsory schooling
Portugal	1919 Introduction of 4 years of compulsory schooling for boys only (extended to girls in 1960)	...	1926: reduction to 3 years of compulsory schooling
Spain	1857 Moyano Act, introduction of primary compulsory school for those aged 6-12 (7 years)	...	
Sweden	1842 Introduction of compulsory education, length of time not defined	1871: 0.4%	1878: introduction of 6 years of compulsory education
Switzerland	1874 Introduction of compulsory education, duration varied according to the canton	1891: 0.8%	
United Kingdom	1880 Introduction of 5 years of compulsory education	...	1918: extension to 9 years of compulsory schooling

Note: [1] a better indicator would have been the age cohort, however it is not available
Source: Data and information have been taken from Flora et al. (1987), Eurydice Database and World Education Encyclopaedia (2002)

Table 2.C: Expenditure on education as percentage of Gross National Product, 1950-2000

	Austria	Belgium	Denmark	Finland	France	Germany*
1950	...	2.1	3.1	3.1	...	3.5
1955	4.0 (1954)	2.3 (1956)	3.8	...	...	3.7
1960	3.7	5.7	3.9	6.6	...	3.9 (1959)
1965	3.7	4.2	5.7	6.0	4.2	3.0
1970	4.5	...	6.7	5.9	4.8	3.4
1975	5.6	6.2	7.6	6.4	5.2	5.2
1980	5.5	6.0	6.7	5.3	5.0	...
1985	5.8	6.0	7.0	5.4	5.8	...
1990	5.4	5.0	7.1 (1991)	5.7	5.4	...
1995	5.6	3.1	7.7	7.5	6.1	4.8
2000	6.4 (1999)	5.7 (1999)	8.6	6.1	5.7	4.5

	Greece	Ireland	Italy	Netherlands	Norway	Portugal
1950	...	2.7	2.9	3.5	3.2	1.4
1955	1.3	3.4 (1954)	2.7 (1954)	2.9	4.1	1.8
1960	2.0	...	4.0	4.9	5.4	2.2
1965	2.3	4.2	5.2	6.3	5.3	1.4
1970	2.0	4.8	3.7	7.2	5.4	1.6
1975	1.8 (1973)	5.8	4.1	8.1	6.3	3.7
1980	1.8 (1979)	6.3	4.4 (1979)	7.6	6.5	3.8
1985	2.4	6.4	5.0	6.4	5.9	4.0
1990	2.5	5.6	...	6.0	7.3	4.2
1995	2.9	6.0	4.7	5.2	8.1	5.3
2000	3.7	5.0	4.7	4.8 (1999)	6.7	5.9

	Spain	Sweden	Switzerland	United Kingdom	*Average 16*	United States
1950	1.2	3.5	2.7	3.2	2.8	3.1
1955	...	2.6	...	...	3.0	4.0
1960	1.5	5.4	3.4	5.3	4.1	5.0
1965	1.6	6.2	4.2	5.1	4.3	6.3
1970	2.1	7.6	3.8	5.3	4.6	6.4
1975	2.0	7.0	4.8	6.6	5.4	6.2
1980	2.6	9.0	4.7	5.6	5.4	6.7
1985	3.3	7.7	4.7	4.9	5.4	4.9
1990	4.4	7.7	4.9	4.9	5.4	5.2
1995	4.9	8.1	5.4	5.3	5.7	5.0
2000	4.5	7.5	4.9	4.7	5.6	6.0

Note: * Data for Germany before 1990 refer to the Federal Republic

Source: Data for 1950-1960 are taken from UNESCO (1965), Statistical Yearbook
Data for 1965 are taken from UNESCO (1978-79), Statistical Yearbook
Data for 1970-1995 are taken from UNESCO (1999), Statistical Yearbook
Data for 2000 are taken from UNESCO (2005) Online Database

Table 2.D: Average years of schooling, 1950-92

Country	1950			
	Primary	**Secondary**	**Higher**	**Total**
Austria	...	...	...	**...**
Belgium	6.00	2.41	0.23	**8.64**
Denmark	...	...	...	**...**
Finland	...	...	...	**...**
France	4.96	3.04	0.18	**8.18**
Germany (West)	4.00	4.37	0.14	**8.51**
Ireland	6.00	2.77	0.28	**9.05**
Italy	3.67	1.13	0.12	**4.92**
Netherlands	6.00	1.17	0.24	**7.62**
Norway	...	...	...	**...**
Portugal	1.77	0.47	0.05	**2.29**
Spain	4.53	0.31	0.11	**4.95**
Sweden	6.00	2.27	0.16	**8.43**
Switzerland	...	...	...	**...**
United Kingdom*	6.00	3.27	0.13	**9.40**
United States	5.61	3.40	0.45	**9.46**

Country	1973			
	Primary	**Secondary**	**Higher**	**Total**
Austria	...	...	...	**...**
Belgium	6.00	3.51	0.54	**10.05**
Denmark	...	...	...	**...**
Finland	...	...	...	**...**
France	5.00	4.11	0.47	**9.58**
Germany (West)	4.00	5.11	0.20	**9.31**
Ireland	6.00	3.38	0.41	**9.79**
Italy	4.34	2.04	0.21	**6.59**
Netherlands	6.00	2.49	0.39	**8.88**
Norway	...	...	...	**...**
Portugal	2.62	1.16	0.19	**3.97**
Spain	3.44	1.75	0.20	**5.39**
Sweden	6.00	2.67	0.35	**9.02**
Switzerland	...	...	...	**...**
United Kingdom*	6.00	3.99	0.25	**10.24**
United States	5.92	5.02	0.80	**11.77**

Note: * Data are not available separately for England, Scotland and Wales
Source: Maddison (1996, p.50)

Table 2.D: Average years of schooling, 1950-92 (cont'd)

Country	1992			
	Primary	**Secondary**	**Higher**	**Total**
Austria	...	...	...	**...**
Belgium	6.00	4.73	1.31	**12.04**
Denmark	...	...	...	**...**
Finland	...	...	...	**...**
France	5.00	5.54	1.60	**12.14**
Germany (West)	4.00	5.22	0.43	**9.65**
Ireland	6.00	...	...	**...**
Italy	4.77	3.99	0.42	**9.11**
Netherlands	6.00	4.14	0.77	**10.91**
Norway	...	...	...	**...**
Portugal	3.54	3.05	0.65	**7.24**
Spain	3.71	4.57	0.70	**8.98**
Sweden	6.00	4.00	1.32	**11.32**
Switzerland	...	...	...	**...**
United Kingdom*	6.00	4.91	0.61	**11.52**
United States	6.00	5.86	1.92	**13.78**

Note: * Data are not available separately for England, Scotland and Wales

Source: Maddison (1996, p.50)

Table 2.E: Public expenditure on education by level of education, 1970-2000

Country	Year	Pre-primary	Primary	Secondary	Tertiary	Other*
Austria	1970	0.7	29.6	47.8	13.4	8.6
	1975	1.2	23.0	50.8	14.7	10.2
	1980	6.1	17.9	53.2	14.5	8.2
	1985	5.9	17.2	46.9	16.6	13.3
	1990	6.0	17.7	46.6	19.1	10.5
	1995	6.3	21.1	47.0	21.6	...
	2000	7.3 (1999)	19.4 (1999)	44.8 (1999)	26.2 (1999)	3.2
Belgium	1970	...	...	51.7	13.3	10.3
	1975	...	...	47.7	15.3	11.5
	1980	...	...	47.3	17.3	10.1
	1985	...	...	46.4	16.7	12.3
	1990	...	...	42.9	16.5	17.4
	1995	9.3	20.6	46.6	20.5	...
	2000	8.0 (1999)	21.9 (1999)	42.0 (1999)	26.9 (1999)	...
Denmark	1970	...	...	...	20.8	8.1
	1975	...	...	...	20.8	8.1
	1980	...	...	...	17.6	10.4
	1985	...	...	...	...	...
	1990	...	...	...	...	...
	1995	11.2	21.5	39.7	22.8	...
	2000	8.5	21.0	36.7	30.0	3.7
Finland	1970	...	...	49.5	9.8	5.0
	1975	...	...	31.3	12.8	9.9
	1980	...	...	40.7	18.9	8.6
	1985	...	...	41.6	18.7	8.9
	1990	...	...	39.4	23.9	8.8
	1995	8.9	24.5	36.1	28.8	...
	2000	5.8	21.4	38.8	34.0	...
France	1970	...	...	...	...	...
	1975	7.8	23.0	38.7	13.4	17.1
	1980	8.4	22.0	40.3	12.5	16.8
	1985	10.0	19.5	40.8	12.9	16.8
	1990	9.8	17.6	40.7	13.8	18.2
	1995	11.9	19.8	50.0	17.0	...
	2000	11.0	20.2	49.9	17.6	1.2

Note: * Other includes "other types" and "not distributed"
Source: UNESCO Statistical Yearbook (1999) and UNESCO Online Education Database (2006)

Table 2.E: Public expenditure on education by level of education, 1970-2000 (cont'd)

Country	Year	Pre-primary	Primary	Secondary	Tertiary	Other*
Greece	1970	2.2	48.8	28.3	15.5	1.4
	1975	3.2	36.7	28.6	20.0	0.3
	1980	4.8 (1979)	36.9 (1979)	36.8	21.0	0.6
	1985	6.1	31.6	45.1	20.1	0.9
	1990	5.9	28.2	45.3	19.5	1.4
	1995	...	...	40.9	22.6	...
	2000	5.7	24.6	40.7	24.0	4.0
Ireland	1970	...	...	40.9	13.9	2.4
	1975	...	...	37.0	17.7	9.5
	1980	8.7	26.1	39.2	17.6	8.4
	1985	10.2	29.1	39.7	17.7	3.2
	1990	8.7	29.0	40.1	20.4	1.7
	1995	7.6	25.6	41.8	22.6	...
	2000	0.1	30.8	34.1	30.3	1.3
Italy	1970	2.7	28.4	38.1	8.8	22.0
	1975	4.8	30.0	42.4	13.3	9.4
	1980	6.0 (1979)	29.2 (1979)	41.0 (1979)	9.1 (1979)	14.8 (1979)
	1985	7.0	23.0	35.5	10.2	24.2
	1990	...	...	...	...	...
	1995	8.4	23.6	49.2	15.0	...
	2000	10.0	23.1	45.4	17.8	2.8
Netherlands	1970	4.8	20.8	38.6	22.1	13.7
	1975	5.7	20.3	36.2	28.3	9.5
	1980	5.5	19.2	33.8	27.5	14.0
	1985	...	...	35.9	26.4	15.1
	1990	5.2	16.3	37.7	32.1	8.6
	1995	7.1	23.2	39.7	29.9	...
	2000	7.3 (1999)	25.7 (1999)	39.3 (1999)	27.5 (1999)	...
Norway	1970	...	...	23.4	12.2	16.8
	1975	...	...	24.7	13.3	13.2
	1980	...	...	24.3	13.6	14.1
	1985	...	...	28.3	13.5	13.0
	1990	...	...	24.7	15.2	20.6
	1995	7.6	31.3	22.8	27.1	...
	2000	10.9	25.7	32.1	25.4	5.7

Note: * Other includes "other types" and "not distributed"
Source: UNESCO Statistical Yearbook (1999) and UNESCO Online Education Database (2006)

Table 2.E: Public expenditure on education by level of education, 1970-2000 (cont'd)

Country	Year	Pre-primary	Primary	Secondary	Tertiary	Other
Portugal	1970	...	...	...	...	...
	1975	0.1	55.1	23.8	10.6	0.6
	1980	...	...	25.4	10.5	6.0
	1985	1.2	49.8	30.6	12.7	1.6
	1990	2.3	42.3	32.5	16.3	3.1
	1995	2.7	35.2	42.7	16.4	...
	2000	5.3	29.9	43.0	18.1	3.7
Spain	1970	...	...	23.4	18.2	1.3
	1975	...	...	...	14.5	1.5
	1980	3.5 (1979)	58.9	19.3	14.0	1.7
	1985	...	...	...	...	...
	1990	6.0	23.3	45.0	15.4	9.9
	1995	8.1	24.1	50.7	15.1	...
	2000	8.6	25.8	43.7	21.8	...
Sweden	1970	...	...	17.7	14.5	24.7
	1975	...	...	13.3	12.3	36.2
	1980	0.1	44.6	13.6	9.3	32.5
	1985	0.1	47.9	20.1	13.1	18.8
	1990	0.1	47.6	19.6	13.2	19.6
	1995	7.2	25.7	39.4	27.7	...
	2000	6.6	27.9	37.7	27.2	...
Switzerland	1970	1.8	33.2	40.2	17.5	7.2
	1975	3.2	...	77.9	17.0	1.8
	1980	2.8	...	73.7	18.6	4.9
	1985	3.1	...	73.6	18.1	5.2
	1990	3.6	49.9	25.1	19.7	5.2
	1995	3.9	26.8	47.5	19.7	...
	2000	4.0	31.4	39.4	22.3	1.9
United Kingdom	1970	...	...	36.2	23.0	14.1
	1975	...	...	39.5	20.7	11.3
	1980	...	...	40.1	22.4	10.8
	1985	3.0	23.7	45.9	19.8	7.6
	1990	3.6	26.1	43.8	19.6	6.8
	1995	2.6	29.7	44.0	23.7	...
	2000	9.4	25.0	48.4	17.2	...

Note: * Other includes "other types" and "not distributed"
Data for Germany are not available
Source: UNESCO Statistical Yearbook (1999) and UNESCO Online Education Database (2006)

Table 2.E: Public expenditure on education by level of education, 1970-2000 (cont'd)

Country	Year	Pre-primary	Primary	Secondary	Tertiary	Other
United States	1970	...	70.5	...	29.5	...
	1975	...	67.5	...	32.5	...
	1980	...	36.5	...	...	...
	1985	...	...	30.3	25.1	...
	1990	...	...	37.0	24.1	...
	1995	7.0	31.7	36.1	25.2	...
	2000	...	...	...	...	...

Note: * Other includes "other types" and "not distributed"
Data for Germany are not available
Source: UNESCO Statistical Yearbook (1999) and UNESCO Online Education Database (2006)

Table 2.F: Expenditure per student from public sources, 1988

in equivalent US dollars converted using PPPs (1988)

Country	Pre-primary	Primary	Secondary	Tertiary
Austria	1607	2610	3198	5029
Belgium	1524	2115	4050	4987
Denmark	2607	3204	4253	10847
Finland	4361	3145	3786	5293
France	1569	1885	3073	3780
Germany	941	2101	2659	5085
Ireland	1060	1125	1891	4740
Italy	1588	2457	2887	4250
Netherlands	...	1913	2263	9542
Norway	870	3900	4842	7439
Portugal	707	1314	1373	4451
Spain	914	1158	1586	1934
Sweden	2240	4423	5146	6334
Switzerland	...	...	...	10187
United Kingdom	1659	2105	2763	7960
United States	2778	3566	4370	6386

Source: OECD (1992) Education at a Glance

Table 2.G: Public Expenditure per student as percentage of per capita GDP, 1975-85

Country	Pre-primary	Primary	Secondary	Tertiary
1975				
Austria	...	...	...	...
Belgium	...	...	...	57.2
Denmark	...	...	...	...
Finland	...	...	31.3	92.1
France	...	25.4	...	...
Germany	...	...	16.4	...
Greece	5.9	11.3	8.8	38.7
Ireland	11.5	7.3	23.4	92.9
Italy	15.5	...	18.9	30.6
Netherlands	10.2	113.3	26.1	113.3
Norway	...	...	39.9	116.0
Portugal	...	40.8[1]	24.7	40.8
Sweden	...	...	32.8	...
Switzerland	7.8	91.4	...	91.4
United Kingdom	...	...	...	...
United States	...	26.9	22.7	26.9

Note: [1] for Portugal only available joint pre-primary and primary
Source: OECD (1990) Education in OECD countries 1987-88

Table 2.G: Public Expenditure per student as percentage of per capita GDP, 1975-85 (cont'd)

Country	Pre-primary	Primary	Secondary	Tertiary
1980				
Austria	...	...	...	...
Belgium	...	...	...	...
Denmark	...	24.7	79.5	...
Finland	...	...	...	...
France	...	...	...	...
Germany	...	...	...	...
Greece	7.8	9.1	11.4	43.5
Ireland	12.9	...	25.3	81.1
Italy	12.9	...	21.8	20.2
Netherlands	13.1	95.6	23.4	95.6
Norway	...	51.4	36.0	51.4
Portugal	...	46.6[1]	19.3	46.6
Sweden	0.1	34.2	33.4	34.2
Switzerland	7.3	82.0	...	82.0
United Kingdom	...	...	...	...
United States	...	25.3	24.7	25.3

Note: [1] for Portugal only available joint pre-primary and primary

Country	Pre-primary	Primary	Secondary	Tertiary
1985				
Austria	...	17.8	...	...
Belgium	...	...	...	...
Denmark	...	26.2	71.6	53.0
Finland	...	21.6	29.3	38.0
France	12.4	15.1	23.5	29.4
Germany	...	15.4	16.5	...
Greece	9.8	9.5	13.5	35.0
Ireland	13.5	...	13.5	62.9
Italy	17.1	...	23.3	36.8
Netherlands	11.4	75.7	21.3	75.7
Norway	...	50.1	34.4	50.1
Portugal	13.1	48.0[1]	18.8	53.1
Sweden	0.1	39.1	37.9	38.6
Switzerland	8.0	68.3	...	69.2
United Kingdom	...	72.0	25.0	...
United States	...	22.3	25.3	22.3

Note: [1] for Portugal only available joint pre-primary and primary
Data for 1985 have been linearly interpolated as the data are available for 1984 and 1986
Source: OECD (1990) Education in OECD countries 1987-88

Table 2.H: Expenditure on educational institutions from public and private sources as percentage of GDP, 1990-98

	1990			1995		
	Public*	**Private****	**Total**	**Public**	**Private**	**Total**
Austria	5.14	...	5.14	4.46	1.00	5.46
Belgium	...	...	...	...	...	...
Denmark	5.99	0.15	6.15	6.42	0.29	6.71
Finland	5.96	...	5.96	6.30	...	6.30
France	5.23	0.43	5.66	5.94	0.38	6.32
Germany	...	...	...	4.49	1.27	5.76
Greece	...	...	...	2.94	...	...
Ireland	4.71	0.50	5.20	4.74	0.53	5.27
Italy	5.77	...	5.77	4.50	0.09	4.50
Netherlands	4.45	0.35	4.80	4.57	0.12	4.69
Norway	6.18	...	6.18	7.05	0.15	7.20
Portugal	4.15	...	4.15	5.26	0.03	5.30
Spain	4.07	0.64	4.71	4.56	0.97	5.53
Sweden	5.28	...	5.28	6.31	0.11	6.42
Switzerland	4.97	...	4.97	...	...	...
United Kingdom	4.65	0.28	4.92	4.84	0.23	5.06
United States	...	...	...	4.99	1.67	6.37

	1998		
	Public	**Private**	**Total**
Austria	5.98	0.38	6.36
Belgium	4.97	...	4.97
Denmark	6.81	0.36	7.17
Finland	5.75	...	5.75
France	5.88	0.36	6.24
Germany	4.35	1.20	5.55
Greece	3.44	1.32	4.76
Ireland	4.31	0.40	4.71
Italy	4.82	0.19	5.01
Netherlands	4.49	0.12	4.61
Norway	6.77	0.13	6.90
Portugal	5.57	0.08	5.65
Spain	4.44	0.85	5.30
Sweden	6.59	0.18	6.77
Switzerland	5.38	0.47	5.86
United Kingdom	4.45	...	...
United States	4.82	1.61	6.43

Note: * Including public subsidies to households and direct expenditure from international sources

** Net of public subsidies attributable for educational institutions

Source: OECD (2001) Education at a Glance

Table 2.I: Sources of public expenditure on education by level of government after inter-level transfers, 1988

Country	Central	Regional	Local	Others
Austria	46.0	29.1	22.5	2.4
Denmark	44.9	10.7	44.4	0.0
Finland	22.6	0.0	71.3	6.1
France	76.5	7.3	15.6	0.7
Ireland	79.2	0.0	20.8	0.0
Italy	71.1	0.8	10.0	9.2
Netherlands	78.5	0.1	21.4	0.0
Portugal	100.0	0.0	0.0	0.0
Spain	22.6	0.0	71.3	6.1
Sweden	18.0	6.9	75.2	0.0
Switzerland	6.3	60.7	32.9	0.0
United States	1.0	24.3	74.2	0.4

Source: OECD (1992) Education at a Glance

Table 2.J: Pupil / Teacher ratio at primary and secondary levels of education, 1950-98

Country	Level of education	1950	1955	1960	1965	1970	1975
Austria	Primary	23.82	21.34	21.50	21.40	21.66	17.81
	Secondary	16.23	17.52	15.74	13.05	14.84	...
Belgium	Primary	...	...	...	...	...	...
	Secondary	...	...	...	...	...	...
Denmark	Primary	...	...	...	...	...	...
	Secondary	...	...	...	...	...	...
Finland	Primary	23.51	24.42	22.93	20.76	19.45	17.14
	Secondary	16.96	19.42	20.67	19.01	18.51	15.56
France	Primay	...	...	...	...	25.99	25.99
	Secondary	...	...	...	...	...	...
Germany*	Primary	48.32	36.29	36.49	34.83	33.76	27.22
	Secondary	23.63	20.09	20.99	20.85	21.57	21.98
Greece	Primary	...	45.80	38.45	35.18	30.96	30.19
	Secondary	...	...	29.40	31.15	32.46	28.29
Ireland	Primary	29.61	30.68	31.01	30.97	30.40	28.38
	Secondary	12.78	13.47	14.77	15.18	15.73	15.51
Italy	Primary	27.29	26.82	22.09	21.84	21.81	19.11
	Secondary	10.39	11.71	11.98	11.58	10.95	...
Netherlands	Primary	35.34	35.68	34.04	31.31	29.72	27.21
	Secondary	18.19	18.29	...	19.17	...	...
Norway	Primary	27.44	29.44	26.42	22.79	19.07	19.97
	Secondary	...	...	...	...	17.88	16.95
Portugal	Primary	42.70	39.70	34.00	31.90	33.51	10.39
	Secondary	41.90	48.93	19.64	20.99	18.51	14.50
Spain	Primary	35.40	40.00	...	...	...	...
	Secondary	...	18.00	23.00	29.90	24.70	16.80
Sweden	Primary	18.76	18.76	14.57	10.61	...	...
	Secondary	...	12.33	16.54	19.71	4.50	4.90
Switzerland	Primary	...	...	...	...	...	...
	Secondary	...	...	...	...	...	...
UK°	Primary	29.89	30.19	28.70	27.99	26.72	23.59
	Secondary	21.11	21.16	20.35	18.41	17.86	16.87
United States**	Primary	...	...	...	...	...	...
	Secondary	...	...	...	...	...	...

Note: * Data refer to the Federal Republic

° Data for the UK refer to England and Wales

** It is not possible to estimate the ratio for the United States as the number of teachers is not separated according to the level of education

Source: Ratios have been calculated by using data from Mitchell (1992)

Table 2.J: Pupil / Teacher ratio at primary and secondary levels of education, 1950-98 (cont'd)

Country	Level of education	1980	1985	1990	1995	1998
Austria	Primary	13.07	9.97	9.42	9.33	9.36
	Secondary	11.99	10.37	8.88	9.17	9.23
Belgium	Primary	...	...	...	...	...
	Secondary	...	...	...	...	...
Denmark	Primary	...	...	...	...	...
	Secondary	...	...	...	...	...
Finland	Primary	15.22	14.39	13.83	14.40	14.20
	Secondary	17.65	15.81	14.23	15.10	14.00
France	Primary	25.34	19.64	13.70	12.76	12.83
	Secondary	...	...	...	...	...
Germany*	Primary	20.34	16.35	16.48	15.90	15.60
	Secondary	19.28	14.96	13.56	15.70	15.40
Greece	Primary	...	...	...	...	...
	Secondary	...	...	...	...	...
Ireland	Primary	26.76	27.13	26.80	23.60	23.50
	Secondary	14.89	17.98	18.52	17.90	18.20
Italy	Primary	...	...	...	...	...
	Secondary	...	...	...	...	...
Netherlands	Primary	23.59	16.62	17.18	15.90	16.30
	Secondary	15.15	15.06	...	...	...
Norway	Primary	19.19	16.95	13.91	12.80	12.70
	Secondary	12.35	11.54	11.50	10.00	10.80
Portugal	Primary	10.39	21.65	...	...	...
	Secondary	14.50	12.78	...	...	...
Spain	Primary	...	...	...	...	...
	Secondary	16.50	16.30	15.55	...	...
Sweden	Primary	...	...	...	...	...
	Secondary"	4.49	4.37	4.22	4.30	4.38
Switzerland	Primary	...	...	...	...	...
	Secondary	...	...	...	...	...
UK°	Primary	22.42	22.12	21.94	22.40	22.16
	Secondary	16.60	15.96	15.28	16.16	15.70
United States**	Primary	...	...	...	...	...
	Secondary	...	...	...	...	...

Note: * Data refer to the Federal Republic

° Data for the UK refer to England and Wales

" Data for secondary school for Sweden do not seem to be correct, for instance according to estimations of OECD (1992), the ratio in 1988 was 11.5

** It is not possible to estimate the ratio for the United States as the number of teachers is not separated according to the level of education

Source: Ratios have been calculated by using data from Mitchell (1992)

APPENDIX Chapter 3

3.A: Data sources

- Data related to real GDP per capita, GDP per capita with respect to the United States and openness have been taken from the Penn World Tables (2002).
- Data related to technology have been extracted from the records on Patents for Inventions of the World Intellectual Property Organization.
- Data related to population have been taken from the Penn World Tables (2002) and Maddison (2001).
- Data related to the population divided according to the age group have been taken from the World Development Indicators (2005) and Mitchell (2003).
- Data related to illiteracy have been extracted from Morrisson and Jutting (2004).
- Data related to the number of years of compulsory schooling in 1950 have been taken from various sources: Eurydice Database (2005), Flora et al. (1987), World Education Encyclopaedias (1988, 2002). Information for Switzerland have been kindly provided by the Swiss Federal Schooling Body, Arnet (2000).
- Data related to the average years of school, the share of the population who has completed primary, secondary and higher education as well as data related to the number of years necessary to complete each level of education have been extracted from the Cohen and Soto (2001) dataset.
- Data for democracy have been kindly provided by Professor Meyer and they have been used in the paper by Meyer and Schofer (2005a).
- Data related to the Gini coefficient have been taken from Dollar and Kraay (2001).
- Data related to the population working in the agricultural, industrial and service sector have been taken from Mitchell (2003).

Note: When there was a missing data for one year and the information could not be found in any of the national and international sources then the linear interpolation technique has been used to fill the gap.

3.B: Variables used in the analysis

This is the list of the explanatory variables used in the analysis:

Real GDP per capita (GDP_{pc}). It is the real GDP per capita measured in international $ in 1996 constant prices

Real GDP per capita growth ($l(GDP/GDP_{(-5)})$). It has been calculated by taking the log of the ratio of the current level of GDP with respect to the level of five years earlier

GDP per capita with respect to the United States (GDP_{pc}/GDP_{pcUS}). It is the current GDP per capita expressed relative to the United States, (US = 100 in each year)

Technology per capita ($Technology_{pc}$). It is the number of patents granted every year to residents and non-residents divided by the population

Openness (Openness). It is calculated as exports plus imports divided by Gross Domestic Product

Population (pop). It is population in '000s

Population according to the age group (pop014; pop1564; pop65above). It is the share of the population divided according to the age groups: 0-14, 15-64 and 65 and above

State capacity (State Capacity). It is the ratio of the pop1564 with respect to pop014

Share of the labour force working in the three sectors of the economy (LFAgriculture; LFIndustry; LFServices). These indicators have been constructed by taking the number of people working in the agricultural, industrial and service sector and by dividing them by the total labour force

Illiteracy (Illiteracy). Share of the population who lacks the basic skills of literacy and numeracy

Average years of school (AvgYearsSchool). It is the average number of years of schooling of the population

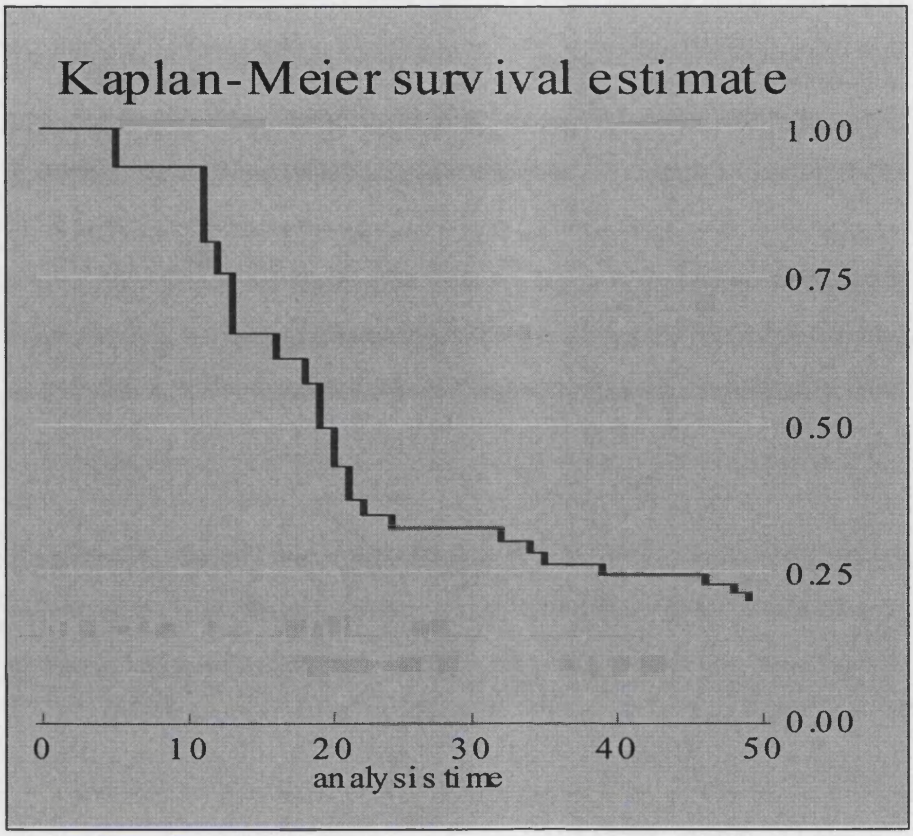
Years of compulsory school in 1950 (CompSchool50). Number of years of compulsory schooling in each country at the beginning of the period, 1950

Share of the population according to the highest level of education completed (Completed Primary, Completed Secondary, Completed Higher). It is the share of the population according to the highest level of completed education: primary, secondary or higher education

Democracy (Democracy). It is an index that can take a value from -10 (when a country is "strongly autocratic") to +10 (when a country is "strongly democratic"). It is based on features such as: competitive and open elections, absence of autocratic characteristics such as unlimited executive authority

Gini coefficient (GINI). It measures the concentration of the distribution of wealth among the population

Figure 3.C: Kaplan-Meier survival function and smoothed hazard function



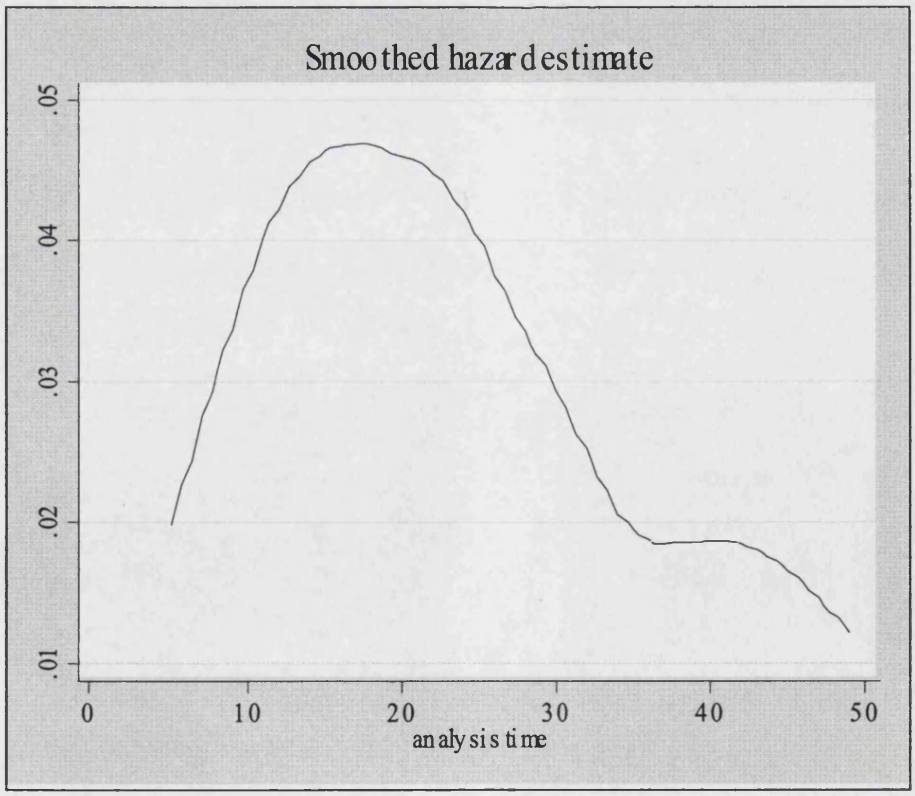


Table 3.D: Test of proportional hazards assumption

The test is based on the estimation of the model for the fifteen European countries in the sample over 1950-2000. The results of this regression are shown in table 3.5.

Variable	rho	chi2	df	Prob>chi2
$Technology_{pc}$	-0.03891	0.04	1	0.8324
Openness	-0.16422	0.88	1	0.3474
YearsComp50	0.07366	0.27	1	0.6030
Democracy	-0.05331	0.10	1	0.7546
Gini	0.05365	0.11	1	0.7414
State Capacity	-0.05605	0.11	1	0.7376
$l(GDP/GDP_{(-5)})$	0.11668	0.35	1	0.5567
country 2	0.14211	0.70	1	0.4020
country 3	0.01427	0.00	1	0.9470
country 4	-0.06431	0.17	1	0.6802
country 5	-0.10843	0.58	1	0.4452
country 6	-0.12200	0.62	1	0.4297
country 7	-0.02459	0.03	1	0.8725
country 8	0.12673	0.38	1	0.5375
country 10	-0.13350	0.72	1	0.3966
country 11	0.07321	0.22	1	0.6407
country 12	0.00576	0.00	1	0.9748
country 13	-0.00003	0.00	1	0.9999
country 14	0.07715	0.17	1	0.6801
country 15	0.01250	0.00	1	0.9513
global test		1.41	20	1.0000

The chi-square statistics checks the relationship between time and the covariates in the model. The test is not significant for the covariates individually and when they are tested in the same model. That is, it is not possibile to reject the hypothesis of proportionality. Therefore the assumption of proportionality of the model is satisfied.

APPENDIX Chapter 4

Table 4.A: ICT qualification profiles and programmes in Germany

Fields of education	VET level 2	VET level 3	VET level 4	HE level 5B	HE level 5M
Arts		Designer of Digital and Print Media	Multimedia Developer	Computer Science Multimedia	Computer Science Multimedia
				Multimedia	
Business and Administration	Assistano for Business	Information Technology Officer	Business Manager in Business Informatics		
	Business Assistant for Data Processing	IT System Support Specialist	Business Manager in Data Processing and Organisation		
	Business Assistant for Economy and Data Processing		Business Systems Administrator		
	Business Assistant for Information Technology		Business Systems Adviser		
	Commercial Assistant for Information Processing		IT Key Accounter		
	Information Technology Assistant for Business		Knowledge Manager System Developer		
	Technical Assistant for Business Information Technology		Technical Writer		
Computing			Specialist for Data Processing- Business Information Technology	Bio Informatics	Computer Science (general) / Informatics
			Specialist for Data Processing- Information Organizer	Computer Science (general) Informatics	Bio Informatics
			Database Developer	Geo Informatics	Geo Informatics
			Device Developer	International Female Studies Computer Science	Medical Informatics

Source: Euquasit Database (2002) and German Ministry of Education

Table 4.A: ICT qualification profiles and programmes in Germany (cont'd)

Fields of education	VET level 2	VET level 3	VET level 4	HE level 5B	HE level 5M
Computing			E Logistic Developer	Medical Informatics	IT System Engineer
			E Marketing Developer	IT Engineer	
			ICT Process Manager		
			IT Configuration Coordinator		
			IT Product Coordinator		
			IT Project Coordinator		
			IT Security Coordinator		
			Network Developer		
			Quality Management Coordinator		
			Software Developer		
			Specialist for Data Processing-Mathematical Technical Information Technology		
			Specialist for Data Processing- Organisational Programming		
			Specialist for Data Processing- Software Developer		
			State Certified Informatics		
			User Interface Developer		
			IT Test Coordinator		
			Database Administrator		
			Web Administrator		
			IT Trainer		

Source: Euquasit Database (2002) and German Ministry of Education

Table 4.A: ICT qualification profiles and programmes in Germany (cont'd)

Fields of education	VET level 2	VET level 3	VET level 4	HE level 5B	HE level 5M
Engineering and trades engineering	Assistant for Automation and Computer Technology	Communication Electronic Technician in Information Technology	Industrial Systems Technician	Communications and Information Technology	Computer Science Engineering
	Industrial Technician for Data Technology	Communication Electronic Technician in Radio Technology	IT Supporter / Service Advisor	Computer Science Engineering	Communications and Information Technology
	Information and Communications Technology Assistant	Communication Electronic Technician in Telecommunication Engineering	IT System Administrator	Micro Electronics	Communications Engineering
	Technical Assistant-Electronics and Data Technology	Information Electronics	IT System Analyst	Micro Systems Engineering	Informations System Technology
	Technical Assistant for Production Informatics	IT System Electronics	IT Systems Developer	New Communications Technologies	Micro Electronics
		Micro Technologist	Master (Craftsman) Information Technology	New Communications Technologies / Telecommunications	Micro Systems Engineering
		Telecommunication Facility Electronic Technician	Master (Craftsman) Telecommunication Facility Electronic Technician	Optical Electronics	Optical Electronics
			Network Administrator		
			Security Technician		
			Technician in (Technical) Informatics		
			Technician in Data Processing Technology		
			Technician in Data Systems Technology		

Source: Euquasit Database (2002) and German Ministry of Education

Table 4.A: ICT qualification profiles and programmes in Germany (cont'd)

Fields of education	VET level 2	VET level 3	VET level 4	HE level 5B	HE level 5M
Engineering and trades engineering			Technician In Information and Communications Technology		
			Technician in Information Electronics		
			Technician in Radio Communication		

Source: Euquasit Database (2002) and German Ministry of Education

Table 4.B: ICT qualification profiles and programmes in the Netherlands

Fields of education	VET level 2	VET level 3	VET level 4	HE level 5B	HE level 5M
			Middle Management Employee IT Media Production	Communication and multimedia design	
Arts			Middle Management Employee Multimedia designer	Graphic media technology	
Business and Administration			Middle Management Employee Office	Business administration informatics	Business Information Technology
			Automation Engineering		Business Mathematics and Informatics
			Short HBO course business administration informatics		Informatics and Economics
Computing	ICT service worker	Assistant Administrator ICT	Developer Software Applications	Computer Techniques	Informatics
	ICT worker	Assistant information systems administration	Administrator Software Applications	Higher education software engineer	Information Science
			Middle Management Employee Telematics	Higher informatics	
			Short HBO course informatics	Informatics	
			Middle Management Employee Administrator ICT	Informatics and information knowledge	
			Administrator ICT		

Source: Euquasit Database (2002) and Dutch Ministry of Education

Table 4.B: ICT qualification profiles and programmes in the Netherlands (cont'd)

Fields of education	VET level 2	VET level 3	VET level 4	HE level 5B	HE level 5M
Engineering and trades engineering	Craftsman Communications Networks	First Craftsman Communications Networks	Middle Management Employee Administrator technical infrastructure	Communication systems	Communication and Information Science
	Craftsman Communications-Installations	First Craftsman Communications-Installations	Middle Management Employee Automation Electronics	Electrical engineering	Electrical engineering
	Craftsman Consumer Electronics	First Craftsman Consumer Electronics	Middle Management Employee Automation Energy Engineering	Electronics engineering	Technical Informatics
	Craftsman Industrial Electronics	First Craftsman Electrics and Instrumentation	Middle Management Employee Computer Interface Engineering	Higher education system engineer	Telematics
		First Craftsman Industrial Electronics	Middle Management Production Automation Engineering	Higher electronics expert	
			Network Administrator	Technical informatics / computer techniques	
			System Administrator		
			Technician Communications Systems		
			Technician Consumer Electronics		
			Technician Electrical Industrial Plants		

Source: Euquasit Database (2002) and Dutch Ministry of Education

Table 4.C: ICT qualification profiles and programmes in Portugal

Fields of education	VET level 2	VET level 3	VET level 4	HE level 5B	HE level 5M
Arts		Multimedia Systems Programmer	Multimedia Applications Operator	Graphic Computer Science	
				Multimedia Design	
Business and Administration				Information Technology for Management	Informatics for Business Administration
					Information and Management
					Statistics and Information Management
Computing	Data Processing Assistant	Database Management – Micro Systems	Software Analyst	Informatics	Informatics
	Informatics assistano Technician	Informatics Technician	Data Analyst	Informatics / Computer Sciences	Informatics / Computer Sciences
	Informatics Operator	Advanced Applications Operator	Data Processing Management	Informatics Systems	Computer Applied Mathematics
		Data Processing Technician	Database manager	Information Technologies	Informatics Engineer
			Database Management – Main Frame		Computer Systems Engineer
			Informatics Applications Analyst		Informatics Systems Engineer
			Informatics Applications Programmer		
			Main Frame Applications Programmer		

Source: Euquasit Database (2002) and Portuguese Ministry of Education

Table 4.C: ICT qualification profiles and programmes in Portugal (cont'd)

Fields of education	VET level 2	VET level 3	VET level 4	HE level 5B	HE level 5M
Engineering and trades engineering	Assistant Technicians of Equipment Maintenance Network (PC's)	Network Maintenance Technician	Maintenance Applications Technician	Electronics and Telecommunications	Electronics and Computer Engineering
	Maintenance Technicians	Hardware Technician	Micro Network Management and Installation Technician	Communications Design	Automation Systems Engineer
		CAD Operator	Industrial design CAD 3D Specialist	Electronics and Computers	New Communication Technologies
					Telecommunications and Informatics Engineering
					Telematics Engineering
					Engineer of Electronics and Telecommunications

Source: Euquasit Database (2002) and Portuguese Ministry of Education

Table 4.D: Timing of the introduction of the ICT-related programmes in Germany

Year	VET 2	VET 3	VET 4	HE 5B	HE 5M	**Total**
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980	6					**6**
1981			1			**1**
1982						
1983						
1984						
1985						
1986	1					**1**
1987		4		1	1	**6**
1988			1			**1**
1989						
1990			1	1	2	**4**
1991				1	1	**2**
1992	4		10	2	2	**18**
1993						
1994						
1995				1		**1**
1996				3		**3**
1997	2	5				**7**
1998	2	2	1	1	1	**7**
1999			1	1		**2**
2000				2	2	**4**
2001				3	1	**4**
2002			31	2	3	**36**

Source: EUQUASIT, BIBB and German Ministry of Education

Table 4.E: Timing of the introduction of the ICT-related programmes in the Netherlands

Year	VET 2	VET 3	VET 4	HE 5B	HE 5M	**Total**
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990				4	1	**5**
1991			1			**1**
1992			1	1		**2**
1993					1	**1**
1994						
1995						
1996				1		**1**
1997		1	2	1		**4**
1998				3		**3**
1999				2		**2**
2000					3	**3**
2001	4	5	10	3	3	**25**
2002	1		1	3		**5**

Source: EUQUASIT and Dutch Ministry of Education

Table 4.F: Timing of the introduction of the ICT-related programmes in Portugal

Year	VET 2	VET 3	VET 4	HE 5B	HE 5M	**Total**
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994			1		1	**2**
1995			1			**1**
1996		3	1	1	2	**7**
1997	3	3	6			**12**
1998			1		2	**3**
1999		1		1	4	**6**
2000	2	1	2	8	3	**16**
2001						
2002			1		2	**3**

Source: EUQUASIT and Portuguese Ministry of Education

Table 4.G: Evolution of the enrolments in general education and vocational education and training at secondary and tertiary level in Germany, 1970-2005

Germany		
	GE	VT
1970	0.65	0.35
1975	0.65	0.35
1980	0.62	0.38
1985	0.59	0.41
1990	0.57	0.43
1995	0.60	0.40
2000	0.60	0.40
2005	0.61	0.39

Source: BIBB and UNESCO Statistical Yearbook (*various years*)

Table 4.H: Evolution of the enrolments in general education and vocational education and training at secondary and tertiary level in the Netherlands, 1970-2005

Netherlands		
	GE	VT
1970	0.45	0.55
1975	0.60	0.40
1980	0.60	0.40
1985	0.56	0.44
1990	0.59	0.41
1995	0.52	0.48
2000	0.58	0.42
2005	0.59	0.41

Source: UNESCO Statistical Yearbook (*various years*)

Table 4.I: Evolution of the enrolments in general education and vocational education and training at secondary and tertiary education level in Portugal, 1970-2005

Portugal		
	GE	VT
1970	0.66	0.34
1975	0.72	0.28
1980	0.78	0.22
1985	0.99	0.01
1990	0.95	0.05
1995	0.87	0.13
2000	0.79	0.21
2005	0.71	0.29

Source: UNESCO Statistical Yearbook (*various years*)

Table 4.J: Evolution of the enrolments and graduation rates in computer science at higher education level in Germany, 1980-2002

Year	Enrolled in 1st year	Number of graduates
1980	3697	470
1981	4040	537
1982	4472	633
1983	5505	676
1984	6391	788
1985	6546	957
1986	6608	1210
1987	6907	1322
1988	8218	1493
1989	8712	1745
1990	8667	1951
1991	8051	2202
1992	7264	2228
1993	9307	2673
1994	8241	3058
1995	7863	3257
1996	9033	3530
1997	9976	3561
1998	13810	3291
1999	18113	2965
2000	25039	2748
2001	22015	2527
2002	18475	2573

Source: Statistiches Bundesamt (2006)

Table 4.K: Evolution of the enrolments and graduation rates in computer science at higher education level in the Netherlands, 1994-2002

Year	Enrolled in 1st year	Number of graduates
1994	2030	
1995	2270	1930
1996	3120	1760
1997	3850	1680
1998	4700	1730
1999	5110	1940
2000	5670	2290
2001	5510	2760
2002	5290	3020

Source: Central Bureau voor de Statistiek (2006)

Table 4.L: Evolution of the composition of the participation in higher education in Portugal, 1980-2005

Portugal								
	Total	Humanities	Education	Fine Arts	Law	Social Sciences	Natural Sciences	Engineering
1980	91373	16145	7731	2726	8968	16702	5156	15716
1990	103585	13284	11996	1760	12765	10062	3172	17896
2005	305279	11579	16971	1861	18958	12436	1403	28916

Source: UNESCO Statistical Yearbook and Portuguese Ministry of Education

Portugal				
	Total	Medical Sciences	Agricolture	Other
1980	91373	14715	2285	1229
1990	103585	8635	3883	7142
2005	305279	6557	2980	13109

Note: "Other" includes: mathematics, computer science and related degrees
Source: UNESCO Statistical Yearbook and Portuguese Ministry of Education

Table 4.M: Evolution of the enrolments and graduation rates in computer science at higher vocational education level (*Fachhoschulen*) in Germany, 1980-2002

Year	Enrolled in 1st year	Number of graduates
1980	1130	435
1981	1459	405
1982	1650	422
1983	2187	581
1984	2277	735
1985	2439	898
1986	2623	1080
1987	3332	1219
1988	3987	1339
1989	4210	1459
1990	4457	1742
1991	4518	2043
1992	4442	2196
1993	4964	2469
1994	5530	2731
1995	5073	2913
1996	6037	2676
1997	7057	3042
1998	8371	2692
1999	9966	2729
2000	13044	2402
2001	14295	2792
2002	14008	3253

Source: Statistiches Bundesamt (2006)

Table 4.N: Evolution of the enrolments and graduation rates in computer science at higher vocational education level (*HBO*) in the Netherlands, 1995-2002

Year	Enrolled in 1st year	Number of graduates
1995	1680	...
1996	1550	...
1997	1550	...
1998	1560	...
1999	1740	...
2000	2040	...
2001	2480	...
2002	2730	...

Note: ... data not available
Source: Central Bureau voor de Statistiek (2006)

APPENDIX Chapter 5

Figure 5.4b Distribution of average years of education and average earnings for individuals born between 1955 and 1957 in the Netherlands

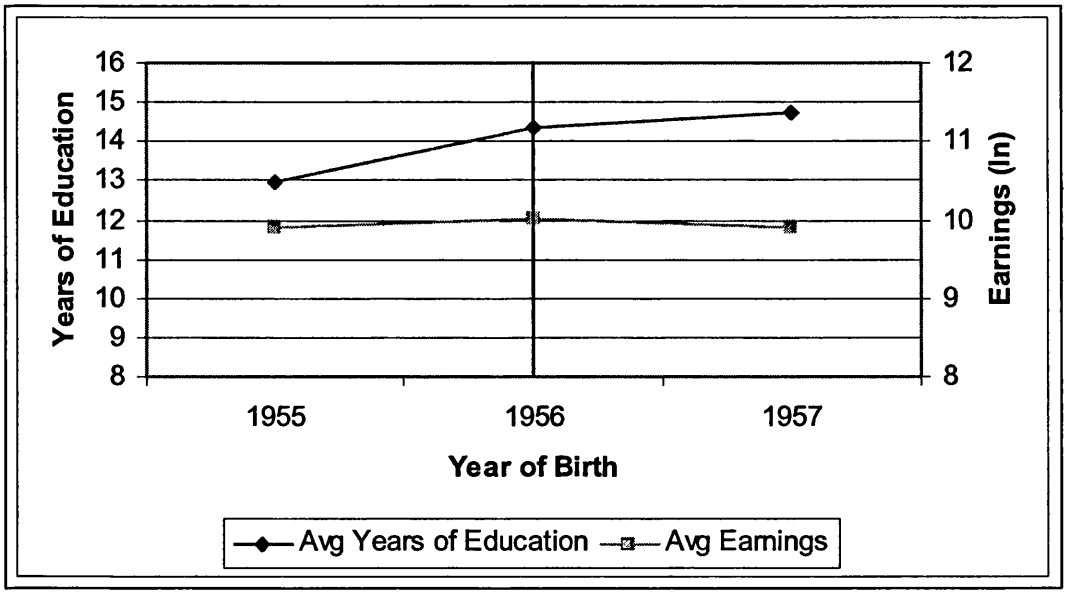


Figure 5.4c Distribution of average years of education and average earnings for individuals born between 1958 and 1960 in the Netherlands

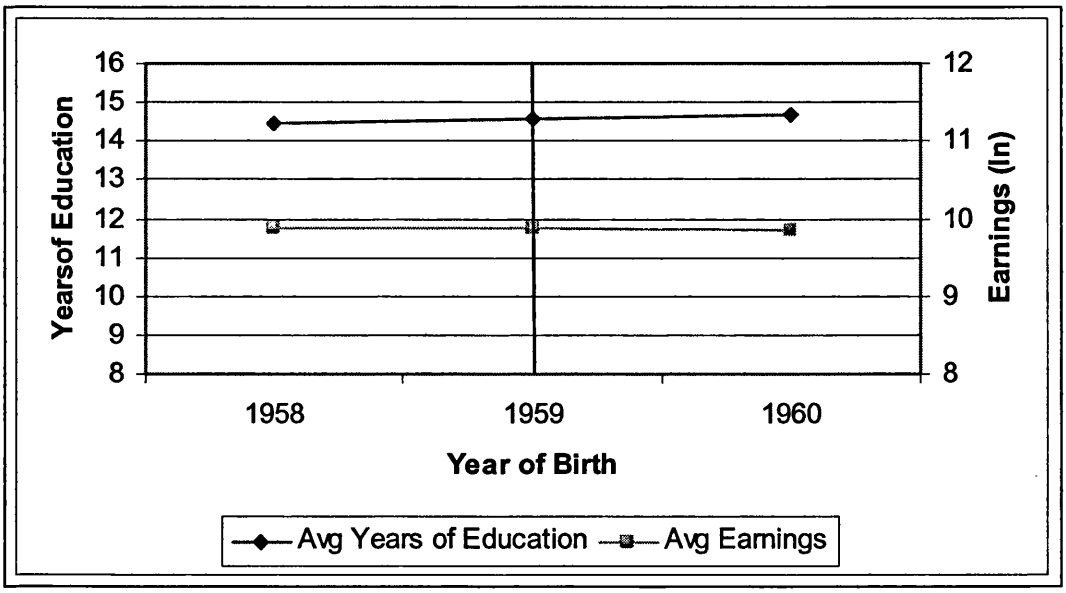


Figure 5.5b Distribution of average years of education and average earnings for individuals born between 1953 and 1955 in Portugal

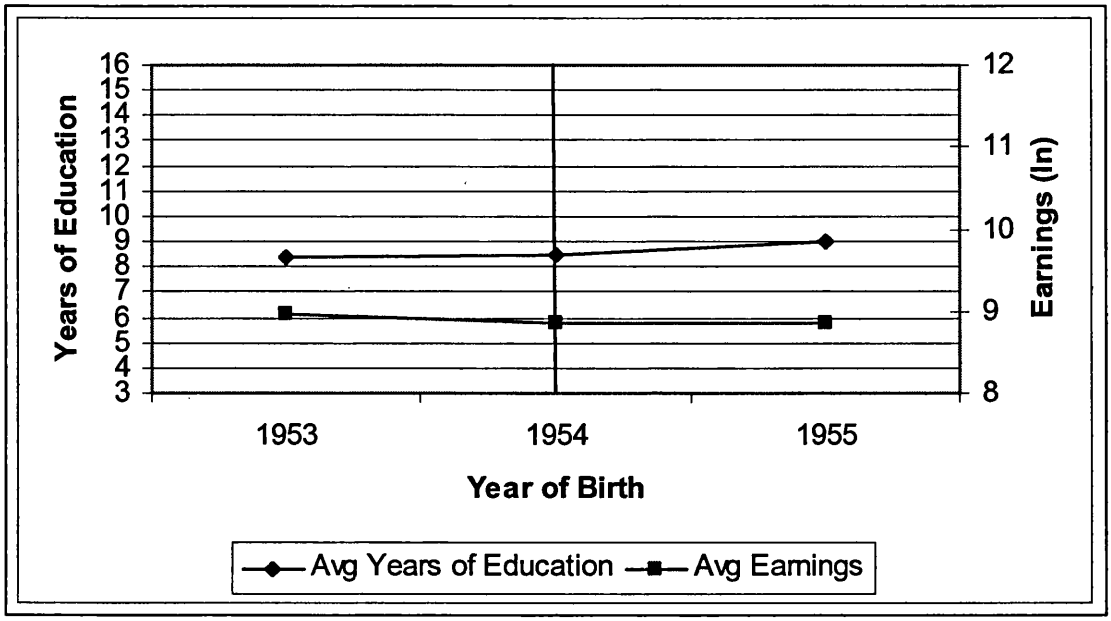


Figure 5.5c Distribution of average years of education and average earnings for individuals born between 1953 and 1955 in Portugal

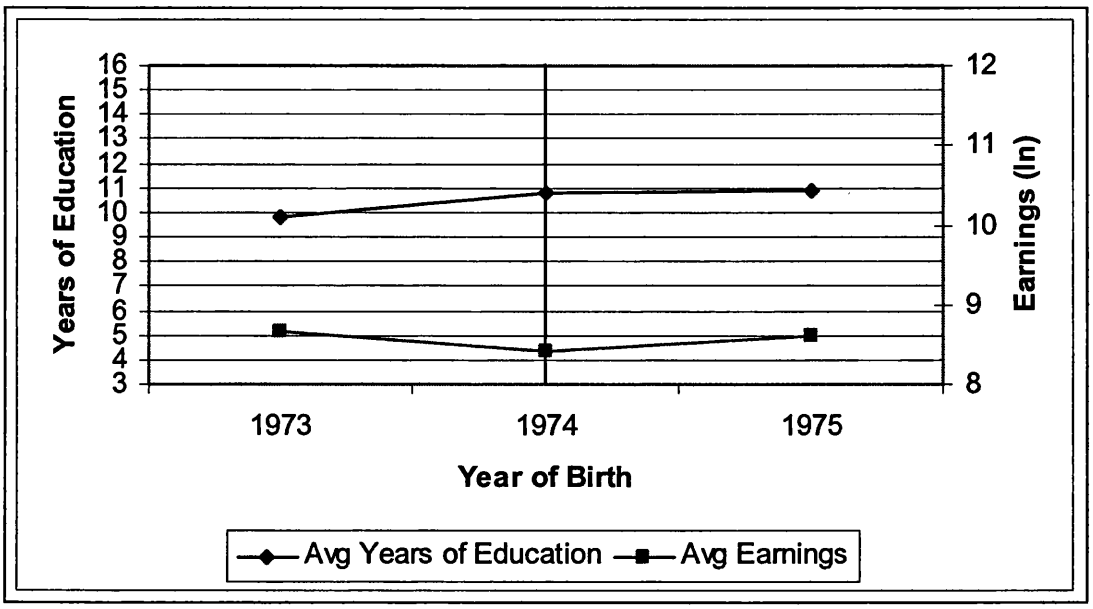


Figure 5.6b Distribution of average years of education and average earnings for individuals born between 1975 and 1977 in Spain

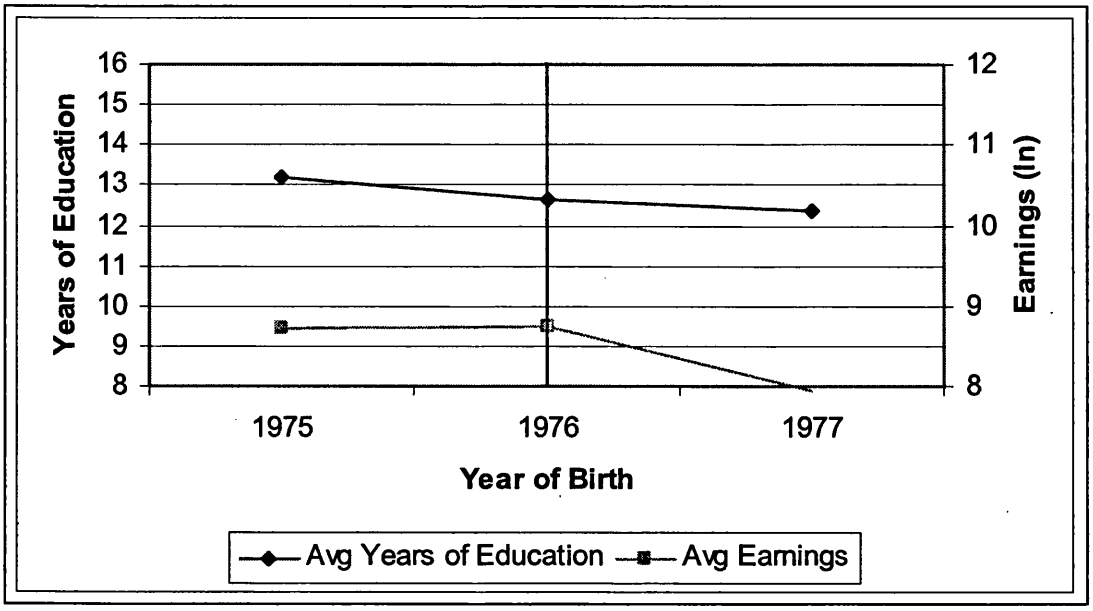


Figure 5.7b Distribution of average years of education and average earnings for individuals born between 1957 and 1959 in the United Kingdom

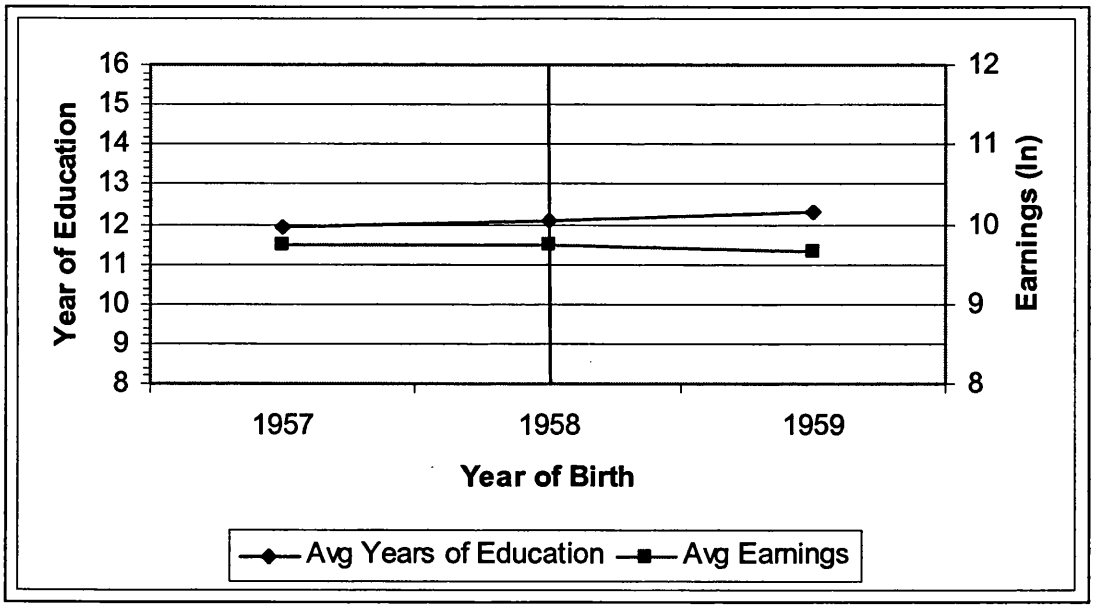


Table 5.A: Full-time employed and unemployed according to the level of education, 7 countries, 1985-2000

	Years of Education	**Total**	**Full-time employed**	***Percentage***	**Unemployed**	***Percentage***
France	11	330	317	*96.06*	13	*3.94*
	12	388	362	*93.30*	26	*6.70*
	13	330	301	*91.21*	29	*8.79*
	14	291	273	*93.81*	18	*6.19*
Ireland	11	360	321	*89.17*	39	*10.83*
	12	837	769	*91.88*	68	*8.12*
	13	867	819	*94.46*	48	*5.54*
	14	508	480	*94.49*	28	*5.51*
Italy	11	310	290	*93.55*	20	*6.45*
	12	848	811	*95.64*	37	*4.36*
	13	1551	1481	*95.49*	70	*4.51*
	14	233	219	*93.99*	14	*6.01*
Netherlands	11	897	835	*93.06*	62	*6.91*
	12	1185	1106	*93.33*	79	*6.67*
	13	742	708	*95.42*	34	*4.58*
	14	843	793	*94.07*	50	*5.93*
Portugal	11	111	104	*93.69*	71	*6.31*
	12	156	142	*91.03*	14	*8.97*
	13	84	78	*92.86*	6	*7.14*
	14	59	53	*89.83*	6	*10.17*
Spain	11	136	116	*85.29*	20	*14.71*
	12	294	238	*80.95*	56	*19.05*
	13	187	157	*83.96*	30	*16.04*
	14	226	194	*85.84*	32	*14.16*
United Kingdom	11	2937	2621	*89.24*	316	*10.76*
	12	922	856	*92.84*	66	*7.16*
	13	873	801	*91.75*	72	*8.25*
	14	1305	1245	*95.40*	60	*4.60*

Source: statistics derived from the ISSP dataset

Table 5.B: OLS estimates - Returns to education by gender, 28 countries, 1985-95

Country	**Males**		**Females**	
	coefficient	*robust SE*	*coefficient*	*robust SE*
USA	0.071	*0.005*	0.098	*0.005*
Great Britain	0.122	*0.006*	0.136	*0.006*
West Germany	0.032	*0.002*	0.046	*0.004*
Russia	0.045	*0.004*	0.052	*0.004*
Norway	0.023	*0.002*	0.028	*0.003*
Australia	0.051	*0.004*	0.054	*0.006*
Netherlands	0.030	*0.002*	0.012	*0.004*
Austria	0.038	*0.004*	0.066	*0.006*
Poland	0.074	*0.005*	0.098	*0.005*
East Germany	0.028	*0.003*	0.041	*0.004*
New Zealand	0.033	*0.004*	0.039	*0.005*
Italy	0.037	*0.003*	0.053	*0.005*
Ireland	0.081	*0.005*	0.099	*0.008*
Japan	0.076	*0.006*	0.098	*0.014*
Hungary	0.074	*0.007*	0.075	*0.006*
N. Ireland	0.173	*0.011*	0.169	*0.011*
Sweden	0.025	*0.004*	0.033	*0.005*
Slovenia	0.082	*0.007*	0.101	*0.007*
Israel	0.057	*0.007*	0.069	*0.007*
Czech Rep.	0.032	*0.006*	0.045	*0.007*
Bulgaria	0.039	*0.009*	0.061	*0.010*
Slovak Rep.	0.054	*0.012*	0.067	*0.009*
Canada	0.037	*0.008*	0.046	*0.008*
Czechoslovakia	0.031	*0.010*	0.040	*0.007*
Spain	0.042	*0.005*	0.048	*0.008*
Switzerland	0.044	*0.007*	0.049	*0.011*
Latvia	0.075	*0.019*	0.077	*0.014*
Philippines	0.121	*0.015*	0.179	*0.031*
Pooled	0.068	*0.003*	0.083	*0.005*

Note: Unless otherwise specified these coefficients are significant at 1 percent level.
The regressions run for the 28 countries separately include number of years of schooling, age, age squared, year dummies, controls for union status, marital status and a constant.
The dependent variable is the logarithmic specification of the wage as before

Table 5.C: OLS estimates- Returns to education by gender, 28 countries, 1985-95 from Trostel et al. (2002)

Country	**Males**		**Females**	
	coefficient	*robust SE*	*coefficient*	*robust SE*
USA	0.074	*0.004*	0.096	*0.005*
Great Britain	0.127	*0.006*	0.130	*0.006*
West Germany	0.036	*0.002*	0.043	*0.004*
Russia	0.044	*0.004*	0.053	*0.004*
Norway	0.023	*0.002*	0.025	*0.003*
Australia	0.051	*0.004*	0.052	*0.006*
Netherlands	0.031	*0.002*	0.019	*0.004*
Austria	0.038	*0.004*	0.064	*0.006*
Poland	0.073	*0.005*	0.100	*0.005*
East Germany	0.026	*0.003*	0.045	*0.004*
New Zealand	0.033	*0.004*	0.029	*0.005*
Italy	0.037	*0.003*	0.053	*0.005*
Ireland	0.085	*0.006*	0.090	*0.008*
Japan	0.075	*0.007*	0.094	*0.014*
Hungary	0.075	*0.007*	0.077	*0.006*
N. Ireland	0.174	*0.011*	0.146	*0.011*
Sweden	0.024	*0.004*	0.033	*0.005*
Slovenia	0.080	*0.007*	0.101	*0.007*
Israel	0.053	*0.007*	0.061	*0.008*
Czech Rep.	0.035	*0.007*	0.043	*0.007*
Bulgaria	0.040	*0.009*	0.057	*0.010*
Slovak Rep.	0.052	*0.012*	0.064	*0.009*
Canada	0.038	*0.008*	0.045	*0.008*
Czechoslovakia	0.031	*0.010*	0.036	*0.007*
Spain	0.046	*0.005*	0.038	*0.010*
Switzerland	0.045	*0.007*	0.048	*0.012*
Latvia	0.067	*0.020*	0.078	*0.014*
Philippines	0.113	*0.015*	0.192	*0.030*
Pooled	0.048	*0.001*	0.057	*0.001*

Source: Trostel et al. (2002, table 2)

Table 5.D: Comparison of OLS estimates, return to years of education in various studies

Country	*males*	*females*	Country	*male*	*females*
UK	1985 0.060 (0.004) 1990 0.064 (0.004) 1995 0.065 (0.005)	 0.111 (0.005) 0.093 (0.005) 0.091 (0.005)	France	1993 0.0873 (0.0007)	 0.0855 (0.0010)
Ireland	1987 0.097 (0.005) 1995 0.115 (0.011)	 0.142 (0.008) 0.109 (0.013)	Portugal	1982 0.0815 (0.0009) 1995 0.0921 (0.001)	 0.1058 (0.0014) 0.1086 (0.001)
Italy	1986 0.042 (0.001) 1991 0.046 (0.001) 1995 0.062 (0.001)	 0.046 (0.051) 0.059 (0.001) 0.077 (0.002)	Spain*	1990-91 0.070 1994 0.075 1995 0.082	 0.083 0.100
Netherlands	1986 0.058 (0.003) 1990 0.061 (0.003) 1994 0.063 (0.002)	 0.062 (0.006) 0.060 (0.004) 0.057 (0.004)			

Note: * For these regression results the standard errors are not provided. (Harmon et al., 2001, p.238)
Source: various studies in Harmon et al. (2001)

Table 5.E: IV estimates (speduc) - Returns to education by gender, 6 countries, 1985-95

Country	**Males**		**Females**	
	coefficient	*robust SE*	*coefficient*	*robust SE*
USA	0.082	*0.009*	0.113	*0.016*
Australia	0.054	*0.103*	0.086	*0.022*
Netherlands	0.045	*0.014*	0.061	*0.015*
Poland	0.071	*0.009*	0.104	*0.013*
Ireland	0.094	*0.014*	0.129	*0.024*
Hungary	0.077	*0.014*	0.085	*0.016*
Pooled	0.077	*0.005*	0.088	*0.009*

Note: Unless otherwise specified these coefficients are significant at 1 percent level.
The regressions run for the 6 countries separately include number of years of schooling, age, age squared, year dummies, controls for union status, marital status and a constant.
The dependent variable is the logarithmic specification of the wage as before

Table 5.F: IV estimates (speduc) - Returns to education by gender, 6 countries, 1985-95 from Trostel et al. (2002)

Country	**Males**		**Females**	
	coefficient	*robust SE*	*coefficient*	*robust SE*
USA	0.084	*0.009*	0.116	*0.015*
Australia	0.055	*0.011*	0.086	*0.021*
Netherlands	0.048	*0.014*	0.053	*0.017*
Poland	0.073	*0.009*	0.102	*0.014*
Ireland	0.088	*0.014*	0.132	*0.023*
Hungary	0.081	*0.015*	0.103	*0.022*
Weighted average	0.064	*0.011*	0.093	*0.017*

Note: The regressions run for the 6 countries separately include number of years of schooling, age, age squared, year dummies, controls for union status, marital status and a constant.
Source: Trostel et al. (2002, table 5)