London School of Economics and Political Science

Regional Consequences of Demographic Change: Regional Development and Disparities in a Context of Ageing and Shrinking Population in Germany

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work.

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Abstract

Demographic change represents the defining trend in population development of the 21st century on a global, national, and regional level. Although some countries are yet to see its impacts, others, such as Germany, have already begun experiencing the effects of demographic change. Sub-replacement level fertility since the 1970s coupled with increases in life expectancy have slowed German population growth and cause pronounced shifts in the age composition. These changes are even more noticeable on a sub-national level, where, in the context of national-level demographic change, shrinking and ageing regions are no longer transitory and exceptional but a wide-spread and permanent phenomenon.

Despite the relative predictability of these trends, there is little empirical research on the consequences of demographic change on regional socio-economic conditions. This thesis analyses demographic change using the case of Germany on a regional level and considers how changes in population size and age composition affect economic outcomes and their geographical patterns. It focuses on three aspects that are central to processes of regional economic development. First, it investigates the role of demographic change in the provision of public services, using the example of primary school closures in response to falling student numbers. Second, it studies the effect of population ageing on availability and composition of human capital in regional labour markets. Third, it examines the relationship between regional age structures and patterns of internal migration, testing for evidence whether the two trends may be mutually reinforcing.

Using administrative and micro-data for 332 German district regions between 1996 and 2010, this thesis documents the current relevance of demographic change for socio-economic conditions and emphasises its future role in shaping regional economic development in ageing and shrinking countries.

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Chapter 1

Introduction

> *"If you are over 45, you have lived through a period when the world population has doubled. No past generation has lived through such an era - and probably no future generation will either. But if you are under 45, you will almost certainly live to see a world population that is declining - for the first time since the Black Death almost 700 years ago."*
>
> (Pearce, 2010, p. 5)

Demographic change is the defining phenomenon of population development of the 21st century. It refers to trends of decreasing fertility and increasing life expectancy which lead to population ageing and a slow-down of population growth on a global scale. Instead of realising Neo-Malthusian fears of "explosive" growth and overpopulation (e.g. Ehrlich, 1968) many countries, especially in Europe, are facing permanently smaller and older populations. These changes are notable not only because they apply globally and represent an unprecedented trend reversal from a situation of fast population growth (see e.g. Coulmas & Lützeler, 2011). Demographic change is also set to have fundamental consequences for economy and society on a global, national, and regional level. Indeed, R. Lee and Reher (2011, p. 1) propose that the change from a situation of high fertility and mortality to a situation of both low mortality and fertility "ranks as one of the most important changes affecting human society in the past half millennium, on a par with the spread of democratic government, the industrial revolution, the increase in urbanisation, or the progressive increases in educational levels of human populations".

Thus, changes to the size and composition of population affect societies in a multitude of aspects (for overviews see e.g. Coleman & Rowthorn, 2011; Kaufmann, 2005; Reher, 2007). On a national level, especially the economic consequences of demographic change, and particularly population ageing, have received considerable attention. Ageing decreases the size of the working-age population relative to the retired population. This threatens the sustainability of "pay-as-you-go" pension systems, where current workers pay contributions for the population in retirement (e.g. Börsch-Supan, Härtl,

& Leite, 2016; von Weizsäcker, 1990). An older population is generally expected to increase public expenditure on the welfare state both through pensions and health care spending (Meier & Werding, 2010; Miller, 2011). A smaller workforce and changes in spending and saving imply that demographic change may have a negative effect on per capita economic growth (Bloom, Canning, & Fink, 2010; Bloom, Canning, Fink, & Finlay, 2010; R. Lee, 2016) although endogenous growth models also suggest potentially positive effects (Prettner & Prskawetz, 2010; Prettner, 2013). In general, the economic effect of demographic change seems to depend on whether productivity increases can be achieved e.g. by increasing participation rates and investing in human capital (Börsch-Supan, 2003; R. Lee & Mason, 2010; Prettner, Bloom, & Strulik, 2013).

Although the economic impact is undoubtedly relevant, the focus on aggregate-level effects and public finances neglects the fact that demographic change will also have more direct consequences for people's lives that do not exclusively work through the macro-economy. Indeed, some consequences of demographic change will be fundamentally regional, i.e. determined by the size and composition of the regional rather than the national population. The local population determines the demand for goods and services, and constitutes the local labour market and the regional tax basis. It also affects regional attractiveness for firms and migrants, thus shaping the wider spatial structure. Therfore, regional living conditions, economic outlook and the spatial structure all are affected by demographic change. In this sense, whether the national average population ages or shrinks may be less relevant for living conditions than whether a region's resident population experiences these effects.

Moreover, regardless of the extent of national demographic change, there is large variation in regional demographic structure: some regions age more quickly than others, and some regions continue growing while others see their population decline. Indeed, many European countries already have shrinking regions despite continuing to grow on a national level (e.g. Bucher & Mai, 2006; Grasland et al., 2008). This implies that a regional perspective allows studying demographic developments that will only emerge on a national scale in the future. Additionally, the parallel existence of opposite trends implies that demographic change is also relevant for the issue of regional disparities. Especially if demographic change and its consequences interact with other regional characteristics, population development could contribute to regional polarization. The regional nature of specific consequences of demographic change, the large variation in demographic outcomes as well as the relevance for issues of regional disparities, imply that the regional dimension of demographic change is a challenge distinct from national considerations and intrinsically relevant to regional development.

A distinguishing feature of demographic change is that, in contrast to other complex societal processes, it is not unanticipated. Population size and composition can be projected and although some uncertainty remains, the sharp decline in number of births observed in Europe since the 1960s is testament to the coming restructuring of the population. Similarly, "Most of tomorrow's population aging is already built into today's age structure" (Coleman, 2006a, p. 69). Considering that demographic change is anticipated and unlikely to be reversed or prevented, the relatively late policy response to the issue has been criticised (Birg, 2014; Grasland et al., 2008; Kaufmann & Krämer, 2015). However, in order to be able to implement policy aimed at issues of demographic change, more knowledge on its consequences is required, especially on a regional level. The central question of this thesis is therefore: How does demographic change affect sub-national regions?

1.1 Demographic change as a topic of economic geography

Demographic change is a complex issue that cuts across a number of different academic disciplines and methodological approaches. Demography itself focuses on the causes, trends, and projections of population development. Analyses of the consequences of these demographic shifts fall into other social sciences, especially economics. As described above, there is a relatively large literature on the consequences of population ageing on issues such as pension systems and aggregate growth on a national level (for a detailed overview see e.g. R. Lee, 2016). However, some of these consequences do not apply to regions (e.g. pension systems, which are normally funded at a national level) and even issues that have regional equivalents (e.g. labour market consequences) are not usually considered from a spatial perspective. Since the topic of this thesis is precisely the regional aspects of demographic change, the analysis is set in the context of economic geography.

Despite the relevance of demographic change on a regional level as well, it has received relatively little attention in economic geography so far. Moreover, the existing literature (in economic geography but equally across other disciplines) is largely theoretical or predictive rather than empirical. Both of these issues may be due to the fact that widespread population shrinkage and ageing are only beginning to manifest in population data even at a regional scale. An exception is the relatively large literature in economic geography and spatial planning on *shrinking cities* (Großmann, Bontje, Haase, & Mykhnenko, 2013; Oswalt, 2006; Pallagst, Wiechmann, & Martinez-Fernandez, 2010; Richardson & Nam, 2014), perhaps because their existence represents such a stark contrast to recent history of urbanization and urban growth. In comparison, the application to regions rather than specific urban areas, has not been widely addressed in economic geography (Bontje & Musterd, 2012) although both urban and rural areas experience demographic change. Moreover, the consequences of population ageing play an even more limited role in economic geography. David Plane (2012, p. 479) even concludes:

> "It seems rather bizarre to me that demographic change has not assumed the same importance within regional science that climate change has within earth science."

The relative disregard of demographic change in economic geography and regional science may further stem from the theoretical frameworks that focus almost exclusively on (economic) growth (Matuschewski, Leick, & Demuth, 2016; Schulz, 2012). A growth-focused perspective often conceptualises shrinkage as the opposite or absence of growth (if it mentions it at all) even while acknowledging that the consequences of decline can be distinct from those of growth (see e.g. the section on regional decline in Breinlich, Ottaviano, & Temple, 2014). Indeed, population shrinkage is not the inverse of growth (Galster, 2017) and problems of shrinkage differ from problems of "small" places (Sousa & Pinho, 2013). In a growth-based paradigm, regional shrinkage is exceptional, problematic, and to be countered by policies aimed at regenerating economic and population growth. However, in a context of national-level demographic change, regions will invariably experience population ageing and shrinkage, which is why some call for a shift towards a *paradigm of shrinkage* (Grasland et al., 2008; Matuschewski et al., 2016; Müller & Siedentop, 2004; Sousa & Pinho, 2013) that would redirect the focus from preventing and reversing shrinkage to policy aimed at managing decline and reducing potential negative consequences.

This thesis argues that consequences of demographic change matter specifically at the regional level and therefore takes on a perspective of economic geography. It considers sub-national demographic change both exemplary for changes that will occur on a national scale as well as distinctly relevant due to its spatially diversified nature. The field of economic geography, while so far relatively scarce of empirical research on the consequences of demographic change nevertheless offers a framework of analysis, some theoretical literature, and a concern for policy making in the context of regional development.

1.2 The case of Germany

In order to investigate the consequences of demographic change empirically, the analysis requires a case of application. Germany represents a relevant case to study for several reasons. First, Germany is considered to be "in the midst of demographic change" (Destatis, 2015b, p. 11) and is thus experiencing changes that other countries will only face in the future. It is the country with the highest median age in Europe and the second-highest in the world, after Japan (Coulmas & Lützeler, 2011; A. Davies & James, 2011). Between 2003 and 2010, Germany experienced eight consecutive years of national-level population decline. In contrast to the migration-driven population shrinkage in some Eastern European countries in the same time period (Coleman, 2006a), the German population declined despite positive net migration. This is symptomatic of relatively far-progressed demographic change and will increasingly affect countries worldwide. Indeed, although the German population has recently been growing again, the 2060 population is projected to be at most 76.9 mio (from 80.8 mio in 2013) in the most optimistic scenario of the official forecast (Destatis, 2015b).

Second, Germany represents a particularly interesting case due to its historical context. Clearly, the division and reunification of Germany caused fundamental restructuring of the political, economic, spatial, and demographic landscape. After reunification, East Germany experienced strong outmigration leading to a declining and quickly ageing population. Thus, although Germany is far-progressed in its demographic transition on a European and global scale, East German regions are still relatively more strongly affected than West German ones. This demographic difference adds a layer of complexity to the general socio-economic disparities between the regions of the former East and West German states. Indeed, even 28 years after reunification, East-West disparities remain prominent and constitute a topic of public debate and policy.

Although Japan is experiencing similar changes (Coulmas & Lützeler, 2011; Matanle & Sato, 2010; Matanle & Rausch, 2011) and faces perhaps even more severe challenges of demographic change, the context of Germany offers potential for lessons applicable specifically to the European case. Indeed, although the principles of demographic change may apply similarly in Japan and Germany (Matanle & Rausch, 2011), socio-political institutions differ markedly. For instance, differences in the cultural role of family and women, and in the attitude towards immigration imply that European policy makers will find it difficult to learn from the Japanese experience (Klingholz & Vogt, 2013).

In contrast, the case of Germany is a relevant example for regional and national governments in Europe as well as for the European scale more generally. It is further an interesting setting in which to study consequences of population shrinkage and ageing because it offers a context of already measurable demographic change combined with concerns of regional disparities. Analysing the consequences of demographic change in Germany thus offers insights not only on the consequences of demographic change but also indications on how regional development and policy making interacts with it. This thesis therefore analyses regional consequences of demographic change for the German case as an example of likely future challenges on a European scale.

1.3 Thesis outline

This thesis proceeds as follows.

Chapter 2 presents the theoretical background underpinning this thesis. It discusses the causes of demographic change from a national level and argues that regional demographic change is a distinct and relevant phenomenon. It then conceptualises three areas of consequences of regional demographic change, which will be analysed in the later chapters. The chapter also defines the study period and unit of study before presenting a descriptive analysis of the demographic trends in Germany.

Chapter 3 focuses on the consequences of demographic change for public service provision. Using the example of primary schools, the chapter analyses the degree of responsiveness of school supply to changes in demand. It further investigates whether the responsiveness of school provision depends on regional characteristics. The results suggest that the supply of primary schools is adjusted more flexibly in regions with adverse economic situations as well as those experiencing more severe demographic shifts.

Chapter 4 takes a labour market perspective and investigates whether demographic change affects the availability of human capital. It analyses the relationship between regional age structure and the availability and composition of human capital. For this purpose, the chapter analyses both aggregate human capital indicators and the shares of six separate educational degrees. The results show that workforce ageing is associated with lower human capital availability, lower shares of university degrees, and higher shares of vocational training degrees. The chapter further examines the relative contribution of demographic changes in explaining shifts in human capital via a decomposition approach and analyses its geographical patterns.

Chapter 5 addresses the interrelations between population ageing and internal migration. It investigates age as a micro-level influence on individuals' migration decisions and whether it affects aggregate migration flows between German regions. The analysis shows that individuals are more likely to migrate out of and less likely to move into ageing regions. The emerging patterns are consistent with age-selective migration patterns across German regions, which supports concerns of ageing as a process of cumulative causation.

Chapter 6 considers the empirical results in a context of policy-making for demographic change and offers concluding remarks.

Chapter 2

Background

Demographic change affects populations at all geographical scales. Worldwide, the number of people aged 60 and above is set to double by 2050 (United Nations, 2017) and some predict that we will see the end of global population growth at some point in the 21st century (Lutz, Sanderson, & Scherbov, 2004). Europe and East Asia have already begun experiencing population ageing and offer some insights into the future changes to be expected (A. Davies & James, 2011). Additionally, some countries are beginning to not only age but see population decline, most notably in Central and Eastern Europe where high outmigration and low fertility coincide (e.g. Coleman, 2006b). The mechanisms of demographic change apply equally also to sub-national regions. However, regional demographic change differs conceptually and empirically from shrinkage at higher levels of aggregation. This thesis focuses on the sub-national scale, i.e. the consequences of ageing and shrinking populations on regions.

This chapter presents background material on the causes, patterns and general consequences of demographic change at a regional level. First, theoretical approaches to demographic change from the perspective of demography are summarised. Second, demographic change is conceptualised from a regional perspective. Third, literature on consequences of these demographic shifts is reviewed and the choice of applications for the following empirical chapters is motivated. Fourth, the empirical case of Germany is introduced by defining the scale and scope of analysis and documenting the German trends of regional population ageing and shrinkage.

2.1 Theory of demographic change

Demographic change here refers to trends of decreasing or low fertility, ageing and a slow-down of population growth as it has been observed especially in Europe in the second half of the 20th century. The literature on the trends, causes and consequences of demographic change is immense and context-dependent. The aspects summarised here are meant to illustrate the core principles of demographic change relevant specifically for the German case. Demographic change as it applies to other institutional contexts, especially developing countries, is not considered.

2.1.1 The drivers of population ageing and shrinkage

All changes to the size of the population are defined by the combined effect of births, deaths and migration rates in a given time period (e.g. Preston, Heuveline, & Guillot, 2001). The size change can further be decomposed into the effect caused by births and deaths (*natural balance*) and the population change due to immigration and emigration (*migratory balance*). Migration refers to all residential movements across borders and can thus be *international* (i.e. crossing national borders), or *internal* (i.e. crossing boundaries of regional units at some sub-national scale).

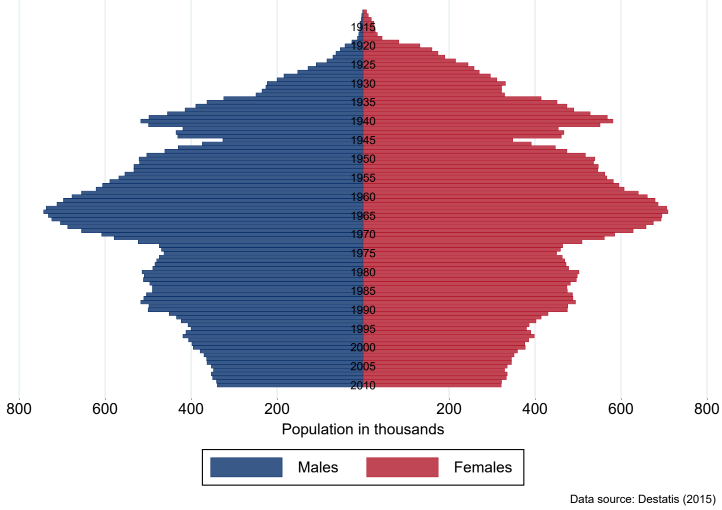
Births and deaths influence population growth through their relative sizes. However, the number of births and deaths depends in part on the population age structure, as both mortality and fertility vary with age. For fertility, the number of women of reproductive age naturally limits the number of births in a given year but fertility also varies over the life course. The *total fertility rate* (TFR) reflects the average number of children born per woman if she experienced current age-specific fertility rates throughout her life (Preston et al., 2001). To maintain cohort sizes at the current level, the TFR needs to be at *replacement level* of around 2.1.

If fertility falls below replacement level, each birth cohort will be smaller than its parent cohort. Continued sub-replacement fertility leads to a negative natural balance: the number of births cannot compensate for the number of deaths. In the absence of a sufficiently positive migration balance, population declines. Simultaneously, the decreasing size of birth cohorts when compared to parent or grandparent generations causes population ageing. The decrease in cohort size is visible for instance in Germany's population pyramid (Figure 2.1). The birth cohorts between 1955 and 1969 in Germany are substantially larger than both previous and following cohorts. Cohorts in this time frame constitute Germany's *baby boom*[1].

Both the ageing of the large baby boom generation and the low number of births cause poulation ageing: the share of elderly population increases, the share of young population falls, and the average and median ages rise. Population size and ageing are therefore closely intertwined: a population that is shrinking due to low fertility is ageing as well although, due to the possibility of compensating immigration, not all ageing populations are necessarily shrinking. Moreover, increasing life expectancy also contributes to population ageing ("from the top"), which compounds the effect of low fertility (e.g. R. Lee, 2003).

[1]Note that a baby boom after the Second World War can be documented for many Western countries. For many countries, e.g. the US and the UK, the baby boom began immediately after the end of the war. In comparison, the German baby boom is delayed by roughly ten years, which is why the German baby boom generation is only now entering retirement age.

Figure 2.1: Germany's population pyramid, 2010



2.1.2 Demographic Transition Theory

Despite the fact that population development clearly differs among countries, common trends can be identified. *Demographic transition theory* provides a descriptive framework of these common trends especially in Western-European countries in the 19th and 20th century (for overviews see e.g. Kirk, 1996; R. Lee, 2003; Zaidi & Morgan, 2017). In this model, societies are described to pass through different phases of demographic development beginning with a phase of high mortality and high fertility and ending in a phase with both low mortality and fertility. From an initial situation of high births and deaths, the transition starts with a fall in mortality, which began around 1800 in northwest Europe, while fertility remains high. This leads to a phase of strong population growth and increases in life expectancy. Between 1890 and 1920, fertility in most European countries began to adjust downwards as well, leading to a slow-down in population growth. In the final stage of the traditional transition theory model, both fertility and mortality rates stabilise at a low level.

Transition theory represents a macro-theory that describes the aggregate patterns but not the causes. It is thus complemented by a wide variety of micro theories that explain patterns in fertility and mortality. Indeed, while the initial mortality decline can be causally attributed to improved public health through better understanding of the nature of infectious disease as well as better nutrition (e.g. Höhn, 2000), the causes of the fertility decline and its timing are less clear and are explained with theories from economics, sociology, and demography (Hirschmann, 1994; Mason, 1997). Economic theories of fertility suggest that parents may base their fertility decisions on the number of surviving children, which would yield a link between lower mortality and reduced fertility. With better survival chances, rising incomes, and growing labour productivity due to technological change, parents may focus their resources on a smaller number of children (Hill & Kopp, 2000; R. Lee, 2003; Mason, 1997).

Traditional demographic transition theory predicted a stabilisation of population size in the final phase, which is at odds with the low and even "lowest-low" fertility rates (with a TFR at or below 1.3) observed in many countries since the 1960s (Chesnais, 1998; Kohler, Billari, & Ortega, 2002). Although continued low fertility and population ageing could be analysed in the context of transition theory (Coleman, 2004; R. Lee, 2003), the observed reversal of population growth has also inspired the suggestion of a *second demographic transition* (Lesthaeghe & van de Kaa, 1986; van de Kaa, 1987).

The second demographic transition specifically refers to the continued slow-down of fertility far below replacement levels along with accelerated population ageing and the absence of a stationary population (Lesthaeghe, 2010). The theory of the second demographic transition emphasises socio-cultural changes as the causes of declining fertility. For instance, increasing acceptance of cohabitation and divorce, the rise of individualism, and the contraceptive revolution are all argued to lead to postponement of first birth and decline of fertility overall. Lesthaeghe (2010) argues that this makes the second transition qualitatively different from the first one and presents evidence to suggest that the emergence of the relevant socio-cultural shifts is not exclusive to Western Europe.

A core criticism of both first and second demographic transition theory is its tendency to generalise across distinct socio-cultural backgrounds. Clearly, the context of 18th century Europe differs markedly from the experiences of developing countries undergoing demographic changes more recently. Similarly, the second demographic transition is explained using generalised societal shifts. Caldwell and Schindlmayr (2003) point out that more recent theoretical approaches to low fertility concentrate on the welfare state and focus on institutional differences between Italy, Spain and Scandinavia but largely neglect the experience of German-speaking countries. The authors describe the prominent role of family and conservative values in Germany and how they shaped an institutional system that makes it difficult for women to combine employment with motherhood. Moreover, in the German historical context, the field of population studies as well as any policy aimed at family planning were met with scepticism due to the prominent role of population in Nazism preventing policy discussions that could have addressed low fertility (Birg, 2014; Kaufmann & Krämer, 2015). These are issues relevant in explaining the demographic transition for Germany specifically.

Additionally, some demographers are critical of the second transition and question whether it actually describes a new transition or merely a continuation of the previous one along with a set of life-style preferences specific to affluent Western societies (Coleman, 2004). Moreover, Zaidi and Morgan (2017) discuss that the theory mostly disregards the rise of gender equality and especially the changing role of women, which represents a central point in most micro-theories of fertility (Hill & Kopp, 2000).

Despite these shortcomings, demographic transition theory provides an encompassing theoretical perspective to frame both past and current demographic developments. Jointly, the theories illustrate that there are common trends and regularities that explain demographic changes and facilitate prediction of future changes. At the same time, population change is a complex process and influenced by micro-level decisions as well as the institutional circumstances. However, demographic transition theory also shows that demographic developments are not set in stone. For instance, recently, fertility rates in Germany and other developed countries have increased slightly, which could imply that the observed very low fertility rates were caused in part by the temporary effect of birth postponement (Goldstein, Sobotka, & Jasilioniene, 2009). For Germany, Pötzsch (2013) analysed the postponement effect on cohort fertility[2] and concludes that it will remain at historically low levels of 1.5 to 1.6 even despite a small increase in completed fertility for women born between 1968 and 1973. It remains to be seen whether recuperation of postponed births is sufficient to increase fertility markedly or whether population momentum, socio-cultural and economic individual factors will lead to a "low-fertilty trap", as suggested by Lutz, Skirbekk, and Testa (2006).

2.2 The regional scale of demographic change

Strictly from a demographic standpoint, the processes of population change described so far are usually formulated on a national level but apply in the same way to sub-national regions. However, shifting the scale from national to regional offers additional insights that distinguish regional demographics from national trends. Indeed, national-level demographic changes represent the average of all regional-level developments. Regional population ageing and shrinkage are thus not just symptoms of national-level demographic change but influential phenomena to be studied in their own right.

2.2.1 Migration and regional demographics

In contrast to population shrinkage on a national level, which is still an exceptional phenomenon, regional population decline has historically been a common occurrence. Throughout time, many regions have grown consistently only to lose population in response to wars, natural disasters, disease, shifts in political power, or more attractive opportunities elsewhere (Beauregard, 2009; Benke, 2004; Rieniets, 2009; Turok & Mykhnenko, 2007). However, in the past, shrinking regional populations (with the exception of external shocks to mortality such as wars and disease) were almost exclusively caused by migratory movements. Prior to the onset of the second demographic transition, a positive natural balance was the status quo. Therefore, regions that were shrinking did so because of a relatively strong negative migration balance.

Thus, traditionally, regional population shrinkage has been almost synonymous with studies of migration. Although international migration also matters for national demographic change, the relative scales of international and internal migration imply that

[2] Cohort fertility refers to the number of children actually born per woman of a specific cohort. In contrast to the TFR, which is a hypothetical average, cohort fertility is based on actual births and can therefore only be calculated once the women of the specific birth cohort have completed their reproductive years.

migration is a more powerful force of change for the demographic structure of specific regions rather than the aggregate national population. Determinants of migration can be both *push factors* of the origin region as well as *pull factors* of respective destination regions. Factors generally emphasised as determinants of net migration are labour market conditions, such as unemployment rates or wage differentials, as well as differences in amenities (see e.g. literature reviews on the macrodeconomic determinants of migration flows in Etzo, 2008; Molho, 1986; Greenwood, 2016; Wright & Ellis, 2016). Beyond influencing the size of the population through net migration, migration can also lead to population ageing, if it is age-selective.

Through their effect on migration, regional economic conditions thus directly influence population change. Additionally, migration itself may affect economic conditions, for instance if outmigration leads to a shortage of skilled labour and thus makes regions less attractive firm locations. The interconnections between regional characteristics and migration thus illustrate potential circular causality between demographic structure and regional economic development (e.g. Bontje & Musterd, 2012; Hoekveld, 2012). Some authors have suggested to explicitly include aspects of economic decline into the definition of a shrinking region, e.g. by adding employment decrease to the definition, especially in an urban context (see e.g. Hoekveld, 2014; Hollander, Pallagst, Schwarz, & Popper, 2009). The theoretical links between population size and economic conditions are well-established but the effects of ageing are less clear, raising the question how such definitions can be reconciled with the observed regional experiences of demographic change. Moreover, while a broader definition of shrinkage emphasises the multidimensional and circular nature of population change on a regional level, it also limits the discussion to a specific type of shrinkage (i.e. caused and accompanied by economic decline).

2.2.2 Regions in a context of national demographic change

So far, we have considered the relevance of migration in shaping regional demographic structure. However, with the fertility trends of the second demographic transition, the natural balance component of population change is often systematically negative rather than positive. For this reason, regions may nowadays not shrink due to emigration but rather because of insufficient immigration. This may seem like a subtle point but illustrates that studying the effects of regional population decline is not equivalent to studying patterns of migration. Instead, regional shrinkage in the context of the second demographic transition can occur in regions that are not structurally or economically weak and even despite considerable immigration. For instance, a study produced on request of the European Parliaments Committee on Regional Development (Grasland et al., 2008, p. 6) concludes that the pattern of population growth between 1980 and 1999 " exhibits none of the conventional centre/periphery, east/west or north/south divides that are usually seen when mapping social and economic indicators".

Moreover, while regional population decline in a context of national-level growth is exceptional, it will become more common in a context of national-level population shrinkage. In this sense, regional population decline will become more wide-spread and also more permanent as it does not only reflect the redistribution from one region to another but also the overall decrease in population caused by demographic change.

Analysing demographic change on a regional level acknowledges the relevance of regional characteristics in shaping population size and structure. All components of population development, i.e. fertility, mortality and migration, are to some degree dependent on local characteristics. For this reason, there is a large degree of variation in regional demographic structure and this heterogeneity is likely to further increase in the future (Bontje & Musterd, 2012; Gans, 2006). Some may argue that regional heterogeneity is more relevant for population size than for age structure because "ageing is a global phenomenon, shrinking is local"(Tivig, Frosch, & Kühntopf, 2008, p. 8). However, although ageing indeed affects almost all regions, the timing and speed of this trend still shows a large degree of regional variation.

The regional diversity in demographic structures means that countries that not yet experience strong effects of demographic change may already have strongly ageing and shrinking regions. This difference between regional and national experiences of demographic change is well documented on a European level (e.g. Bucher & Mai, 2006, 2008; Gans & Schmitz-Veltin, 2004; Gans, 2006; Tivig et al., 2008). It illustrates that demographic change is not a future trend that will eventually come into effect but rather that it is already affecting people's lives across regions. The prevalence of measurable regional but not national demographic changes thus allows empirical investigation into the consequences of population ageing and shrinkage with sufficient sample size.

Although demographic change has been attracting increasing attention, the literature on regional demographic change remains limited. The discipline of demography has engaged perhaps most actively with the regional scale but usually in a descriptive or projective manner. Beyond this, demographic change has been addressed especially in the context of migration studies and with a focus on population size. In comparison, the literature on the effects of regional ageing is relatively small. A. G. Champion (1992) already emphasises the relevance of regional ageing, although the literature he addresses mostly refers to the concept of *ageing in place*, i.e. the effect of regional conditions on the elderly rather than the reverse. 20 years later, Plane (2012) diagnosed a continued lack of literature on ageing in regional science despite its clearly relevant nature. Moreover, as Bontje and Musterd (2012) observe, the majority of social science investigation into demographic change has focused on shrinkage in rural versus urban areas or, more recently, specifically on the urban context.

Rural and peripheral regions have historically been threatened by shrinkage, especially in the context of the fast urbanisation that accompanied early industrial growth in Europe (Rieniets, 2009). In this sense, urban population growth occurred at the expense of demographic changes for rural regions, exemplary for the notion of backwash effects (e.g. Gaile, 1980; Partridge, Bollman, Olfert, & Alasia, 2007). It could be argued that effects of shrinkage are perhaps more noticeable in rural regions where population density and size is already comparatively low. In this sense, population shrinkage in small, peripheral and rural regions may threaten the very existence of the place in extreme cases.

Although urban areas were also affected previously, global industrial changes after the Second World War as well as tendencies of suburbanisation and urban sprawl caused urban population losses to become more widespread and prominent (Beauregard, 2009; A. G. Champion, 1992; Haase, Athanasopoulou, & Rink, 2016; Martinez-Fernandez, Audirac, Fol, & Cunningham-Sabot, 2012; Reckien & Martinez-Fernandez, 2011). Perhaps due to the striking contrast between global urbanisation and the observation of urban population decline, *shrinking cities* inspired a large literature for which an extensive review is beyond the scope of this thesis[3]. Urban shrinkage literature spans a wide variety of topics and disciplines from architecture and urban design (e.g. Oswalt, 2006) to comparative studies (Haase, Bernt, Großmann, Mykhnenko, & Rink, 2013) as well as causes and consequences (Fol, 2012; Reckien & Martinez-Fernandez, 2011) and planning policy for shrinking cities (Hollander et al., 2009; Hollander & Németh, 2011; Sousa & Pinho, 2013). Due to the nature of the concept, studies on shrinking cities frequently consider the experiences of specific cities. Moreover, the national context also matters in the context of shrinking cities: whereas recently shrinking cities in the US are often caused by industrial decline as in the cases of Detroit, Pittsburgh, Cleveland and Youngstown, demographic change is becoming an increasingly prominent factor for European cities (Wiechmann & Pallagst, 2012).

The existing literature on sub-national demographic change shows that the phenomena of population ageing and shrinkage are neither an exclusive feature of rural nor of urban areas. Instead, in a context of demographic change at a national level, regions of all settlement types will experience effects of population shrinkage and ageing. Thus, rather than restricting analysis to either rural or urban regions, this thesis considers the *regional scale of demographic change*. There are two notable conceptual aspects of this choice.

First, using the concept of a region as the unit of analysis acknowledges that the regional landscape is simultaneously shaped by rural and urban features and their spatial interactions. Even on a regional scale, urban and rural characteristics can still be distinguished but studying both within the same framework provides empirical insights that cover the entire geography not a few selected points on the map. Moreover, from a policy perspective, addressing issues of demographic change requires coordination on a regional scale rather than potentially counteracting policies at the urban and rural scale (e.g. Grasland et al., 2008).

Second, by focusing explicitly on demographic change, both population shrinkage and ageing are included. As described above, ageing and population shrinkage are inherently

[3]See for example Bontje and Musterd (2012); Großmann et al. (2013); Martinez-Fernandez et al. (2012); Pallagst et al. (2010); Richardson and Nam (2014).

related. Considering ageing regions separately from shrinking regions thus creates an artificial separation between changes that are driven by the same trend: demographic change. Moreover, in contrast to historical experiences of regional population change, an ageing and declining national population means that regions' experiences of these trends are not a sign of crisis but representative of global demographic shifts. Thus, ageing and shrinking populations are not a temporary and acute problem but rather represent a likely permanent transition to older and smaller populations. To study and address this new situation, there have been calls for a paradigm shift in regional science (e.g. Grasland et al., 2008; Müller, 2003; Müller & Siedentop, 2004; Sousa & Pinho, 2013). In particular, the paradigm of economic growth shapes theoretical as well as policy approaches to regional development and does not even consider the possibility of decline (Matuschewski et al., 2016). The empirical research presented in this thesis is therefore set in the context of the discussion of long-term demographic changes and their consequences[4].

2.3 Regional consequences of demographic change

As mentioned previously, the fundamental shifts towards an older and smaller population are accompanied by a variety of consequences affecting all aspects of economy and society. Some effects that have been addressed in great detail at a national level (e.g. on the welfare system), are less relevant on a regional scale. This section aims to conceptualise and describe areas of consequences of demographic change that are fundamentally regional. In particular, regional consequences can be grouped in three broad areas of effects, which will be discussed in turn: effects on regional living conditions, effects on the regional economy, and effects on sub-national spatial structure and regional disparities.

2.3.1 Regional living conditions

Prominent consequences of demographic change address the living conditions for people in shrinking and quickly ageing regions. In Germany, the concern for this issue is postulated in basic law under the principle of creating *Equality of Living Conditions* (*Herstellung gleichwertiger Lebensverhätnisse*, § 72, Abs.2, GG). Additionally, the Federal Regional Planning Act (*Raumordunungsgesetz*, § 2, Abs.1, ROG) includes the requirement to strive for balanced social, infrastructural, economic, ecological, and cultural conditions across rural and urban, economically leading and lagging regions. Although these requirements are not legally binding (Brandt, 2015), they represents the guiding principle of spatial planning policy (e.g. BBSR, 2012).

[4] Some authors (e.g. Grasland et al., 2008; Hoekveld, 2012) use the term *shrinking region* as a concept that combines the regional perspective with an emphasis on decline-oriented planning as suggested by Müller and Siedentop (2004). However, there is little formalised conceptualisation of the term, little concern for ageing and it confounds two separately relevant issues: the scale of analysis and the paradigm of decline versus growth. For these reasons, we use the term regional shrinkage literally here, i.e. referring to a region that experiences a decrease in population.

A central aspect of the principle of equal living conditions is to ensure adequate access to public services[5]. What constitutes a public service is defined by the respective government but they usually include provision of water, electricity, and waste services; transport and communicative infrastructure; medical care; and education and cultural services (see e.g. BBSR, 2012; Kersten, 2006). Some of these public services constitute *technical infrastructure*, whereas provision of education, health care and cultural services are usually considered *social infrastructure* (see e.g. Kuckshinrichs, Kronenberg, & Geske, 2011).

Demographic change affects the provision of public services because it changes the quantity and type of services demanded. A smaller population will demand less of all public services, whereas an older population will shift demand away from services for the young and towards services demanded by older age groups (Kuckshinrichs et al., 2011). Since public services are characterised by economies of scale due to high fixed costs, reduction in demand (whether due to population shrinkage or ageing) causes increasing cost of per unit provision. At the same time, adjusting the supply of public services is costly especially if it concerns physical infrastructure (e.g. Koziol, 2004; Moss, 2008).

The effect of demographic change on public services thus poses a dilemma for policy makers because maintaining a high level of supply may be inefficient but reducing supply may be costly as well as politically infeasible. Ensuring equality of living conditions implies that basic public services need to be provided with adequate access regardless of regional demographic trends (although the definition of "adequate" is open to interpretation (Brandt, 2015)). Moreover, closing service points (such as schools, libraries or bus routes) is often met with considerable public opposition and the concern that it might stimulate outmigration (Barakat, 2015; Hyll & Schneider, 2011). Policy makers may therefore have an incentive to maintain an inefficient level of service provision for political reasons thus straining municipal budgets (Geys, Heinemann, & Kalb, 2007; Lais & Penker, 2012; Wolf & Amirkhanyan, 2010).

The majority of the literature on service provision in a context of demographic change focuses on technical infrastructure. Schiller and Siedentop (2005) summarise the literature on the cost increases for infrastructure provision drawing predominantly on studies of settlement structure. Issues of service provision are also considered in the context of urban sprawl (e.g. Klug & Hayashi, 2012), however, as Schiller and Siedentop (2005) point out, the phenomenon of regional shrinkage is different in its dynamics because addressing problems by increasing density is generally infeasible. For instance, shrinking populations can increase costs of water provision because underutilisation of existing networks leads to sediment build-up and danger of germination but reducing overcapacity is costly (Hummel & Lux, 2007; Koziol, 2004; Moss, 2008). Nevertheless, Koziol (2004) in analysing the potential effects of demographic change on water,

[5]In German, these services are referred to as *Daseinsvorsorge*, which roughly translates to *existential care*. The European Commission uses the term *services of general economic interest* but for brevity the term *public services* is used here.

sewage, heating, and transport provision, concludes that the likely cost increases due to overcapacity outweigh the costs of systematically downscaling the network. The burden of the cost increases on consumers as well as the environmentally irresponsible need to increase water consumption artificially to avoid damage to the network, illustrate the severe impact a shrinking population can have on public services.

The literature on provision of social infrastructure is smaller and focuses predominantly on projections or specific case studies. For instance, Naumann and Reichert-Schick (2012) present a detailed analysis of the changes in both technical and social infrastructure availability for the case of Uecker-Randow, a perhipheral rural area in East Germany. In general, age composition is of high relevance for the provision of social infrastructure because age groups demand different types of services. Increasing proportions of the elderly will increase requirements on medical and care facilities, which is especially problematic due to the already unequal provision of health services across urban and peripheral areas (Hämel, Ewers, & Schaeffer, 2013). This also applies to the demand for emergency services, which is expected to increase by 25% until 2050 in Germany despite the projected fall in population (Behrendt & Runggaldier, 2009). Buckner, Croucher, Fry, and Jasinska (2013) project an increasing demand for elderly care in the North of England and emphasise especially that the age group currently providing the majority of unpaid care (the baby boomers) will soon require care themselves. The consensus in this literature is that demographic change presents a large challenge for service provision and will require innovative solutions, e.g. ICT-based service provision (Buckner et al., 2013) or combining different services in one location, e.g. by using petrol stations as an alternative to supermarkets (Neumeier, 2015).

Beyond the effects on public service provision, demographic change can also affect living conditions through other channels. Cortese, Haase, Grossmann, and Ticha (2014) present case studies of three shrinking cities and conclude that demographic change, coupled with selective migration patterns, may reduce social cohesion. Similarly Swiaczny (2010) argues that demographic change represents a challenge to civil society and that this is visible for instance in reduced volunteering participation. Both these points are relevant for living conditions directly but also because a closer-knit social network may be needed precisely to reduce the negative effects of inferior public service provision.

A dimension where demographic change may be beneficial for living conditions is in its potential to improve environmental surroundings. Repurposing built land in favour of green spaces or even natural reserves may be a favourable change, especially in shrinking cities (Rave, 2014; Rink & Kabisch, 2009; Rink, 2009). However, such urban restructuring programs are costly, as illustrated for instance by the €2.5 billion program *Stadtumbau Ost* aimed at reducing the vacant housing stock and encouraging urban renewal in East Germany (Wiechmann & Volkmann, 2012). It should further be noted that the evaluation of living conditions here is mostly based on observable factors but that subjective well-being may not necessarily be affected by demographic change (Delken, 2008).

In general, the existing empirical and theoretical literature suggests that demographic change has a negative effect on living conditions for those regions that experience population shrinkage and ageing. Chapter 3 of this thesis contributes to the literature on the consequences of demographic change on living conditions, and public service provision specifically. It uses the example of primary school provision to analyse changes in the supply of social infrastructure in response to changes in demand caused by demographic change.

2.3.2 Regional economy and labour markets

A closely related issue to living conditions is the question of how a smaller and older population will affect economic growth. Clearly, the effects of the absolute and relative sizes of the working-age population applies both at the national and regional scales although issues specific to the regional level will be emphasised here.

Demographic change affects the size and structure of the working-age population, both in absolute and relative terms. On the one hand, the working-age population declines in absolute terms because cohort sizes have been decreasing (as illustrated by the population pyramid in figure 2.1 above). On the other hand, population ageing implies a relative decrease in the population of working-age relative to the population of retirement age and above. The relative size of these age groups is captured by the *old-age dependency ratio* defined as the ratio of the number of people above retirement age (above 65 years) to the population of working-age (15 to 64 years by standard definitions). The old-age-dependency ratio is relevant in the context of pay-as-you-go pension systems but also acts more generally as a measure of the productive share of the population.

When fertility declines from a high level (as in the context of the first demographic transition) income is positively affected because the working-age population increases relative to the dependent age groups. This factor is often called the "demographic dividend". However, as an opposite to the demographic dividend, continued low fertility and population ageing will eventually decrease the share of the working-age population, increase the old-age-dependency ratio and negatively affect economic growth (Bloom, Canning, & Fink, 2010).

Besides the direct effect of labour force size and age on aggregate economic growth, the effect of ageing on labour force productivity is frequently emphasised. An older workforce may for instance affect labour performance and increase labour costs due to potentially declining capability and health (Dixon, 2003; Leibold & Voelpel, 2006) as well as potentially reduced innovative capabilities. Studies of innovation behaviour over the life-course suggest an inverse U-shaped relationship for instance for scientific output (e.g. Jones, Reedy, & Weinberg, 2014) or more generally age and innovation (for a review see e.g. Frosch, 2011). Younger workers may have advantages for technology adoption (Morris & Venkatesh, 2000; Prskawetz et al., 2007) as their human capital is not outdated (Berk & Weil, 2015).

The relationship between firm productivity and employee age has been addressed in a range of studies and while some find an inverse u-shape of age and productivity (e.g. Brunow & Faggian, 2018; Mahlberg, Freund, & Prskawetz, 2009; Skirbekk, 2008) others find no negative effect of a larger share of older workers (see e.g. Mahlberg, Freund, & Prskawetz, 2013; Malmberg, Lindh, & Halvarsson, 2008). Older workers have a large stock of work experience which may more than compensate for decreasing capabilities in other areas (Skirbekk, 2008). Indeed, retirement of large older cohorts may lead to loss of some of the accumulated experience and knowledge, which itself could affect productivity, a concern that was expressed for simultaneous retirement of baby boom cohorts from 2007 on the so-called "Year 2007 Problem" in Japan, see e.g. Kohlbacher (2011). On a regional level, while Frosch and Tivig (2007) do not find an aggregate negative effect of age on patent activity, Bönte, Falck, and Heblich (2009) document an inverse U-shaped relationship between age-structure and entrepreneurial start-up activity.

Specifically from perspectives of economic geography, a shrinking population could affect regional economic growth also through its effect on agglomeration economies. In this sense, population shrinkage could even change the balance between dispersion and agglomeration forces and affect the distribution of economic activity (Eckey, Kosfeld, & Muraro, 2010; Grafeneder-Weissteiner & Prettner, 2013; Poot, 2008). Moreover, ageing and shrinkage could also lead to labour or skill shortages, which may be of more relevance on a regional than a national level. In particular, potential skill shortages may be solved by market mechanisms if scarcity increases wages for specific skills or educational degrees thus increasing the incentive to invest in developing the scarce skills. From this theoretical stand-point, the German Institute for Labour Market research argues that demographic change may lead to short-term mismatch but will not cause long-term skill shortages in Germany (Brücker et al., 2013). However, on a regional level, skill shortages could have serious consequences for future economic growth. Limited regional mobility implies that wage differentials due to shortages of specific degrees or skills may persist thus counteracting the market adjustment (Brunow & Garloff, 2011). Also, since regional differences in labour supply or wages factor into firms' location decisions, such skill shortages can affect a region's attractiveness and potential for future economic growth. For instance, if there are agglomeration benefits for high-skilled labour (Peri, 2002) or labour supply affects labour demand (Büttner, 2006) local skill shortages could induce patterns of selective migration that worsen rather than alleviate skill shortages. The effect of ageing on agglomeration forces as well as migration patterns will be discussed in more detail in the following section on regional disparities.

Although there is a large amount of literature on the theoretical and expected effects of demographic change on economic growth, the empirical literature focuses on the effect of population ageing rather than shrinkage (since ageing already affects more countries on a national scale). Some conclusions on the consequences of population shrinkage can be drawn from studies of the effect of population growth on economic growth. For instance, Headey and Hoge (2009) present a meta-analysis of population and economic growth and find a positive effect of adult population growth on economic growth, which could suggest that a decrease of the working-age population will have a negative effect. Prskawetz et al. (2007) analyse the relationship between economic growth and population ageing for the EU between 1950 and 2005 and find that the age group 50-64 years is associated with growth, while a large young and old-age population are negative for growth. Additionally, the authors also test the effect on technology absorption and find that the youngest age group (15-29), while negative for economic growth, may be driving the adoption of technology.

Also on a regional level, the effects of ageing on economic growth are more widely addressed than the effect of population shrinkage. Franz (2003) suggests that shrinking cities in East Germany do not generally experience negative economic effects although his analysis is mostly descriptive. Since regions offer more variation in demographic change, some empirical studies on the economic effect of population ageing investigate the regional level. For instance, Maestas, Mullen, and Powell (2016) use US states for the time period 1980 to 2010 and find that a 10% increase in the share of population above 60 years of age is associated with a decrease in the GDP per capita growth rate of 5.5%. The authors further estimate that the projected degree of ageing between 2020 and 2030 would reduce the annual growth rate by 0.6 percentage points illustrating a large effect of population ageing on regional economic growth. Although Maestas et al. (2016) use state-level data, they only include time dummies and industry structure but no further controls for regional characteristics. A more detailed and regional analysis of the relationship between age and economic growth is presented for the case of Germany by Brunow and Hirte (2009b). Rather than using an aggregate indicator of ageing by the share of elderly population, they control for number of employees by age group as well as a range of regional controls and account for spatial autocorrelation. Brunow and Hirte (2009b) find evidence for an inverse U-shaped relationship between age and the growth rate between 1996 and 2005 with the age group 45-54 years most positive for economic growth. In a different study, Brunow and Hirte (2009a) analyse the effect of age structure on regional productivity and find a U-shaped pattern, with the age group 30-39 less productive than younger and older groups.

Across the theoretical and empirical literature on the economic consequences of demographic change, increasing labour productivity emerges as the prime policy suggestion. Börsch-Supan (2003, p. 17) argues, based on the projected smaller share of German working-age population to total population, that "annual productivity gains need to increase by a third if we are to experience the sustained levels of growth to which we are accustomed". This may be achieved by increasing labour force participation (and the retirement age), increasing capital intensity, or investing in human capital. van Der Gaag and de Beer (2015) show that meeting the Europe 2020 employment targets would compensate for the effect of ageing on the working-age population although, for the case of Germany it would not compensate for the effect of the shrinking population. Brunow and Faggian (2018) analyse how different channels aimed at increasing labour force participation would affect firm productivity. They suggest that increasing female labour force participation may be preferable to other policies because the share of female employees is associated with higher firm productivity, whereas the results for alternative policy channels (increasing elderly participation or immigration) are more mixed.

Another core policy suggestion is to increase productivity through investment in education and human capital formation (Börsch-Supan, 2003). This may prevent negative effects of workforce ageing on innovativeness as well as potential shortages of skilled labour. Indeed, Anger and Plünnecke (2010) illustrate that low fertility and age structure mean that a large proportion of new university graduates are needed only to replace retiring academics, thus leaving only a small supply of new academics to cover expansion demand. On a regional level, the effectiveness of such policy measures depends crucially on whether human capital investment actually increases local availability of skilled labour. Imbalances in the population structure as well as potential age-and skill-selective migration may lead to regional differences in human capital development, which could affect the effectiveness of education investment as a policy measure. Chapter 4 investigates whether population ageing is associated with changes in the availability and composition of regional human capital.

2.3.3 Spatial structure and regional disparities

So far, the discussed consequences concern how demographic change may affect living conditions and economic outcomes at a regional level. However, as discussed above, demographic change is characterised by large regional variation (e.g. Bucher & Mai, 2006, 2008; Gans & Schmitz-Veltin, 2004; Gans, 2006). For instance, while population shrinkage threatens the provision of basic public services in some regions, the diversity in regional demographic structure means that other regions may continue growing in population. In this sense, there are regional disparities in the incidence of demographic change. Additionally, even comparable demographic changes may affect regions differently, which has consequences for regional disparities as well as policy.

As previously discussed, demographic change does not generally exhibit the same patterns as economic indicators (Grasland et al., 2008) and the fact that countries age and shrink at a national scale means that not only rural, peripheral or economically lagging areas experience consequences of demographic change. Nevertheless, demographic change may interact with other characteristics of lagging regions thus implying that the consequences of an additional change in population or age structure may represent a larger challenge for some areas than others. For instance, if public service provision depends on some minimum number of users, it is more likely that this minimum continues to be met in a shrinking city than in a shrinking rural area with low population density. Although both urban and rural regions experience demographic change, population shrinkage in small, rural and peripheral regions may threaten the very existence of the places. Thus, the consequences of demographic change may differ in intensity across regions.

Moreover, demographic change may itself affect spatial structure and the nature of disparities. If population size and composition affects agglomeration economies, shifts in demographic structure could influence the broader geographical distribution of economic activity. Models of urbanisation have been integrated with fertility reductions for instance by modelling fertility differences between rural and urban regions (Zhang, 2002). Sato and Yamamoto (2005) present a theoretical model that integrates the demographic transition with urbanisation. Their model is based on differences in fertility between urban and rural areas based on the costs of having children (see also Sato, 2007) and thus shows that a mortality reduction as observed during the first demographic transition can explain increased rural-to-urban migration, and a subsequent slow-down of national fertility. While illustrating the connections between demographics and agglomeration, both Zhang (2002) and Sato and Yamamoto (2005) present models meant to explain the historical experience of urbanization and demographic transition rather than the current demographic change experienced by industrialised countries.

In contrast, Gaigné and Thisse (2009) investigate the role of population ageing on the urban system with a two-sector model with two types of consumers: workers, who produce and consume, and retirees, who only consume. They show that, when retirees are mobile, population ageing acts as a dispersion force and that large working cities will therefore remain the dominant feature of the urban system. Grafeneder-Weissteiner and Prettner (2013) propose a comprehensive model of the consequences of demographic change for spatial distribution of economic activity that combines New Economic Geography with a life-cycle savings model. They show that population growth represents a dispersion force while ageing contributes to concentration and conclude that agglomeration forces in Europe and Japan (i.e. countries with low population growth and an old age structure) may be larger than in emerging markets. These theoretical models show that location of economic activity is influenced by demographic factors and further that ageing may increase regional disparities if it progresses as suggested by Grafeneder-Weissteiner and Prettner (2013).

Clearly, migration plays a central role in linking demographic change to regional disparities. On the one hand, as described in section 2.2.1, migration is an influential determinant of regional demographic structure because it affects both population size and composition. On the other hand, the consequences of demographic change may make regions more or less attractive, thus triggering migration flows. Migration in response to consequences of demographic change can introduce circularity into population development (Hoekveld, 2012). In this sense, reduced provision of public services or labour shortages could for instance cause path dependencies and permanently affect the spatial distribution of economic activity. Moreover, selective migration processes, e.g. in terms of age or skill-level implies that the most mobile population groups (e.g. the young and highly-skilled) are also those who could contribute most to preventing or reversing negative consequences of population ageing and shrinkage. In contrast, the most vulnerable population groups (the elderly, the low-skilled or those with low income) may not be able to migrate and thus get left behind in shrinking and ageing regions (Fol, 2012).

More generally, the theme of regional disparities is inherent in most regional-level analyses of consequences of demographic change. This applies especially in the context of discussions of equality of living conditions described in section 2.3.1. Clearly, the principle of equal living conditions, like the EU concept of *territorial cohesion* aims to reduce regional disparities although the two approaches are not equivalent (Böhme & Zillmer, 2015; Kersten, 2006). Although the notion of truly *equal* living conditions is arguably unattainable, the potential impact of demographic change on the extent of regional disparities is central to policy discussions.

From an empirical standpoint, the current regional variation in demographic change itself is well-documented (e.g. Gans, 2006). Paluchowski (2012) demonstrates large regional disparities in demographic structure for Germany and the UK and predicts that these will increase in the future. Discussions on economic regional disparities in Germany are usually framed in the context of East-West convergence. While these differences persist, international comparison suggests that Germany is characterised by a relatively low degree of economic disparities and a more balanced urban structure (Paluchowski, 2012; Sander, 2018). Eckey et al. (2010) empirically analyse the effect of the agglomeration level on gross value added for Germany and use population forecasts to predict effects on future disparities. They find that urban-rural and East-West disparities will be worsened by the population shrinkage in low-density and peripheral regions. Furthermore, Gregory and Patuelli (2015) present an exploratory spatial analysis that suggests patterns of regional polarization in demographic structure and innovation output in Germany. Interestingly, they conclude that the East-West divide may become an urban-rural divide since both East German and rural regions experience age- and skill-selective migration.

While there is a large theoretical and empirical literature on the relationship between migration and regional disparities generally, demographic change is rarely addressed in this context. Despite the clear intuitive reasoning that demographic change may be a self-reinforcing process, there is little empirical literature on the role of migration as a consequence rather than cause of demographic change (see e.g. Barakat, 2015). Chapter 5 of this thesis investigates this further by considering the patterns of internal migration across German regions with different age structures and investigating whether migration indeed flows from old to young regions.

2.4 Setting the scene: German demographic trends

The previous section presented the conceptual background of this thesis and presented the three areas of regional consequences of demographic change that will be analysed in more detail in the following chapters. As motivated in the introduction, the case analysed in this thesis is Germany. This section briefly presents the main data sources, sample period and regional definitions used in the further analysis before presenting some descriptive statistics on demographic structure and trends in Germany.

2.4.1 Data sources, sample period, and regional definitions

The data used in this thesis stem from three sources. First, we use official statistics mostly provided by the Federal Statistical Office and Statistical Offices of the Länder (2014). This data is openly available for instance via the *Regional Database Germany.* Some additional indicators were obtained from the Federal Institute for Research on Building, Urban Affairs and Spatial Development via their online database INKAR (BBSR, 2016). Second, we use the *Sample of Integrated Labour Market Biographies 1975-2010*[6] referred to as SIAB7510 (vom Berge, Burghardt, & Trenkle, 2013). This dataset represents an anonymised 2% sample of the administrative German social security database and is described in detail in chapter 4. Third, data on aggregate migration flows came from the *German Migration Database* (Sander, 2014) and is used and described in detail in chapter 5.

The data sources restrict both the feasible sample period as well as the definition of regional units. The population data provided by the Federal Statistical Office and Statistical Offices of the Länder (2014) represents rolling estimates based on population registers because Germany does not maintain a regular census. The only census for reunified Germany occurred as part of the European Union census in 2011. Prior to this, the most recent census was in 1987 for West Germany and 1981 for East Germany.[7] Due to the long gap in the census data, the European Census in 2011 led to a significant downward correction of German population size when compared to the data based on rolling estimates: The census counted 1.5 million fewer people than expected. This correction represents a break in the time series for population data, which is why the period of analysis for all empirical chapters in this thesis ends in 2010. Moreover, due to the division and reunification of Germany, reliable regional-level data is only available starting from 1995 (or 1996 for some variables). Thus, for reasons of data availability, the analysed time period is 1996 to 2010.

Regional demographic change can be measured at a variety of geographical scales. For the majority of the analysis here, 332 district-regions are used. These regions represent an adjusted version of German districts (*Kreisebene*)[8], corresponding to NUTS 3.

[6] Data access was granted via a Scientific Use File supplied by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB).

[7] The lack of a German census is an expression of the sense of suspicion towards collection of personal information and fears of surveillance prevalent in the 1980s. A West-German census planned for 1983 had to be postponed due to widespread protests and a lawsuit before the Federal Constitutional Court, which ruled part of the census law unconstitutional (in 1984). Although the census was eventually performed in 1987, this court decision led to the creation of a *basic right of informational self-determination* ("Recht auf informationelle Selbstbestimmung"), which has shaped the discussion surrounding data collection and privacy in Germany ever since (Hornung & Schnabel, 2009).

[8] Some English-speaking literature refers to this same administrative level as "counties". We follow the translation set out in the style guide for EU documents, which uses "districts" (European Commission Directorate-General for Translation, 2017).

Districts can be city-districts (*Kreisfreie Städte/Stadtkreise*) as well as rural-districts (*Landkreise*). They represent the smallest geographical unit for which official statistics are widely available. The original 2010 definition of the German administrative boundaries includes 412 districts. However, in order to combine official statistics with the information derived from the Sample of Integrated Labour Market Biographies, some of the districts had to be aggregated upwards. In particular, due to data protection concerns the SIAB7510 regional file aggregates small districts to ensure that each region has at least 100 000 inhabitants. Thus, while the 262 districts with population above 100 000 are considered separate regions, the remaining 150 are aggregated to a total of 70 regions. These 332 regions are the preferred definition here because they allow comparability across data sources.

Regions differ in many respects but two important categories that are used here are the settlement type, i.e. whether a district is predominantly urban or rural, and the geographical location in the East or West of Germany. Settlement type is based on regional classification as urban or rural by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR, 2010). The categorisation in East and West is based on the territorial division prior to reunification. Districts in Federal States that constituted the German Democratic Republic (GDR) are considered to be *East* whereas the Federal States of the Federal German Republic (FRG) are *West*. It is not clear whether Berlin should be classified as East or West and both approaches can be found in the literature. Since Berlin is structurally quite different from other districts in the East, it is categorised as West here (following e.g. Brunow & Hirte, 2009a).

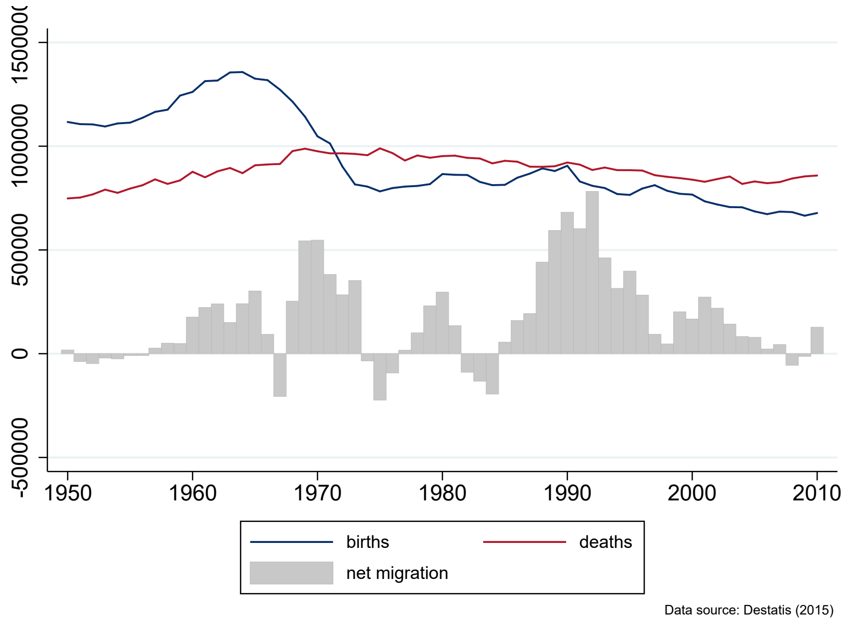
2.4.2 Demographic change in Germany

In Germany, the latest drop in fertility occurred in the 1970s, when the total fertility rate decreased from 2.5 children per woman (during the baby-boom of the 1960s) to below 1.5 (Kaufmann, 2005). East Germany experienced a period of record low fertility (0.8) following reunification (Destatis, 2012). The unified German fertility rate has fluctuated around 1.4 since the 1970s and slightly increased since 2012: the TFR stood at 1.5 in 2015, the highest value in 33 years (Destatis, 2017a). The compounding effects of consecutively smaller parent-age cohorts have led to falling number of births in Germany: 2009 recorded the lowest number of births since the Second World War (Destatis, 2012). Due to the increasing wedge between births and deaths, all German population growth since 1972 is attributable to immigration (figure 2.2a). As the spread between birth and deaths increases, an ever larger migration surplus is necessary to stabilise the population. Indeed, between 2003 and 2010 the German population was decreasing and fell by a total of 0.95% despite a positive migratory balance.

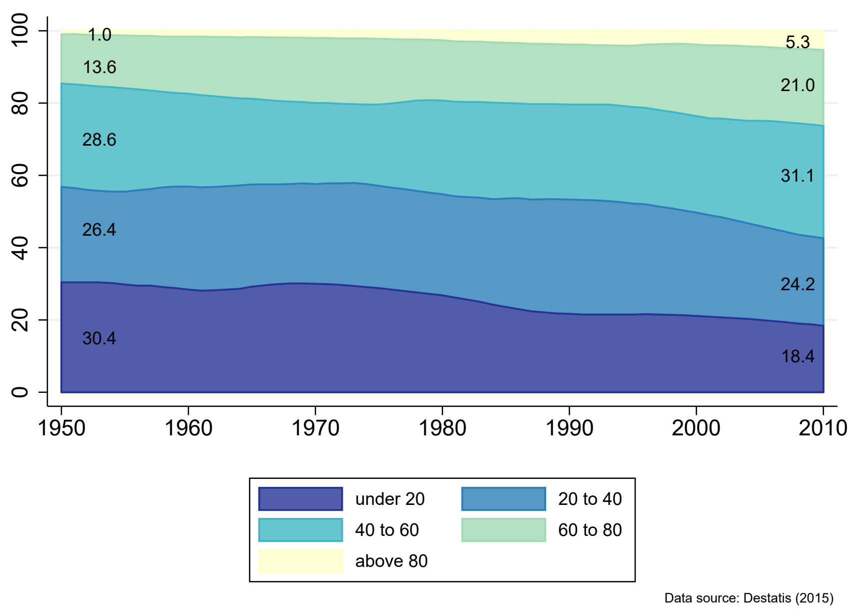
Relative to the decreasing number of children, older age groups (and especially the baby boom cohorts) are large, thus causing the population to age rapidly. Figure 2.2b shows the extent of population ageing since 1950: In 2010, people over 60 years of age

Figure 2.2: German national-level population development

(a) Population change by components



(b) Population composition by age group



make up 26.3% of the total population. The German median age was 44.1 years in 2010 and is projected to increase up to 50.9 years in 2050 (Destatis, 2015b). Germany is usually named as the oldest EU country and the second-oldest country worldwide after Japan (e.g. A. Davies & James, 2011)) although the ranking with Italy depends also on whether median age or share of population over 65 years is considered.

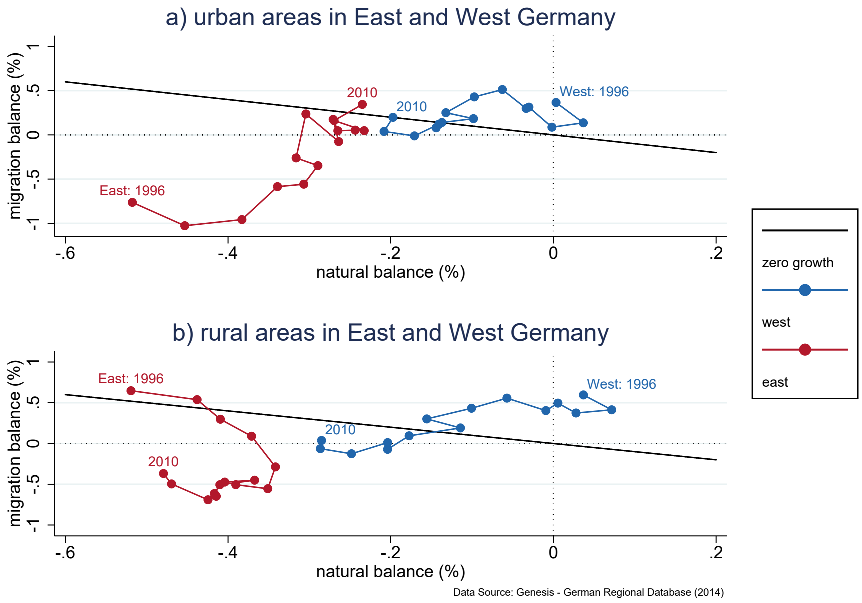
Due to unusually large net migration (especially in the context of the European Refugee Crisis in 2015/16), population has increased by 1.8 million (2.3%) between 2011 and 2015. While such immigration surges can stabilise population in the short run, they will not be sufficient to reverse or prevent population shrinkage and especially ageing in the long-term (Coleman, 2006a, 2008). Problems stem from the fact that fertility levels of immigrants converge to native population quite quickly (Mayer & Riphahn, 2000; Milewski, 2010) and that migrants themselves albeit initially younger, age in their host country. In their estimation of the validity of *replacement migration* as a policy instrument, the United Nations (2000) conclude that Germany would need a net migration surplus of 324,000 per year to stabilise population levels until 2050. In order to maintain the German potential support ratio (i.e. the population aged 15-64 per one person aged above 65 years) at its level of 1998, a net gain of 3.4 million international immigrants would be required *per year*[9]. Thus, while immigration may slow-down processes of population shrinkage and decline, it will not be able to halt or reverse the effects of demographic change. Even accounting for the unprecedented level of immigration in 2015, German population is projected to decrease to 76.5 million in 2060 (Destatis, 2017b). The demographic trends for Germany are clearly characterised by population decline and fewer children in absolute and relative terms.

2.4.3 Regional patterns of demographic change in Germany

For sub-national regions, the demographic patterns are shaped by strong disparities between the East and West of the country. The historical context of division and re-unification influences the demographic structure in profound ways, although Klüsener and Goldstein (2014) argue that the differences in fertility behaviour between East and West Germany emerged as early as the 19th century. Extremely low fertility rates towards the end of the German Democratic Republic as well as pronounced outmigration after the fall of the Berlin wall caused the East German regions to shrink and age more quickly than the rest of Germany through the 1990s (e.g. Bucher, Schlömer, & Lackmann, 2004; Swiaczny, Graze, & Schlömer, 2008). Wolff (2006) estimates that 2.77 million people moved from the East to the West between 1989 and 2002. The large volume of outmigration is especially problematic because East-to-West migrants seem to be relatively young and highly educated (e.g. Mai, 2006; J. Hunt, 2000) leading to patterns of brain drain within Germany (Nelle, 2016; Schneider, 2005). Moreover,

[9] An even more striking illustration is this: in order to maintain the South Korean potential support ratio at its level of 1998, the country would require immigration of the scale of the entire global population (United Nations, 2000). Coleman (2006a, p. 73) concludes that “the“Korea Syndrom” is the *reductio ad absurdum* of this option”.

Figure 2.3: "Snail trails" by settlement type and East and West



Schlömer (2004) observes that the East German population decline is to a large part caused by too little in-migration. The role of East-West migration and its relevance for regional disparities within Germany has inspired a large and diverse literature, some of which will be discussed in more detail in chapter 5.

The different demographic dynamics between East and West Germany are illustrated using *"snail trail"*[10] graphs in figure 2.3. These graphics plot the migration balance versus the natural balance for average urban areas in East and West (panel a) and rural areas (panel b). The black line of slope (-1) represents the line of zero growth: to the right of that line population grows and to the left it decreases. Comparing the panels shows that urban and rural areas in West Germany seem to, on average, follow a similar trend. They started with both a birth surplus and positive net migration in 1996 and then see their natural balance decrease over time, whereas the migration balance remains more or less stable. By 2010, the population of both urban and rural regions in the West has decreased for at least 4 year consecutive years, (although urban population growth was essentially zero in 2010). This pattern is consistent with patterns of continuing suburbanization observed for Germany (see e.g. Swiaczny et al., 2008).

Urban regions in East Germany show almost opposite population development to their West German comparison case (panel a). They started out with both negative migration and natural balances and thus pronounced population decrease. Over time, both migration and births increase for East German regions and population growth in 2010 is even positive. The relatively positive population development of urban areas in East Germany is driven by migration gains specifically among young age groups and has been suggested to be an example of a re-urbanization trend in East Germany (see Köppen, Mai, & Schlömer, 2007). Panel a also suggest that the demographic devel-

[10]Thanks to Dave Maré for bringing my attention to snail trail graphics.

Table 2.1: Webb classification for German regions 1996-2010

Webb-Type	regions	% regions	% population (2010)
Population Growth	175	52.71	59.64
1 Natural + >Migration -	1	0.30	0.15
2 Natural + >Migration +	7	2.11	1.82
3 Migration + >Natural +	70	21.08	23.17
4 Migration + >Natural -	97	29.22	34.50
Population Decline	157	47.29	40.36
5 Natural - >Migration +	57	17.17	14.94
6 Natural - >Migration -	56	16.87	15.30
7 Migration - >Natural -	40	12.05	9.23
8 Migration - >Natural +	4	1.20	0.89
Total	332	100	100

opments among urban areas in East and West Germany seem to be converging rather than diverging.

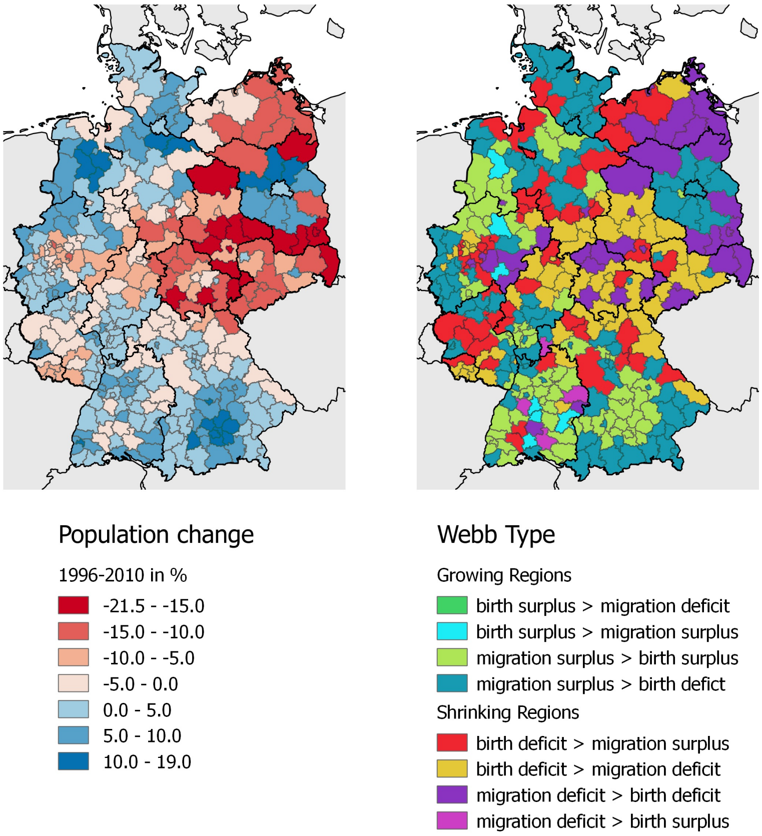
In contrast, panel (b) shows a very distinct snail trail pattern for rural areas in East Germany. In 1996, rural East German areas experienced population growth despite a relatively large negative natural balance. However, over time the positive net migration declined and the natural balance only increased temporarily. The snail trail for rural East German regions thus curves in on itself, showing a similarly negative natural balance in 1996 and 2010 but a strongly negative migration balance in the latter case.

The average snail trails by settlement type disguise the large degree of small-scale geographical variation in demographic outcomes. Instead, the Webb classification (Webb, 1963), which conceptually underlies the snail trail graphs, can be used. The Webb-type essentially refers to each region's position in the quadrants of figure 2.3. The classification depends on the relative size of natural and migratory balances and is presented in Table 2.1.

Table 2.1 shows that close to half of all regions experienced a decreasing population between 1996 and 2010. 40% of the German population lived in a shrinking region in 2010. This illustrates strikingly that population decline was not an isolated event in Germany in this period but an influential trend. Moreover, the national-level observation of an increasing wedge between births and deaths of course also applies on a regional level. Adding up the population living in regions with a positive natural balance shows that just over a quarter of the population (26%) lives in regions with a birth surplus. This means that 74% of Germans live in regions that would be shrinking if not for immigration. There is only one region where a birth surplus is enough to compensate a migratory deficit[11] whereas a positive net-migration outweighing a birth deficit is the most common constellation (97 regions accounting for 34.5% of population in 2010). In contrast, 14.9% of the population live in regions where even positive net migration cannot compensate for a birth deficit.

[11] City-district Offenbach am Main, adjacent to Frankfurt am Main.

Figure 2.4: Webb type of German regions

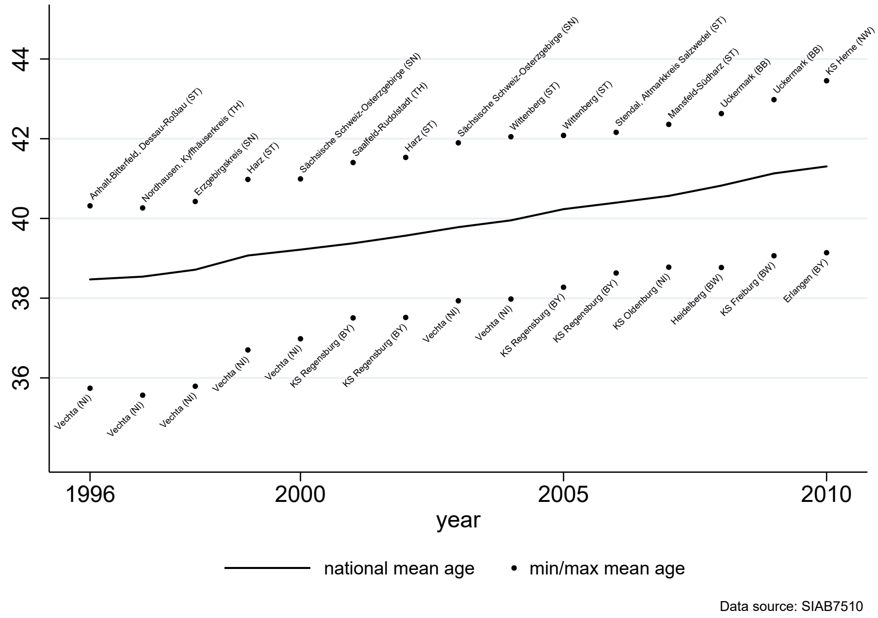


The geographical dimension of population change and the Webb Types is illustrated in figure 2.4. The left hand map shows that, as expected, the most strongly shrinking regions are located in the East of Germany. However, shrinking populations are clearly not only a phenomenon of East Germany but occur across Germany. Taking a closer look at the geographical location of different Webb types, an equally mixed picture emerges[12]. Overall, the shrinking regions in East Germany shrink overwhelmingly both because of a birth deficit and a migration deficit (yellow and purple). In contrast, many West German regions that are shrinking do so despite positive migration (red). The 8 regions with a relatively large birth surplus are all located in West Germany, especially Baden-Württemberg. Berlin and its surroundings as well as most of Schleswig-Holstein in the north and the border regions towards Austria are characterised by migration compensating for a birth deficit.

Turning towards the sub-national patterns in age structure, Figure 2.5 shows the strongly increasing trend in mean age on a regional and national scale. Note that the data source for this figure is the SIAB7510 data, which only represents a sample of the employed labour force. The mean age of the employed labour force covered in the SIAB7510 is slightly lower than a population-wide mean age would be, but it neverthe-

[12]Note that the colour scheme in the right panel of figure 2.4 is intentionally not graduated. While the figure is meant to illustrate the difference between growing (green and blue) and shrinking regions (red, yellow, purple) this figure does not represent the degree of population change but only the Webb type.

Figure 2.5: German mean age of the employed labour force



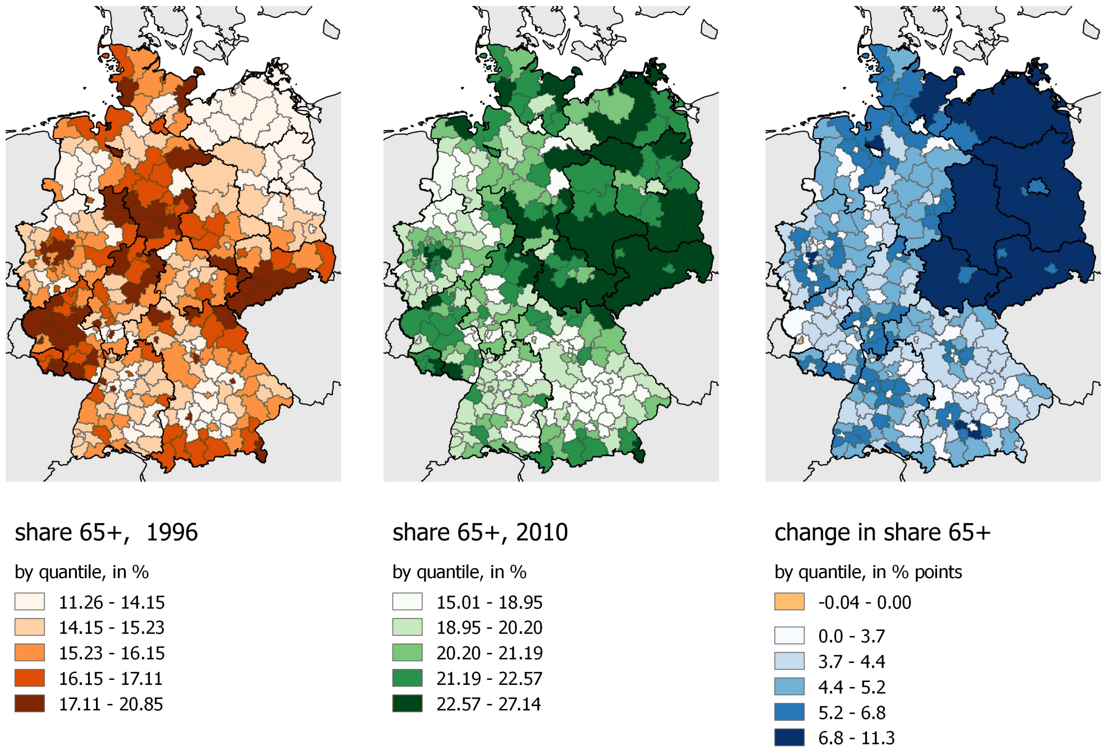
less illustrates the dynamics in the variable. In particular, the region with the lowest mean age in 2010 (Erlangen in Bavaria) still had a mean age above the national mean from 1996. Moreover, all regions but one (Potsdam) record an increase in mean age when comparing 1996 to 2010, illustrating that population ageing is not an exception but the rule.

As an alternative indicator of population age, the maps in figure 2.6 present the share of population above 65 years in 1996, in 2010, and the change between these two years by quantile. In line with the development of population ageing on a national level, the share of population above 65 years increased in all but one German region: Trier, a city-district in the West of Germany, is the only region in Germany that experienced a small decrease (of 0.04 percentage points) in the share of population above 65 years.

In 1996, the regions with the highest share of population above 65 years are relatively well distributed across Germany and some East German regions (especially in the Federal State Mecklenburg-Vorpommern) stand out as relatively young. In contrast, the map for 2010 shows a distinct clustering of the oldest regions in the East of Germany. This observation is even more striking when considering the third map, which illustrates the change in the share between 1996 and 2010: Almost all of the most strongly ageing regions are located in the East of Germany.

Having described the conceptual background as well as the empirical case for this thesis, the next chapter presents the first of three analyses of the regional consequences of demographic change for Germany.

Figure 2.6: Maps illustrating share of population above 65 years



Chapter 3

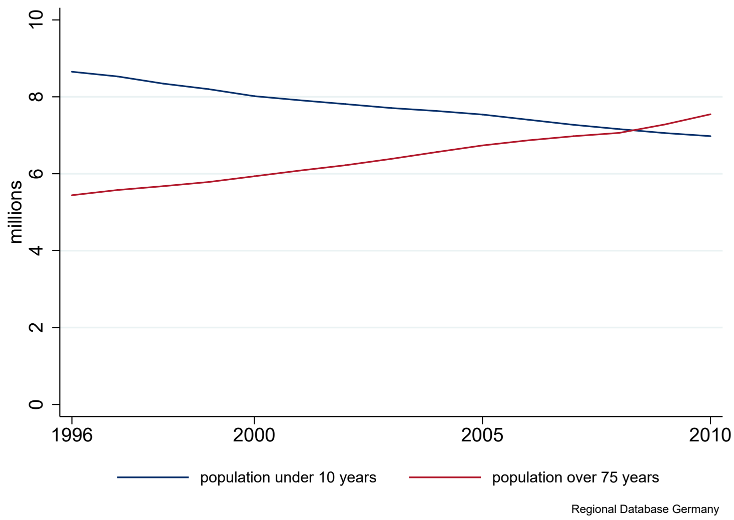
Primary School Provision and Demographic Change

3.1 Introduction

The increase in elderly population due to rising life expectancy is a prominent feature of demographic change. However, as discussed in Chapter 2, sub-replacement fertility is the main driver of demographic change and leads to both population ageing and shrinkage. Thus, demographic change does not only mean more elderly people, it, crucially, also means fewer and fewer children. In Germany, the number of children under 10 years has fallen by 1.64 million between 1996 and 2010, a fall of 19.3% in just 15 years. As of 2008, there are more people living in Germany who are aged 75 and above than children younger than 10 (see Figure 3.1). Clearly, demographic shifts of this magnitude have direct consequences for the amount and types of public services demanded. In particular, due to the reduction in the number of children, demand for schooling has decreased, while services targeted at the growing older age groups are gaining in relevance.

From an economic perspective, the observed strong fall in the number of children should lead to a significant contraction of the supply of primary schools, especially if school provision is characterised by economies of scale (Andrews, Duncombe, & Yinger, 2002). However, as a public service, adjusting school supply implies a trade-off between cost considerations and ensuring accessible and equitable provision of education. Regional differences in the degree of responsiveness of school supply therefore raise issues of regional disparities. If regional characteristics such as settlement type, geographic location or the broader economic and demographic trends mediate the elasticity of school supply, different responses to a comparable fall in demand could undermine the German constitutional principle of equal living conditions (*Gleichwertigkeit der Lebensverhältnisse*, § 72, Abs.2, GG). This chapter therefore addresses two questions. First, how responsive is regional primary school supply to changes in demand? And, second, how does this responsiveness differ with regional characteristics such as loca-

Figure 3.1: Population under 10 years and above 75 years



tion in East or West Germany, by settlement type, or with the local economic and demographic circumstances?

We focus on primary school provision as an example of how demographic change affects public services for three reasons. First, primary schooling is compulsory and it is therefore provided for a clearly defined age group. This means that demographic shifts in the number of children feed through directly to the current demand for primary schooling. The effect of demographic change can therefore be identified relatively clearly, which is not the case for some other public services, such as health care, which is used by individuals of all ages. Second, primary schooling is predominantly publicly provided and organised relatively similarly across German Federal States, which allows comparisons that would be more difficult for secondary education[1]. Third, primary schooling in particular is an issue raised frequently in public debate because schools often act as focal points of local communities. In contrast to effects on physical infrastructures such as water- and waste-networks, school closures attract widespread attention and are often met with public resistance (e.g. Basu, 2004; Bartl & Sackmann, 2016). Thus, considering the effect of demographic change on primary school provision does not only have advantages from an empirical standpoint but is also of high relevance for policy makers.

Despite the current and projected extent of demographic changes in Germany, the quantitative empirical literature on its consequences is limited. This is in part due to the fact that currently available data only captures a small proportion of the projected future changes. It is also impeded by data availability at smaller geographical scales. Education spending, for instance, is only reported at the level of Federal States, which is why this chapter uses primary school numbers to assess supply. Thus, studies investigating the relationship between school provision and student numbers in Germany and internationally are usually set at state-level (for Germany e.g. Baum & Seitz, 2003;

[1]In Germany, education policy is organised at the level of Federal States, which means substantial variation in the details of school provision across the 16 Länder.

Kempkes, 2009) or as case studies of specific areas. Considering the large regional heterogeneity in demographic patterns and the actually observed changes in primary school supply, a smaller unit of analysis allows more detailed insights into the effects experienced by the local population.

This chapter analyses a panel of 322 German district-regions in the time period 1996-2010. The aim of the chapter is twofold. First, it estimates the elasticity of primary school supply to changes in the number of children and compares it to results from studies on education spending (Baum & Seitz, 2003; Kempkes, 2009) and tests robustness using an instrumental variable approach. Second, it investigates the role of economic, geographic and demographic regional characteristics in mediating the relationship between school demand and supply.

This chapter proceeds as follows. Section 2 presents the theoretical and empirical background on the relationship between demographic change and primary school provision. Section 3 describes the dataset and methodology. Section 4 presents the results of the panel analysis and considers the potential issue of reverse causality due to migration. The last section discusses the results before concluding.

3.2 Theoretical and empirical background

Demographic change causes shifts in population size and composition both on a national and on a regional scale. As a consequence, overall demand for public services falls and shifts towards different types of services. Due to the continuous decline in birth numbers, services with young target groups (e.g. maternity wards, paediatricians, childcare, and schools) already face noticeable falls in demand. Thus, the demand-side effects of demographic change on primary school provision are clear. This section describes the theoretical and empirical background on how regional primary school supply will react to falling student numbers.

3.2.1 How does demographic change affect primary school supply?

A fall in demand alone would justify decreasing the provision of primary schooling because fewer children require fewer schools. However, there are two more nuanced reasons why school supply should contract in response to demographic change: cost effects and intergenerational competition.

If primary school provision, as most public services, is characterised by economies of scale, falling student numbers imply increasing per-unit costs (Andrews et al., 2002). This is the case if schooling has residual costs, i.e. expenditures that do not decline proportionally to the number of users, such as the costs of administration or maintaining the school building. Under the assumption of economies of scale, falling demand increases per-unit costs of provision. Since German primary schools are predominantly publicly funded[2], cost increases affect public finances. Indeed, empirical literature suggests that school spending is relatively inelastic to changes in student numbers (e.g. Baum & Seitz, 2003; Borge & Rattsø, 1995; Poterba, 1997, 1998). Thus, primary school spending per-head may increase as the number of children falls.

In Germany, both Federal States' as well as municipalities' budgets would be affected by such cost increases. Federal States fund roughly 80% of primary (and secondary) education expenditure while municipalities pay the remaining 20% (Kempkes, 2009). In particular, teachers (who are usually public servants) are paid by the Federal State whereas the municipality is responsible for maintenance costs of the school, i.e. expenses on infrastructure and non-teaching staff (see e.g. KMK, 2013). Depending on the source of cost increases from declining student numbers, demographic change can strain both state-level and municipal budgets. However, whereas Federal States may encompass municipalities with different degrees of demographic changes, municipalities are directly affected by demand shifts. Additionally, due to small size, municipalities may already function at inefficient cost levels and are therefore at risk of facing additional budgetary pressure from demographic change (Geys et al., 2007; Lais & Penker, 2012). Thus, cost considerations would imply that under-used schools will eventually need to be closed.

Besides the effect of falling demand on costs of school supply, demographic change also implies shifts in the age composition which affect the political economy of public expenditure (for an overview see e.g. Zaiceva & Zimmermann, 2014). In particular, since the elderly do not directly profit from school expenditure, population ageing may lead to the median voter's preference to shift towards reduced school spending. Intergenerational competition for public funds could thus reduce per-head education spending and has been documented for instance for US states (Poterba, 1997, 1998), Swiss cantons (Grob & Wolter, 2005) and Japanese prefectures since 1990 (Ohtake & Sano, 2010). However, on a smaller geographical scale of US counties, there is some evidence that the elderly sort into areas with fewer children (Ladd & Murray, 2001) and that they may support increased education spending because it might increase house prices or due to altruistic preferences (Brunner & Balsdon, 2004).

From a budgetary as well as political economy perspective, the pronounced fall in the number of children should thus lead to a significant reduction in primary school supply. However, there are several factors that could introduce rigidities in the supply of primary schools and ensure high provision even despite considerable cost increases.

Due to fixed costs and indivisibilities, opening and closing schools is costly, making supply relatively inflexible in the short-term. This is a common feature among public services more generally (Koziol, 2004). Although the number of classes and teachers can in principle be adjusted, even these adjustments may be difficult, for example if employees are non-dismissible public servants[3]. In this sense, the flexibility of the public sector labour market may influence the ease of adjustment of service provision

[2]Less than 5% of German primary schools are private (Destatis, 2012) and even these are often publicly subsidized.

[3]76% of teachers in Germany in 2013 (Destatis, 2015a).

to changes in demand (Sackmann, 2015). Moreover, due to the inherent uncertainty regarding the future size and composition of population, adjusting the supply of public services based on current and future trends is difficult (Wiechmann, 2008).

School closures that do occur also bring a number of consequences. Since primary school is compulsory, closing a school implies a redistribution of students to other schools. For the remaining schools, a closure could thus increase enrolments and restore profitability illustrating the network effects of primary school provision. However, closing a school may increase the travel distance for students (especially in rural and peripheral areas) and thus reduce accessibility. Longer travel distances are costly especially because primary school students can only travel short distances unsupervised. For this reason, proximity of primary schools is a prominent concern for parents, exemplified by the notion of "short legs, short ways" (*"Kurze Beine, kurze Wege"*) (Diller & Frank, 2014) and often used to justify maintaining even small schools if their closures would significantly increase travel times. Moreover, if a municipality provides transportation for school children, these travel costs will also reduce potential cost savings from closing a school.

A further concern is whether falling student numbers may affect the quality of primary education. Initially, if resources such as teaching time and facilities are not adjusted to the decrease in enrolments, quality of education may increase (Poterba, 1997). However, cost increases are likely to require a reduction in the resources devoted to a smaller number of students. Additionally, if schools in shrinking regions are less attractive workplaces, recruiting highly qualified teachers may be difficult. This is particularly problematic because the age-structure of the teaching profession in Germany suggest a shortage of teachers by 2020 even despite the fall in students (Jeschek, 2003). In response to recruitment difficulties in rural areas, some federal states, such as Brandenburg, offer incentives for teachers willing to move to specific schools (Kramer, 2015).

Decreasing demand due to regional demographic change may thus affect efficiency, accessibility and quality of primary schooling. Moreover, these consequences may reinforce the trends of demographic change, if school provision affects migration decisions (Barakat, 2015; Hyll & Schneider, 2011). Schools are often described as bringing life to communities and serving as focal points in space (Hahne, 2009; Witten, McCreanor, Kearns, & Ramasubramanian, 2001), thus making a region attractive to migrants. In the context of national demographic change, regions are effectively competing for a limited number of inhabitants. The threat of a primary school's closure alone could become a self-fulfilling prophecy if families decide to move to regions with more secure primary school provision. This possibility illustrates the difficulties in establishing causality in the effects of regional demographic change (Haase et al., 2013; Hoekveld, 2012) and raises issues of endogeneity in the empirical analysis, which will be discussed in Section 6.

For these reasons, closing primary schools is a politically unattractive choice and often met with considerable resistance among parents. Due to the negative connotation of population decline as a sign of crisis (Sousa & Pinho, 2013), policy approaches that aim to reverse population shrinkage may be politically more popular than decline-oriented planning (Müller & Siedentop, 2004; Sackmann, 2015). It is possible that regions may maintain inefficiently high levels of public service provision in the hopes of attracting enough immigration to halt or reverse population decline.

3.2.2 Empirical literature

The theoretical discussion illustrates that, although a fall of school-aged children provides incentives to close primary schools, rigid supply may prevent closures. Whether a fall in demand due to demographic change actually leads to an adjustment in the supply of primary schools is therefore an empirical question.

The literature on demographic change and school supply is heavily influenced by Poterba's (1997, 1998) analysis of the effects of cohort size on per-head education spending. As mentioned above, studies of so-called demand effects of education generally find that education spending is not flexibly adjusted to the number of children so that cohort size is negatively correlated with per-capita education expenditure (e.g. Borge & Rattsø, 1995, 2008; Ohtake & Sano, 2010).

For Germany, Baum and Seitz (2003) show that the education expenditure for West German Federal States does not react strongly to demographic changes, supporting the notion of per capita spending increases. In contrast, for East Germany, Kempkes (2009) shows that declining student numbers are associated with adjustment in education spending for primary schools especially in the period 1996 to 2002, when fertility rates were very low. Although both of these studies distinguish between budget items funded by the Federal State versus the municipality, they only consider differences between Federal States, i.e. compare average municipal education spending across German Federal States. Education spending data for smaller geographical units than Federal States is not available because the Federal and the municipal spending are not consolidated (Makles & Schwarz, 2011).

More generally, the majority of existing studies on the relation between demographic change and school provision are at the state level and hence ignore the degree of regional variation within Federal States. Besides the lack of data on education spending on a district or smaller level, data on the number of teachers for units below the state level is also unavailable. Moreover, data on school quality for Germany is extremely limited in international comparison. Unlike, for instance the UK, Germany does not publish test scores or school inspection reports (e.g. Lankes, 2016) and student performance studies such as the OECD PISA study (Prenzel, Sälzer, Klieme, & Köller, 2013) do not report on geographical units smaller than Federal States. Data availability for Germany thus means that quality effects of the reduction in student numbers as well as effects on financing cannot be measured at a small geographical scale, and that alternative measures of school provision need to be used. Therefore, this study measures the effect of demographic change on primary school provision by using primary school numbers on a district level.

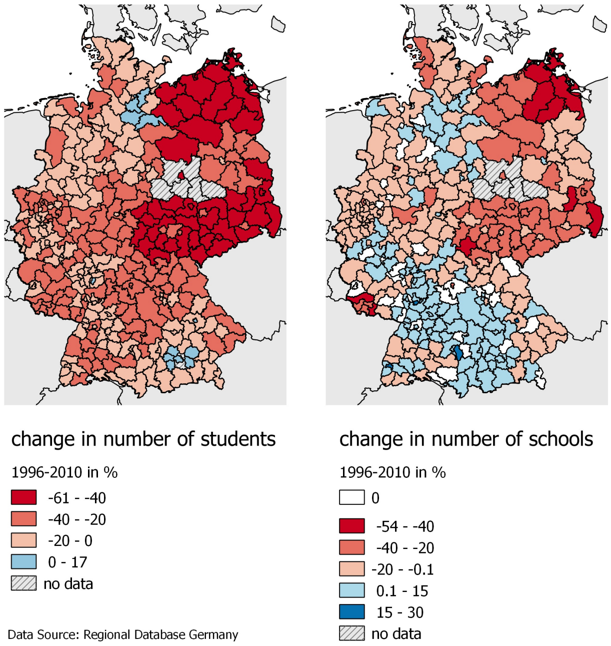
Case study approaches to specific municipalities or regions provide insights into the phenomenon, but often focus on rural and peripheral areas (Ribchester & Edwards, 1999; Budde, 2007; Slee & Miller, 2015) or cities experiencing industrial decline, such as Manchester (Bondi, 1987). Since population decline is still an isolated phenomenon in many countries, cases of school closures naturally occur in these peripheral and rural communities. However, under conditions of demographic change as it is occurring in Germany, school closures are more frequent, thus allowing the issue to be considered in a quantitative empirical analysis.

Despite a different institutional background, studies on consolidation of US school districts represent a comparable stream of literature, because it emphasises the role of regional characteristics in determining whether school provision is reorganised (e.g. Brasington, 1999, 2003). In this context, Billger (2010) examines the likelihood of closure for schools in Illinois and finds that low enrolment and rural locations are relevant but that the proportion of minority and low-income students is also influential. This result suggests that demand effects will indeed lead to school closures but that other regional circumstances are also relevant. In terms of factors increasing rigidity of school supply, Basu (2004) suggests that regional social capital may prevent school closures because it helps parental organisations to influence decision-makers.

The only study of responsiveness of German school supply to changes in demand for smaller geographical units is presented by Bartl (2014, 2015). The author analyses the responsiveness of the number of schools to student numbers for districts in Saxony-Anhalt between 1992 and 2010 and concludes that the supply of primary schools is relatively less elastic than of other school types. However, due to the very low sample size and the use of simple bivariate regression analysis without controls, the power of these results is limited. Nevertheless, the estimated elasticity of 0.41 in Bartl's (2014, 2015) analysis serves as benchmark value for the results presented in this article.

The existing literature on the topic has three shortcomings that this chapter addresses. First, due to the isolated occurrence of population decline and ageing, there are few studies that set school closure in a context of widespread demographic change as it is currently occurring in Germany. Second, despite the large variation of demographic developments on a regional level, the majority of quantitative studies focus on state-level analyses both for Germany and internationally. Third, the existing empirical analyses do not account for inherent differences in regional characteristics. However, as described in the following section, how demographic change affects primary school supply is particularly relevant on a regional level. This chapter therefore takes an explicitly regional perspective by analysing district level school numbers in a panel setting and testing the mediating effect of regional characteristics.

Figure 3.2: Change in the number of primary schools and students



3.2.3 Regional relevance of primary school supply

The effects of demographic change on primary school supply are particularly relevant on a regional level for two reasons. First, there is a large degree of regional variation in both the extent of demographic change and the incidence of school closures. Figure 3.2 presents maps of the change in both number of primary schools and students between 1996 and 2010. Due to changes in the boundary definition in the Federal State of Saxony-Anhalt, data is only available as of 2005 for 5 district regions and these are not considered in the map. The left-hand panel of Figure 3.2 illustrates that almost all regions experienced a decrease in the number of primary school students albeit to a varying degree. The only areas that saw (modest) increases in student numbers are the cities of Hamburg and Munich as well as surrounding areas. Almost all regions in East Germany (with the exception of Berlin and its hinterland) saw student numbers fall by more than 40% between 1996 and 2010. In contrast, a substantial number of districts, especially in the South of Germany, did not close any schools and some even increased primary school supply. The map shows that the largest incidence of school closures is in East Germany as well as in the Federal State of Saarland in the West.

Some of the regional variation in school closures may be explained by differences in the mechanisms governing school closure decision. Generally, the decision to close a school can be taken by municipalities, by district-level school-boards or by the state-level Ministry of Education. Currently, four federal states maintain legal requirements for minimum sizes at the school level while other states require a minimum number of classes (see Appendix 3.A.1). Thuringia and Hesse do not state a legal minimum size in their education laws. Legal minimum school sizes range from 42 students (in Mecklenburg-Vorpommern) to 92 (for municipalities with more than one school in North Rhine-Westphalia). Most Federal States require primary schools to have at least one class for each of the four primary school years and some further require these classes to be of a minimum size (usually around at least 15 students).

However, even in Federal States with minimum school sizes, the explicit possibility for exceptions (e.g. if closure would increase travel time by unacceptable amounts) implies that there is substantial leeway in the application of the requirements. Indeed, Bartl (2014) points out that there were 75 primary schools below the minimum requirement of 60 students in Saxony-Anhalt in 2013. The absence of a unified and binding procedure for school closures implies that the degree of responsiveness of primary school supply to changes in demand may depend on regional characteristics. Thus, considering the regional heterogeneity, analysing the effect of demographic change on primary school provision warrants analysis on a regional level.

Second, primary school provision has inherently local effects on living standards and equality of opportunity for inhabitants of shrinking regions. Dealing with the effects of demographic change implies a trade-off between maintaining the living standards for the remaining inhabitants on the one hand, and efficiency and fiscal responsibility on the other. Heterogeneous responses to this trade-off raise issues of regional disparities. The German constitutional principle of equal living conditions is relevant in this context. In legal terms, it serves to prevent national legislation that increases regional disparities (Brandt, 2015), but it also represents the guiding principle for policies on regional disparities, similar to principles of territorial cohesion on a European level (Böhme & Zillmer, 2015). Despite the fact that equal living conditions represent a philosophical aim rather than a politically binding and achievable goal (Herfert, 2007; Kawka, 2015; Kersten, 2006), the potential of demographic change in undermining this aim is frequently discussed, especially in the context of public service provision (Winkel & Spiekermann, 2014).

As demonstrated in Figure 3.2 and the previous chapter, the incidence of demographic change shows strong regional differences. However, the question remains whether there are systematic differences in regions' reactions to demographic change, e.g. in terms of the number of schools that are being closed. If such differences exist, demographic change could be an additional burden for lagging regions and exacerbate regional disparities.

Three dimensions of regional characteristics stand out and will be explored in this chapter. First, geographical factors may play a role. Since travel distances are generally larger in rural areas, school supply might be less responsive to changes in demand in rural than in urban areas. Moreover, comparison of results presented by Kempkes (2009) and Baum and Seitz (2003) suggests that there may be systematic differences between regions in East and West Germany. Second, economic conditions could affect the responsiveness of public services. Economically stronger regions may be able to afford a higher degree of service provision even in the face of falling demand, for example due to larger municipal tax income. Third, the demographic structure of the regions could explain differences in their responsiveness to a fall in school demand. In particular, in line with the notion of intergenerational competition for public services, we test whether elasticities of primary school supply vary with the share of regional elderly population. Moreover, if population decline strains municipal budgets, as suggested by Lais and Penker (2012), we would expect shrinking regions to be more responsive to changes in school demand than regions growing in population.

3.3 Method

3.3.1 Data source and unit of analysis

Data on primary schools and most regional characteristics was obtained from the Regional Database Germany (Federal Statistical Office and Statistical Offices of the Länder, 2014) with supplementary school data obtained directly from the statistical offices of Schleswig-Holstein and Brandenburg. Some additional regional characteristics (e.g. tax income) were obtained from the INKAR database of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR, 2016). In addition, we use the SIAB7510 file, which is a 2% representative sample of employees covered by compulsory social security (*Sozialversicherungspflichtige Beschäftigte*) to obtain a measure of regional human capital, i.e. the share of employees with tertiary education.[4]

As described in Chapter 2.4, the geographical unit represents an adjusted version of German districts (NUTS3) based on the regional definitions used in the SIAB7510 file. In the context of primary school provision, it is important to have an intuitive understanding of the scale of analysis. In particular, as mentioned above, primary schools are usually maintained in cooperation between municipalities and Federal States. The unit of analysis, i.e. districts, represents the administrative region between municipalities and Federal States. Districts are sufficiently large to have several primary schools throughout the study period. While municipalities may have to close their only primary school, the average number of schools per district is 51 and even the smallest district has at least 11. The geographical and administrative size of districts is relevant because it limits the role of migration and, as shall be elaborated upon in Section 6, reduces the risk of reverse causality in the estimation. In particular, even if the last primary school in a given municipality were closed, children would likely attend the next closest primary school within the district.

However, districts are very heterogeneous in area, population size, and economic structure. On the one hand, a district may be composed of mostly rural municipalities in the form of a rural district (Landkreis). On the other hand, cities are part of urban districts (Stadtkreis) or themselves constitute a district-free city (Kreisfreie Stadt). As a consequence, the administrative unit of a district refers to both, and anything between, major cities and peripheral rural areas with low population density. Indeed, the two

[4]This dataset is described in detail in Chapter 4.

largest German cities, Berlin and Hamburg, are simultaneously districts and Federal State (i.e. both NUTS2 and NUTS3 level). This is due to their status as a city-state (along with Bremen, which consists of two cities). Thus, while the district level allows investigating a much larger range of variation than would the Federal State level, it is crucial to control for other factors that capture the degree of heterogeneity among regions.

Of the 332 SIAB7510 district regions, all observation in the Federal State Saarland were excluded due to a discontinuous time series in the number of schools. Saarland introduced a minimum school size in 2005 (Schraml, 2005), which led to 80 primary schools being closed in a single year with no closures before or after this change. Moreover, 5 regions in Saxony Anhalt have missing school data before 2005, due to changes in the boundary definitions. The final sample is an unbalanced panel dataset of 322 district regions for the time period 1996-2010.

3.3.2 Estimation strategy

As mentioned previously, following Bartl (2014, 2015) we measure primary school supply using the number of public primary schools per district. Usually, children in Germany begin primary school at six years and it comprises the first four years of general education.[5] Private schools and primary schools that are integrated with secondary schools (e.g. *Gemeinschaftschulen*) are excluded to ensure comparability. School demand is measured as the enrolment in primary schools (i.e. year 1 to 4). As primary school attendance is compulsory, we assume that enrolment represents the actual demand relatively closely.

$$\ln \text{schools}_{it} = \beta_0 + \beta_1 \ln \text{students}_{it} + \beta_2 \text{controls}_{it} + \mu_i + \tau_t + \varepsilon_{it} \tag{3.1}$$

The dependent variable, number of primary schools, and the number of students enter the estimation in logarithmic form. This allows directly estimating the elasticity of school supply with respect to demand: β_1 represents the estimate of the percentage change in the number of primary schools associated with a 1% change in the number of students. In order to control for invariant unobserved factors in the panel structure of the data, district fixed effects and year fixed effects are included.

To control for regional characteristics affecting the number of primary schools, a set of socio-economic and demographic characteristics are included. GDP per capita, the unemployment rate and the share of services in value added enter as controls for regional economic conditions. We also include the tax revenue per capita as an indicator of the district's fiscal situation. The share of employees with tertiary education (university of applied sciences or university degree) is used as a measure of regional human capital.

[5] Since there is no single German education system but each Federal State has its own rules, it should be noted that there is some variation in what constitutes primary schools. For instance, primary school in Brandenburg and Berlin lasts six years rather than four. These variations are not relevant for the estimation or results of this chapter and are therefore not discussed in more detail.

Following the literature on education spending and demographic structure, the share of population above 65 years and the share of population with non-German citizenship are included. A full description of the variables, their sources and summary statistics is presented in Appendix 3.A.2.

The fixed effect specification in (3.1) takes advantage of both time and spatial variation in the data and accounts for unobserved heterogeneity among regions. However, as the region fixed effects absorb observed and unobserved time-invariant heterogeneity, this specification cannot identify the effects of constant factors, such as whether a region is an urban or rural area or whether it is located in the East or West of Germany. To test whether the elasticity of primary school supply with respect to demand differs with regional characteristics, interaction terms are included:

$$\begin{aligned} \ln \text{schools}_{it} = \beta_0 + \beta_1 \ln \text{students}_{it} + \beta_2 \text{controls}_{it} \\ + \beta_3 (\ln \text{students} * \text{regional characteristics})_{it} + \mu_i + \tau_t + \varepsilon_{it} \end{aligned} \quad (3.2)$$

3.4 Results

3.4.1 Elasticity

To obtain baseline estimates, we begin with a short descriptive analysis of the relationship between primary school numbers and student enrolments on a national level (Figure 3.3). Relative to the initial values in 1996, the number of primary schools decreased quite linearly over time. In contrast, after an initial strong fall, the number of students stabilised from 2002-2005 before starting to decrease again. The number of primary schools in Germany fell from 17 246 in 1996 to 15 849 in 2010, corresponding to a fall of 8.1%. Simultaneously, enrolments fell by 803 294 students or 22.4%. Based on these figures, the national level elasticity of primary schools with respect to student numbers is 0.361. Thus, decreasing the number of students by 1% is, on average, associated with a 0.36% fall in the number of primary schools. This result is close to Bartl's (2014, 2015) estimate of 0.41 for primary schools in Saxony Anhalt between 1992 and 2009.

Table 3.1 presents the results of the baseline elasticity estimations. All three columns show, as expected, that the number of students is positively significant for the number of primary schools. Thus, student numbers are apparently influential in primary school supply decisions. Including time fixed effects (column 2) increases the coefficient on the number of students slightly. When including both time fixed effects and a set of regional characteristics (column 3) the estimated elasticity of primary school supply is 0.312. Thus, a 1% decrease in the number of students is associated with a decrease in schools of 0.31%. The estimated elasticity from the district-level is only slightly lower than the rough national level estimate of 0.36 and the 0.41 reported by Bartl (2014, 2015).

Figure 3.3: National level primary schools and students (normalised)

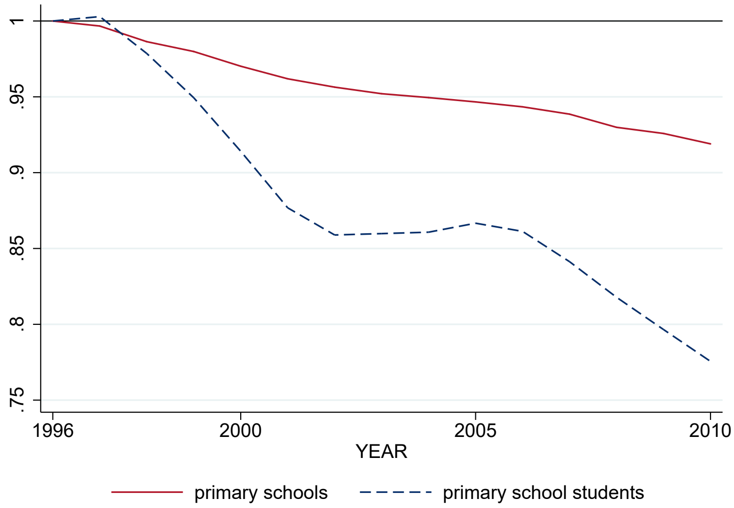


Table 3.1: Elasticity baseline results

	(1) ln schools	(2) ln schools	(3) ln schools
ln students	0.340***	0.384***	0.312***
	(0.0175)	(0.0189)	(0.0184)
ln GDP p.c.			0.031
			(0.0385)
unemployment			0.003**
			(0.0015)
services			-0.001
			(0.0007)
ln tax p.c.			-0.050***
			(0.0153)
high-skilled			0.003
			(0.0019)
elderly			-0.029***
			(0.0035)
foreign			-0.009**
			(0.0035)
Constant	0.736***	0.322*	1.677***
	(0.1579)	(0.1721)	(0.2673)
Observations	4,830	4,830	4,820
R-squared	0.478	0.497	0.631
Number of region	322	322	322
Year FE		yes	yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Evaluating whether this figure is large or small is difficult without comparison studies using a similar dependent variable. A back-of-the-envelope calculation for the average district helps to illustrate the size of the effect. Based on the average of 51 primary schools per district, closing down one primary school corresponds to a 1.96% change. With an elasticity of 0.31, closing down one primary school in the average district would be associated with a reduction in student numbers by 6.3%. Based on the average number of students per district (9826), the average district would thus need to see student numbers fall by 619 in order to for one school to be closed. Considering that the average number of students per school in the sample is below 200, this appears to be a substantial effect. Thus, it seems that the supply of primary schools is on average relatively inelastic and that large shifts in student numbers are necessary before schools are closed.

In terms of the control variables for regional characteristics (column 3), neither GDP per capita nor the share of services or the share of highly-skilled employees are significant. Interestingly, both lower unemployment rates and higher tax revenue per capita are associated with fewer primary schools per student. This result suggests that beneficial economic conditions are associated with fewer rather than more primary schools per student. Thus, we find no evidence that economically lagging regions provide less primary schooling. In line with the empirical literature on demographic structure and school provision (e.g. Billger, 2010; Poterba, 1997; Ohtake & Sano, 2010), the share of elderly population as well as the share of non-German citizens are negatively significant. Holding the number of students constant, an increase in the share of population above 65 years by 1 percentage point is associated with a 2.9% fall in the number of primary schools. This substantial effect could indicate the existence of intergenerational competition for public services.

3.4.2 Role of regional characteristics

The baseline calculations of the previous section showed that primary school numbers do adjust based on demand but that the supply is not very elastic. We now turn to estimating whether regional characteristics may explain differences in elasticity between districts. The results for the interaction model are presented in Table 3.2.

First, the role of economic conditions in mediating the elasticity of school supply is tested (columns 1-3). The interaction term between student numbers and GDP per capita is significantly negative at a confidence level of 10% (p-value 0.068). The coefficient on the interaction with tax revenue per capita is also significantly negative, whereas the interaction with unemployment is significantly positive. Thus, school supply in regions with lower GDP or tax revenue per capita as well as higher unemployment are on average more responsive to changes in demand. These findings are in line with the notion that a more beneficial economic situation may allow districts to maintain primary schools even in the face of decreasing demand.

Geographical factors are examined in columns 4 to 6. As expected from the patterns

Table 3.2: Interaction results

dep. var.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ln schools	Economic Conditions			Geography			Demographic Structure			
ln students	0.466***	0.226***	0.561***	0.106***	0.318***	0.065	0.290***	0.324***	0.196***	0.264***
	(0.0848)	(0.0299)	(0.0933)	(0.0358)	(0.0191)	(0.0405)	(0.0368)	(0.0207)	(0.0376)	(0.0257)
ln student*GDP	-0.054*									
	(0.0292)									
ln students*unem.		0.005***								
		(0.0014)								
ln student*tax			-0.046***							
			(0.0164)							
ln student*east				0.241***						
				(0.0375)						
ln student*urban					-0.025					
					(0.0305)					
ln student*easturban						0.248***				
						(0.0533)				
ln student*eastrural						0.294***				
						(0.0442)				
ln student*westurban						0.091**				
						(0.0444)				
ln student*elderly							0.001			
							(0.0018)			
ln student*foreign								-0.004		
								(0.0045)		
ln student*shrinking									0.135***	
									(0.0340)	
ln student*%Δpop										-0.006***
										(0.0020)
ln GDP p.c.	0.509*	0.030	0.025	0.006	0.032	0.009	0.032	0.030	0.022	0.030
	(0.2619)	(0.0384)	(0.0392)	(0.0393)	(0.0384)	(0.0384)	(0.0383)	(0.0392)	(0.0396)	(0.0384)
unemployment	0.004***	-0.040***	0.004***	0.004***	0.003**	0.005***	0.003**	0.003**	0.003*	0.004**
	(0.0014)	(0.0128)	(0.0014)	(0.0014)	(0.0015)	(0.0014)	(0.0015)	(0.0015)	(0.0015)	(0.0015)
services	-0.001	-0.000	-0.001	-0.001	-0.000	-0.001	-0.000	-0.000	-0.001	-0.000
	(0.0007)	(0.0008)	(0.0008)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
ln tax p.c.	-0.052***	-0.050***	0.355**	-0.012	-0.048***	-0.014	-0.048***	-0.047***	-0.048***	-0.046***
	(0.0151)	(0.0150)	(0.1447)	(0.0146)	(0.0157)	(0.0146)	(0.0160)	(0.0160)	(0.0149)	(0.0153)
high-skilled	0.003*	0.004**	0.004**	0.004**	0.003	0.005***	0.003	0.003	0.004*	0.004**
	(0.0020)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0018)	(0.0020)	(0.0019)	(0.0019)	(0.0019)
elderly	-0.028***	-0.028***	-0.029***	-0.023***	-0.028***	-0.023***	-0.039**	-0.028***	-0.027***	-0.026***
	(0.0035)	(0.0035)	(0.0035)	(0.0033)	(0.0034)	(0.0032)	(0.0164)	(0.0034)	(0.0034)	(0.0033)
foreign	-0.010***	-0.009***	-0.009***	-0.006*	-0.009**	-0.007**	-0.009**	0.029	-0.009***	-0.009**
	(0.0035)	(0.0034)	(0.0034)	(0.0031)	(0.0035)	(0.0035)	(0.0035)	(0.0431)	(0.0036)	(0.0035)
constant	0.303	2.406***	-0.514	2.887***	1.728***	2.754***	1.857***	1.540***	2.171***	2.035***
	(0.7617)	(0.3484)	(0.8211)	(0.3580)	(0.2876)	(0.3528)	(0.3772)	(0.2715)	(0.3422)	(0.3243)
Observations	4,820	4,820	4,820	4,820	4,820	4,820	4,820	4,820	4,820	4,820
R-squared	0.633	0.636	0.634	0.648	0.631	0.651	0.631	0.631	0.642	0.639
No. of region	322	322	322	322	322	322	322	322	322	322
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

in Figure 3.2 and in line with the results presented by Kempkes (2009), there is a significant difference in elasticity between districts in the East and West of Germany. A 1% decrease in student enrolment is associated with a 0.241 percentage point larger decrease in primary schools in the East than in the West. In contrast, there is no significant difference in elasticity between urban and rural regions (column 5). Testing for combined differences between urban and rural regions in East versus West Germany, the stronger elasticity in East Germany clearly holds for both settlement types. However, column 6 also shows that the elasticity of primary school supply to demand is actually higher in urban than in rural areas in West Germany. The difference between urban and rural areas in East Germany is insignificant.

Columns 7 to 10 show the results of including interaction terms with demographic factors. Neither the share of elderly population nor the share of non-German citizens are significant. In contrast to US literature on demographic influences on schooling (e.g. Billger, 2010; Poterba, 1997) we therefore find no evidence that regions with more elderly or foreign population may reduce school supply more strongly. Column 9 illustrates that primary school supply is more elastic in regions that were experiencing population shrinkage between 1996 and 2010. A 1% decrease in student enrolment is associated with a 0.135 percentage point higher effect on school numbers in a shrinking region than in a growing one. This result also holds in column 10: higher population growth between 1996 and 2010 is, on average, associated with a lower responsiveness of primary school supply to changes in demand. Thus, while intergenerational competition and cultural diversity do not explain differences in school adjustments, population development is relevant. The result that primary school supply is more elastic in shrinking regions and decreases with population growth implies that rigidities may be less severe than assumed.

The regional economic, geographic and demographic characteristics may also be interrelated. The disparities between East and West are of course also reflected in economic differences, which is why these two dimension may need to be considered jointly. Regressions using triple interactions between economic conditions and the East dummy are presented in Table 3.3. For the economic conditions, the interactions identified above hold and are larger in absolute value in East Germany than in the West. For instance, higher tax revenue per capita is associated with a lower elasticity of primary school supply with respect to demand in both East and West. However, an increase in tax revenue is associated with a larger reduction in elasticity for regions in the East than in the West. Thus, the effect of economic conditions on primary school supply seems to be stronger in East Germany.

Column 4 tests for differences across shrinking and growing regions in East and West Germany using growing West German regions as base category. The primary school supply in both East and West is more responsive in shrinking than in growing regions. Additionally, even in growing regions in the East primary school supply is estimated to be more elastic than in shrinking regions in the West. As in Table 3.2, the interaction between population change and student numbers is significantly negative, indicating that larger population growth decreases the responsiveness of primary school supply to changes in demand. However, the triple interaction with the East dummy is significantly positive. Therefore, the effect of population growth in decreasing elasticity of supply is stronger in the West than in the East. These more complex interactions show consistently that East German regions are more likely to adjust primary school numbers to changes in demand and that mediating effects of other regional characteristics serve to further increase the responsiveness in comparison to the West.

3.4.3 Robustness check

A relevant concern regarding the validity of the estimation technique is the endogeneity of student numbers. If the supply of primary schools in a district also affects the number of students, the two variables are simultaneously determined. In this case, the number of students in equation (3.1) is correlated with the error term and yields biased estimates (Wooldridge, 2008). Reverse causality could be caused by selective migration: families with school-aged children might leave districts with low or decreasing school supply thus reducing student numbers. This is in line with the notion that school closures reduce social cohesion and vitality of communities (e.g. Witten et al., 2001) but also reflected for example in studies showing that property values reflect school quality (e.g. Gibbons & Machin, 2003; Gibbons, Machin, & Silva, 2013). In principle, school provision could also affect fertility rates, if people in districts with better school provision choose to have more children or parents-to-be sort into such districts. However, it seems unlikely that school closures or openings could affect fertility behaviour in the short and medium term. Of these two potential channels, fertility differences are likely to have smaller effects and act less immediately, which is why we focus on families' migration decisions here.

Figure 3.4 presents simple cross-sectional scatter plots of migration of population under 18 years (as a measure of family migration) and primary school indicators. In line with the notion that people might move in response to school supply, net migration across the entire sample period (1996-2010) is positively associated with the change in the number of primary schools (Figure 3.4a). However, when considering the average number of primary schools per 1000 students (Figure 3.4b), the relationship becomes negative: districts with higher average school supply record lower net migration rates. While larger relative school supply is associated with lower out-migration (Figure 3.4c), it is also associated with lower in-migration (Figure 3.4d), which contradicts the notion that people move towards districts with higher school supply. However, it is not clear whether districts with more schools per student are truly an indicator of superior supply of primary schooling because more schools per student could also indicate excess supply and a larger risk of future school closure. This cursory analysis illustrates that the relationship between migration patterns and school supply is complex.

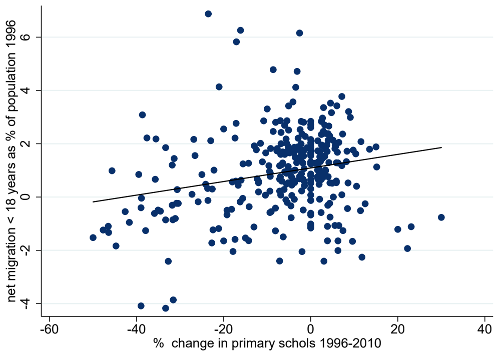
However, while reverse causality between school supply and demand is theoretically plausible, the issue might not be detrimental in this analysis for two reasons. First,

Table 3.3: Extended interaction results with East

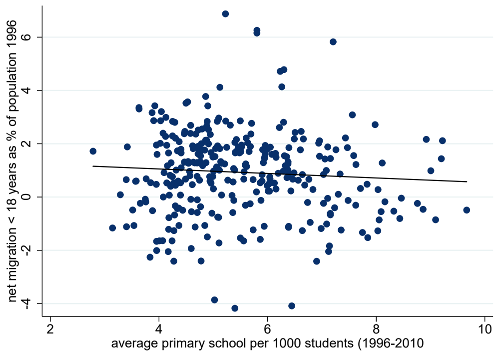
	(1)	(2)	(3)	(4)	(5)
	ln schools	ln schools	ln schools	ln schools	ln schools
ln students	0.343***	0.108***	0.372***	0.006	0.076**
	(0.0914)	(0.0395)	(0.1041)	(0.0471)	(0.0385)
ln student*east	0.205***	0.161***	0.233***		0.251***
	(0.0364)	(0.0411)	(0.0370)		(0.0421)
ln student*ln GDP	-0.047*				
	(0.0277)				
ln student*ln GDP*east	-0.036***				
	(0.0072)				
ln student*unem		0.004***			
		(0.0014)			
ln student*unem*east		0.001***			
		(0.0002)			
ln student*ln tax			-0.033**		
			(0.0158)		
ln student*ln tax*east			-0.017***		
			(0.0028)		
ln student*east shrinking				0.350***	
				(0.0478)	
1n student*west shrinking				0.144***	
				(0.0418)	
ln student*east growing				0.262***	
				(0.0611)	
ln student*%Δ pop					-0.014***
					(0.0043)
ln student*%Δ pop*east					0.012**
					(0.0048)
ln GDP p.c.	0.509**	0.003	-0.009	-0.001	0.007
	(0.2544)	(0.0384)	(0.0389)	(0.0398)	(0.0391)
unemployment	0.003*	-0.032**	0.003*	0.004***	0.004***
	(0.0015)	(0.0131)	(0.0014)	(0.0015)	(0.0014)
services	-0.000	-0.001	-0.001	-0.001	-0.001
	(0.0008)	(0.0007)	(0.0008)	(0.0007)	(0.0007)
ln tax p.c.	0.013	-0.013	0.354**	-0.014	-0.015
	(0.0157)	(0.0142)	(0.1434)	(0.0144)	(0.0143)
high-skilled	0.002	0.004**	0.003	0.005**	0.005**
	(0.0019)	(0.0019)	(0.0018)	(0.0018)	(0.0018)
elderly	-0.017***	-0.022***	-0.017***	-0.022***	-0.022***
	(0.0035)	(0.0033)	(0.0037)	(0.0032)	(0.0032)
foreign	-0.006*	-0.007**	-0.005*	-0.007**	-0.007**
	(0.0029)	(0.0032)	(0.0029)	(0.0033)	(0.0033)
Constant	0.498	2.996***	0.192	3.273***	3.298***
	(0.8203)	(0.3929)	(0.9397)	(0.3986)	(0.4052)
Observations	4,820	4,820	4,820	4,820	4,820
R-squared	0.665	0.653	0.666	0.656	0.655
Number of region	322	322	322	322	322
Year FE	yes	yes	yes	yes	yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

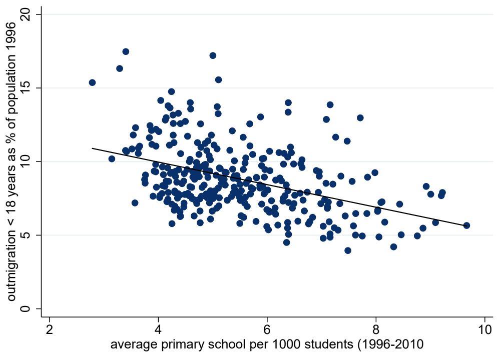
Figure 3.4: Migration of population under 18 years and primary school provision



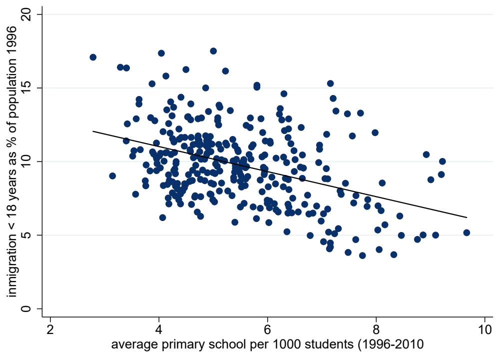
(a) Net migration and %Δ in primary schools



(b) Net migration and schools per student



(c) Outmigration and schools per student



(d) Inmigration and schools per student

Note: Districts acting as border transit zones (Grenzdurchgangslager) excluded: Göttingen, Unna, Plön, Osnabrück, Freudenstadt, Rastatt, Ostprignitz-Ruppin, Dortmund.

despite popular assertions that primary schools are crucial for local communities, the evidence on school closures causing outmigration is weak. Barakat (2015) analyses municipalities in the German Federal State Saxony and concludes that closing a municipality's last primary school has negligible effects on outmigration. Hyll and Schneider (2011) find that, in Saxony-Anhalt, closing the last primary school in a municipality leads to reductions in both immigration and outmigration with no effect on net migration. A case-study of rural communities in Scotland similarly suggests that primary school supply does not affect a communities' attractiveness as much as expected and that other factors (such as employment and affordable housing) are more relevant (Slee & Miller, 2015). Thus, although the contribution of primary schools to the liveability and vibrancy of local communities is widely emphasised by planners and affected municipalities, the empirical evidence does not support the hypothesis of school closures driving outmigration.

Second, as described in the previous section, German districts, which represent the unit of analysis for this study, are relatively large. Since the empirical studies on two German Federal States of Saxony (Barakat, 2015) and Saxony-Anhalt (Hyll & Schneider, 2011) did not find strong evidence for the link between school closures on migration for a municipal level, we would not expect a strong link to exist on a higher level of aggregation (i.e. district-level). In the entire sample, the minimum number of primary schools per district is 11 indicating that primary schooling should remain reasonably accessible (although travel distances may increase). Since migration is costly and moving is likely to increase travel distances to other relevant locations (e.g. the workplace), the incidence of migration across districts in response to primary school closures is likely small.

Nevertheless, as a robustness test of the baseline elasticity results, a supplementary analysis was undertaken by means of an instrumental variable approach. An adequate instrumental variable (IV) for the number of students needs to be correlated with the variable of interest (instrument relevance condition) while not itself explaining variation in the number of primary schools (exogeneity condition). In order to disentangle the number of students per district from migratory patterns, a possible identification strategy uses the variation in the number of children born rather than the number of students, which is in part determined by migration. Thus, the identification strategy relies on instrumenting the number of students by a lagged value of how many "potential students" were born in the district.

There are two challenges in this approach. First, district-level data only starts in 1995 and children start primary school when they are 6 years old. In order to construct a measure of children born a lag of 6 years is required. Thus, the data from 1995 allows construction of an IV for the year 2001 onwards but not before. Second, using the number of births directly is likely to violate the exogeneity condition because a district's school supply is affected by the projected number of students, which may take into account the number of births[6]. In contrast, the share of potential parents

[6]Note that the legal minimum size requirements at Federal State level (Appendix 3.A.1) refer to current

per district, while closely related to the number of births, should only affect primary school provision through its effect on the number of students. Thus, we use the share of population of child-bearing age, here defined as the age group 20-44 years, as an instrumental variable.

Table 3.4: Robustness check instrumental variable results

	(1) OLS	(2) First	(3) IV
ln students	0.144**		0.157**
	(0.0610)		(0.0685)
share potential parents		0.072***	
		(0.0086)	
ln GDP p.c.	-0.007	-0.164***	-0.002
	(0.0517)	(0.0623)	(0.0502)
unemployment	0.004**	-0.017***	0.004*
	(0.0018)	(0.0018)	(0.0020)
services	-0.000	-0.001	-0.000
	(0.0010)	(0.0012)	(0.0009)
ln tax p.c.	-0.002	0.134***	-0.005
	(0.0194)	(0.0244)	(0.0198)
high-skilled	0.007***	-0.003	0.006***
	(0.0023)	(0.0027)	(0.0023)
elderly	-0.018***	0.052***	-0.019***
	(0.0041)	(0.0048)	(0.0045)
foreign	-0.008	0.011*	-0.008
	(0.0048)	(0.0064)	(0.0048)
Constant	2.842***		
	(0.5820)		
Observations	3,220	3,220	3,220
R-squared	0.217		0.217
Number of region	322	322	322
Year FE	yes	yes	yes
First stage F-stat		70.27	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.4 compares the results for the baseline fixed effects panel specifications with the instrumental variable versions. Due to the 6 year lag of the instrument, the estimations in Table 3.4 are only for the time period 2001-2010. In this shorter time series, the baseline estimated elasticity of primary school supply with respect to student enrolment is estimated as 0.144. The instrumental variable, the share of potential parents lagged by six years is positively and highly significantly related to the number of students per district. The first stage F-statistic is 70.27 thus further illustrating instrument relevance. Estimating the regression via instrumental variable analysis yields estimates that are very close to the OLS estimate. For the time period 2001-2010, the estimated elasticity via IV is 0.157 versus 0.144 when using the baseline fixed effects estimation from above. The remaining coefficients are also comparable across estimations.

students only.

Based on this shorter time period, the IV estimations seem to confirm the previous results and show that endogeneity may not be a severe problem. Clearly, it would be preferable to use the instrument on the full time series of 1996 to 2010 but this is prevented by data availability. Moreover, testing the role of regional characteristics in mediating school supply elasticity as in Table 3.2 would require instrumenting the interaction terms as well. Finding instruments for each of the interactions is beyond the scope of this chapter but represents a relevant future extension to this analysis.

3.5 Discussion and conclusion

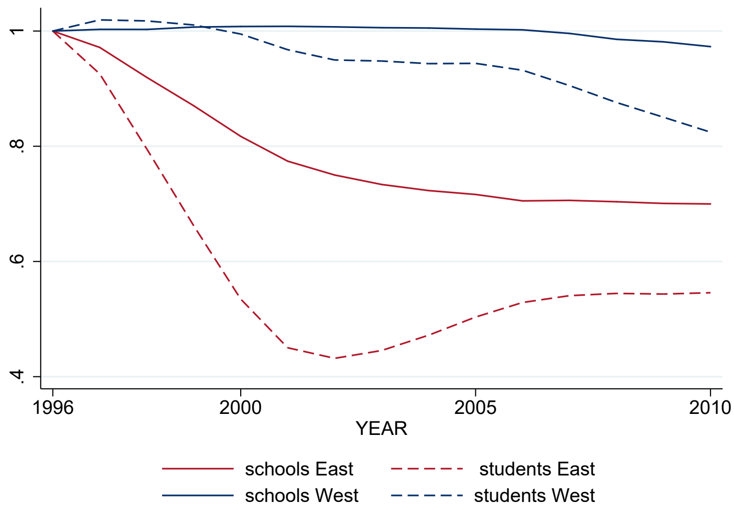
The aim of this chapter was to estimate the responsiveness of regional level primary school supply to the changing demographic composition of the population in contexts of national level population ageing and shrinkage. Using a panel dataset of 322 German districts for the time period 1996-2010, we estimated the elasticity of primary school supply with respect to changes in demand and investigated the role of regional characteristics in mediating this elasticity. The results suggest that a 1% decrease in student enrolment is on average associated with a 0.312% change in the number of primary schools. This result is just slightly lower than a rough national-level estimate as well as the results presented by Bartl (2014, 2015) for Saxony Anhalt. However, across regions, the elasticity of supply differs with economic, geographic and demographic factors.

More beneficial economic indicators (i.e. higher GDP and tax revenue per capita, lower unemployment) are associated with less elastic primary school supply. This result supports the narrative that regions facing adverse economic situations may need to adjust public service provision because they cannot afford maintaining underused services. In this sense, regions facing economic as well as demographic challenges simultaneously may need to take more extreme measures than regions with economically beneficial conditions.

From a perspective of broader demographic trends, regions that are growing in population are less likely to adjust primary school supply than those that are shrinking. Considering that population shrinkage may itself strain municipal finances (Geys et al., 2007; Lais & Penker, 2012), this finding illustrates that cost efficiency of school supply may be relatively more important in regions facing population decline. It may also reflect, however, awareness for the future extent of demographic change. In particular, although some regions may have experienced population growth and perhaps even increasing student numbers, demographic projections clearly indicate that population will start decreasing at some point in the next 20 years. It could be argued that even regions currently experiencing population growth, e.g. due to the peak in international migration in the context of the 2015 European Refugee Crisis (Destatis, 2016a), will (and ought) not invest in opening new schools in the face of long-term projections of population shrinkage.

The results do not suggest general differences in elasticity of primary school provision

Figure 3.5: Primary schools and students in East and West Germany (normalised)



in rural versus urban areas. Although school closures in rural areas may increase travel time for students more than in urban areas, schools seem to be closed at similar rates. One caveat of the analysis here is that the geographical unit of districts (NUTS 3) may be too large to pick up systematic urban and rural differences because districts often include both urban and rural municipalities. Data availability currently does not allow testing school provision at a municipal level but future research into the relationship between travel distances and school closures could help illustrate the network effects of education access.

The supply of primary schools is significantly more elastic for districts in the East of Germany than in the West. This result is in line with Kempke's (2009) finding of larger elasticity of primary school expenditure for East German Federal States indicating that primary school count may be an adequate approximation for unavailable expenditure data. A 1% change in the number of students is estimated to lead a 0.293 percentage point larger adjustment in the East of Germany than in the West.

The relatively large difference compared to the overall elasticity estimates may be due to the timing and severity of demographic changes as visible in the decomposition by East and West in Figure 3.5. Student numbers in West Germany increased initially and began falling in 2000. Similarly, school numbers only fell below the level of 1996 in 2007. In contrast, East Germany recorded a dramatic fall in student numbers until 2002 with numbers recovering slightly and stabilising at around 50% of the 1996 value. Along with the fall in students, East German school supply was reduced substantially from 1996 onwards.

Clearly, and as described in Chapter 2, due to low fertility and high rates of outmigration following re-unification, East Germany has been experiencing the consequences of a shrinking and ageing population before the trends of demographic change began affecting the rest of the country. The scale and persistence of the experienced falls in demand may therefore explain why relatively more schools were closed in the East of

Germany. Moreover, East Germany experienced not only demographic changes but also fundamental economic restructuring. Due to the general conditions of reorganisation and change following reunification, it could be argued that the institutional framework was better suited to foster policies of adapting to demographic change. The relatively more pragmatic attitude towards dealing with demographic change is reflected for example in large scale redevelopment policies aimed at downsizing and adapting existing infrastructure and housing, such as the project Stadtumbau Ost ("City redevelopment East") (Wiechmann & Pallagst, 2012). Thus, the extent of the demographic changes, the relatively dire economic situation when compared to the West and the institutional setting of fundamental changes may jointly create circumstances where policy can (and may have to) adjust public service provision more flexibly to changes in demand.

A few limitations of the analysis should be noted. First, as discussed above, the estimation may suffer from endogeneity issues. Although an exploratory robustness check using an instrumental variable supports the OLS results, instruments for the interaction results and the entire time period would further strengthen the findings. Second, the exclusion of the Federal State of Saarland, while ensuring representativeness of the estimates, implies that inherently interesting outliers were not analysed. In particular, Saarland is one of the few Federal States in the West of Germany that experienced population decline and falls in the number of students on a comparable level to East Germany. The strong population decline and the introduction of a legal minimum school size in 2005 make Saarland an interesting case of analysis that warrants investigation in future research. Third, although responsiveness of primary school supply may affect regional disparities, the conclusions to be drawn from the present analysis are limited by the fact that we can only investigate change in the number of schools. Alternative indicators such as per capita education spending, indicators of teaching quality, or measures of accessibility (such as average distance to the nearest school) on a district level would be necessary to further evaluate the consequences of demographic change for regional primary school provision.

Nevertheless, the presented results suggest that regional primary school supply in Germany responds to distinct demographic patterns less rigidly than could be assumed. Regions that face more severe demographic shifts (i.e. shrinking regions and districts in the East of Germany) exhibit, on average, more rather than less elastic primary school supply. While this is good from a standpoint of efficient school provision, the consequences for living standards in these regions depend on whether adequate accessibility and quality of education can be maintained in the face of school closures. However, from residents' and parents' perspectives, any reduction in primary school supply (whether economically efficient or not) may represent a deterioration in living conditions. This dilemma illustrates the difficulty of adjusting a communities' essential public services and shows that policy makers will need innovative measures to address the challenges of demographic change. In a context of long-term population decline and continuous shifts in age composition brought on by demographic change, regions are going to increasingly face these issues and cannot hope for trend reversals in demographic structure to restore sufficient demand for public services. Instead, regions may need to rely on technology or cooperative and community-led initiatives to ensure adequate education provision. Whether demographic change undermines the principle of equal living conditions remains to be seen and crucially depends on how these adjustments are made.

3.A Appendix

3.A.1 Minimum sizes for primary schools

Table 3.A.1: Legal minimum sizes for primary schools by Federal State

Federal State	students	classes	Details	Exceptions
Baden-Württemberg[1]	-	-	minimum size for secondary schools but not primary	
Bavaria[2]	-	1	minimum 1 class per year or 1 class per 2 years	
Berlin[3]	-	2		to be approved by local school board
Brandenburg[4]	-	1		if there are at least 3 classes in the school
Bremen[5]	-	-	minimum size determined by municipality	
Hamburg[6]	-	2	closed if minimum not met for 2 consecutive years	to ensure equal provision and access
Hesse[7]	-	-	no minima mentioned for primary schools	
Lower Saxony[8]	-	1		if closure would substantially increase travel time
Mecklenburg-Vorpommern[9]	42	1		to be granted by education authority (oberste Schulbehörde)
North Rhine-Westphalia[10]	92 (46)	2	46 if the only primary school in municipality, otherwise 92	
Rhineland-Palatinate[11]		1		in special circumstances or if minimum is not met temporarily
Saarland[12]	80	-	closed if minimum not met for 2 consecutive years.	for pedagogical, organisational, or economic reasons
Saxony[13]		1	minimum 15 students for first class when opening, 14 after.	for pedagogic reasons, to protect Sorbian minortiy, due to features of school building, if travel times become unacceptable
Saxony-Anhalt[14]	60	1	min. 15 students per year and 20 in densely populated areas	to grant better accessibility
Schleswig-Holstein[15]	80	-	schools can maintain subsidiaries with min. 44 students	for islands and when approved by ministry of education
Thuringia[16]	-	-	no requirements published	

[1] §30 Schulgesetz für Baden-Württemberg vom 1.8.1983 (GBl.Baden-Württemberg 1983,15, S. 397 ff.), zul. geänd. durch Gesetz vom 9.5.2017 (GBl. Baden-Württemberg 2017,10, S.251);
[2] Art. 32 Bayerisches Gesetz über das Erziehungs- und Unterrichtswesen vom 31.5.2000 (GVBl. Bayern 2000,17, S. 414 ff., berichtigt in GVBl. Bayern 2000,20, S. 632), zul. geänd. durch Gesetz vom 12.07.2017 (GVBl. Bayern 2017,12, S. 362 f.)
[3] §17 Abs.5 Schulgesetz für das Land Berlin vom 26.1.2004 (GVBl. Berlin 60.2004,4, S. 26 ff.), zul. geänd. durch Gesetz vom 7.7.2016 (GVBl. Berlin 72.2016,19, S. 430 ff.)
[4] §103 Gesetz über Schulen im Land Brandenburg vom 2.8.2002 (GVBl. I Brandenburg 13.2002,8, S. 78ff.), zul. geänd. durch Gesetz vom 1.7.2017 (GVBl. I Brandenburg 28.2017,16, S. 1ff.)
[5] §6 Bremisches Schulverwaltungsgesetz vom 28.6.2005 (GBl. Bremen 2005,31, S. 280 ff., berichtigt in GBl. Bremen 2005,38, S. 388 f., zul. ber. in GBl. 2005,39, S. 399), zul. geänd. durch Gesetz vom 2.8.2016 (GBl. Bremen 2016, S. 434)
[6] §87 Hamburgisches Schulgesetz vom 16.4.1997 (GVBl. I Hamburg 1997,16, S. 97 ff.),zul. geänd. durch Gesetz vom 15.9.2016 (GVBl. I Hamburg 2016,38, S. 441 ff.)
[7] Hessisches Schulgesetz vom 30.6.2017 (GVBl. I Hessen 2017,153, S. 150 ff.)
[8] §4 Verordnung für die Schulorganisation (SchOrgVO) vom 17. Februar 2011 (Nds.GVBl. Nr.5/2011 S.62; SVBl. 4/2011 S.106), geändert durch Art. 4 des Gesetzes vom 16.3.2011 (Nds.GVBl. Nr.7/2011 S.83) und Art.2 des Gesetzes v. 19.6.2013 (Nds.GVBl. Nr.10/2013 S.165; SVBl. 8/2013 S.297)
[9] §45a Schulgesetz für das Land Mecklenburg-Vorpommern vom 10.9.2010 (GVBl. Mecklenburg-Vorpommern 2010,17, S. 462 ff., ber. in GVBl. 2011,14, S. 859, ber. in GVBl. 2012,19, S. 524), zul. geänd. durch Gesetz vom 20.4.2017 (GVBl. 2017,4, S. 66)
[10] §82 Schulgesetz für das Land Nordrhein-Westfalen vom 15.2.2005 (GVBl. Nordrhein-Westfalen 59.2005,8, S, 102 ff.), zul. geänd. durch Gesetz vom 6.12.2016 (GVBl. Nordrhein-Westfalen 70.2016,40, S. 1052 ff.)
[11] §13 Schulgesetz Rheinland-Pfalz vom 30.3.2004 (GVBl. Rheinland-Pfalz 2004,8, S. 239 ff.), zul. geänd. durch Gesetz vom 16.02.2016 (GVBl. Rheinland-Pfalz 2016,3, S. 37 ff.)
[12] §9 Abs 2 Gesetz zur Ordnung des Schulwesens im Saarland Gesetz Nr. 812 zur Ordnung des Schulwesens im Saarland vom 21.8.1996 (ABl. Saarland 1996,37, S. 846 ff., berichtigt in ABl. Saarland 1997,9, S. 147), zul. geänd. durch Gesetz vom 20.1.2016 (ABl. I Saarland 2016,6, S. 120)
[13] §4a Sächsisches Schulgesetz vom 16. Juli 2004 (SächsGVBl. S. 298), zul. geänd. durch Gesetz vom 26.04.2017 (GVBl. Sachsen 2017,6, S. 242 ff.)
[14] Verordnung zur Schulentwicklungsplnaung 2014 aufgrund 22 Abs 6 und 82 Abs 2 des Schulgesetzes des Landes Sachsen-Anhalt vom 22.2.2013 (GVBl. Sachsen-Anhalt 24.2013,5, S. 68 ff.), zul. geänd. durch Gesetz vom 25.2.2016 (GVBl. Sachsen-Anhalt 27.2016,7, S. 89 ff.)
[15] Landesverordnung über die Bestimmung der Mindestgröße von öffentlichen allgemein bildenden Schulen und Förder-zentren nach 52 Schleswig-Holsteinisches Schulgesetz vom 24.1.2007 (GVBl. Schleswig-Holstein 2007,3, S. 39 ff.; ber. in GVBl. 2007,11, S. 276), zul. geänd. durch Gesetz vom 14.12.2016 (GVBl. Schleswig-Holstein 2016,21, S. 999 ff.)
[16] Thüringer Schulgesetzes vom 30.4.2003 (GVBl. Thüringen 2003,7, S. 238 ff.),zul. geänd. durch Gesetz vom 31.11.2013 (GVBl. Thüringen 2013,1, S. 22 ff.)

3.A.2 Variable descriptions and summary statistics

Table 3.A.2: Variable descriptions

Indicator		Source
ln schools	ln of primary school number	RDG
ln student	ln of student enrolment in primary schools	RDG
ln GDP p.c.	ln of GDP per capita	RDG
ln tax p.c.	ln of tax revenue per capita	INKAR
unemployment	unemployment rate	RDG
services	share of services in total value added	RDG
high-skilled	share of employed with tertiary education	SIAB7510
elderly share	proportion of population above 65 years	RDG
foreign	share of population with non-German citizenship	RDG
urban	dummy for settlement type with 1=urban, 0 = rural	BBSR
east	dummy for regions of former GDR excluding Berlin	
shrinking	dummy for regions decreasing in population 1996-2010	
% Δpop	percentage change in population between 1996 and 2010	RDG

Data Sources	
RDG	Regional Database Germany
SIAB7510	Regional File of the Sample of Integrated Labour Market Biographies 1975-2010
INKAR	Indicators and Maps for Spatial and Urban Development (BBSR, 2016)

Table 3.A.3: Summary statistics

variable	obs	mean	std. dev.	min	max
schools	4,830	51.26087	35.331	11	505
students	4,830	9826.057	8392.004	1866	146172
GDP p.c.	4,830	24.83473	9.88162	10.75161	83.51962
tax revenue	4,822	508.3349	188.3293	123.3	1973.4
unemployment	4,828	10.40584	4.744129	1.9	27.7
services	4,830	66.07021	10.09692	27.98073	94.6322
high-skilled	4,830	9.338283	4.280237	1.821192	31.22003
elderly	4,830	18.19451	2.632657	11.26126	27.13732
foreign	4,830	7.666213	4.759265	.6256323	26.28347
urban	4,830	.5621118	.4961785	0	1
east	4,830	.1832298	.3868949	0	1
shrinking	4,830	.4565217	.4981576	0	1
% Δpop	4,830	-.1043797	7.44106	-21.50957	18.96314

Chapter 4

Demographic Change and Regional Human Capital

4.1 Introduction

Human capital investment is considered to be fundamental in coping with the challenges of demographic change in industrialised countries. With progressing demographic change, the European working-age population is projected to decrease by an average of 0.3% per year until 2060 (European Commission, 2015, p. 43) as well as change in composition. To compensate for a relatively smaller working-age population, ageing countries will require productivity increases in order to maintain long-term economic growth. Thus, investment in human capital is central in addressing shifts in the structure of the labour market induced by demographic change. However, if age groups have different levels of human capital, the process of population ageing itself affects the available human capital in the labour market. This is especially relevant at a regional level since labour markets are locally defined and regions differ markedly in their demographic structures. This chapter investigates the relationship between population ageing and regional human capital for the German labour market between 1996 and 2010.

Demographic change affects the structure of the labour market both quantitatively and qualitatively. While population growth and shrinkage influence the size of the labour force, the shifts in population composition drive the restructuring of economies. On the one hand, the size of elderly age groups increases relative to the working-age population, which threatens the sustainability of pay-as-you-go pension systems (e.g. Börsch-Supan et al., 2016; von Weizsäcker, 1990). On the other hand, the ageing process of the working-age population itself implies that current labour market entrants may differ from the retirees that they are replacing.

Indeed, younger cohorts are generally more highly educated than older ones. Changes in the returns as well as access to education have facilitated the education expansion, which has also been linked to global trends of democratization and scientisation

(Schofer & Meyer, 2005). However, on a regional level, the available supply of labour is influenced by the education choices of the local population, the age-composition of the labour force, and also by in-and out-migration (both national and international). Thus, even though the average educational attainment in Germany has been rising steadily (Autorengruppe Bildungsberichterstattung, 2016), regional differences in human capital levels and composition may persist or even increase. Thus, the potential interaction between the processes of demographic change and human capital has consequences for broader notions of regional disparities.

The relevance of human capital as a driver of economic growth is documented in a large range of influential studies especially at the cross-country (Barro, 2001; Mankiw, Romer, & Weil, 1992) but also at the sub-national level (Glaeser, Scheinkman, & Shleifer, 1995; Rauch, 1993; Simon, 1998; Simon & Nardinelli, 1996). Due to its positive effect on labour productivity, human capital also represents a central factor in policy suggestions to cope with an ageing and shrinking labour force (Börsch-Supan, 2003; Crespo Cuaresma, Loichinger, & Vincelette, 2016). However, few studies have so far addressed the interrelations between population ageing and human capital itself, especially at a regional level. The existing relevant literature focuses either on the role of demography in individual-level educational attainment (e.g. country-level cohort studies such as Fertig, Schmidt, and Sinning (2009)) or on describing regional patterns of human capital development, convergence and its consequences (Brunow & Hirte, 2009b, 2009a; Gregory & Patuelli, 2015; Südekum, 2008, 2010). To the author's knowledge, there are no empirical studies investigating how demographic change affects the availability and composition of human capital. Moreover, human capital is usually approximated with broad measures, e.g. the proportion of population with a tertiary education degree. Especially for Germany, where the education system emphasises not only academic tertiary education but also vocational training (Powell & Solga, 2011), conventional measures of "high-skill" labour neglect a large portion of the skill composition.

In the face of progressing demographic change, the aim of this chapter is to analyse the role of population ageing in explaining regional differences in the availability and composition of human capital. The chapter addresses three closely related questions. First, is population ageing associated with regional differences in the availability of human capital? Second, does the human capital composition in strongly ageing regions develop differently than in younger regions? And third, to what degree can the observed changes in human capital be explained by demographic shifts rather than other factors?

These questions are investigated using demographic and educational data on 326 German districts for the period 1996 to 2010. We analyse the availability of human capital using and comparing three different indicators: the share of employees with tertiary education, average years of schooling, and an occupation-based share of complex skills based on Brunow and Blien (2015). The composition of human capital is examined via the relative prevalence of 6 levels of educational attainment for different age groups. To estimate the contribution of demographic changes relative to other trends, we implement a shift-share decomposition of changes in human capital based solely on changes in the demographic structure.

The chapter proceeds as follows. The next section summarises the theoretical background, relevant literature, and describes the German educational system. Section 3 contains the analysis of human capital availability. Section 4 extends these results to consider the composition of human capital. Section 5 presents the shift-share decomposition and analyses its geographical patterns. Section 6 discusses the results jointly and concludes.

4.2 Background

Human capital is widely acknowledged as a central driver of economic growth from theoretical and empirical standpoints (see e.g. Faggian & McCann, 2009). In the context of endogenous growth theories (e.g. Romer, 1990), human capital investment is thought to contribute to technological progress and a larger stock of human capital will thus lead to faster economic growth. The relevance of human capital for growth has been demonstrated empirically in a large number of cross-country studies (e.g. Barro, 2001; Breton, 2013; Mankiw et al., 1992). Faggian and McCann (2009) emphasise that national-level growth models do not directly translate to the regional level, due to the large mobility of factors and the relevance of local characteristics. However, empirical investigations of regional economic growth have confirmed the relevance of human capital for economic growth also at the sub-national level (e.g. Gennaioli, La Porta, Lopez-De-Silanes, & Shleifer, 2013).

Regional-level considerations of human capital need to take into account direction of migration flows, such as from peripheral to agglomerated regions. Indeed, the literature on regional human capital predominantly stresses the role of urban areas as knowledge centres shaped by and continuously attracting highly-skilled individuals (Faggian & McCann, 2009). The urban and regional economics research on human capital especially emphasises the concept of human capital externalities, i.e. that social returns to education exceed private returns for instance due to productivity spillovers (Moretti, 2004). These positive externalities may explain urban wage premia (Glaeser & Maré, 2001; Glaeser & Resseger, 2010; Rauch, 1993) and thus also city growth (Glaeser et al., 1995; Simon & Nardinelli, 1996). Moreover, the empirical evidence also suggests that human capital availability may increase firm formation (Acs & Armington, 2004) and employment growth (e.g. Shapiro, 2006; Simon, 1998).

Thus, both empirical and theoretical literature emphasises the role of human capital in regional development. In a context of demographic change, this relevance is further supported by the economic challenges posed by an ageing and shrinking labour force. For Germany, the low fertility rate (fluctuating around 1.4 since the 1970s) implies that each cohort of children has been $\frac{1}{3}$ smaller than their parent generation (Klingholz, 2016). Therefore, the size of the working-age population decreases and its average age increases over time. This is attenuated by the baby-boom generation (birth cohorts between 1955 and 1969 in Germany), which is significantly larger than following cohorts. The German Federal Statistical Office and Statistical Offices of the Länder (2009, p. 13) estimate that the size of the labour force is predicted to fall in all German Federal States except Hamburg, and on average by 11.6% between 2005 and 2030. Projections show that even with increasing participation rates and considerable net migration a decreasing German labour force potential is unavoidable (J. Fuchs, Söhnlein, & Weber, 2011). Simultaneously, the share of the labour force above 50 years, which represented only 25% in 2005 increased to 29% by 2010 and is projected to increase to at least 34.9% in 2020 (Federal Statistical Office and Statistical Offices of the Länder, 2009, p. 14). It should be noted that this rapid ageing of the labour force is driven by the ageing baby boom generation. When the baby boomers enter retirement, the change in age structure will slow down.

As discussed in Chaper 2, the demographic changes within the working-age population lead to a variety of social and economic challenges (Kaufmann, 2005; Reher, 2011). For instance, a relatively smaller working-age population will need to provide for a larger group of retirees, which strains social security and transfer systems. As a flipside to the demographic dividend of population growth, demographic change can limit economic growth if a decreasing share of the total population is active on the labour market (Bloom, Canning, & Fink, 2010; Tyers & Shi, 2007).

There are also concerns that an older labour force may be inherently less productive than a young one. Studies of innovation behaviour over the life-course suggest an inverse U-shaped relationship between age and innovation (for a review see e.g. Frosch, 2011), scientific output (Jones et al., 2014), and entrepreneurial activity even at a regional level (Bönte et al., 2009). Moreover, Meyer (2008) finds that firms in the ICT-intensive sector are less likely to adopt new technologies if they have a higher share of older workers. For these reasons as well as potentially reduced absorptive capacity for technology among older labour forces (e.g. Morris & Venkatesh, 2000; Prskawetz et al., 2007), demographic change represents a challenge to innovation systems (Wydra, 2010).

To counteract the potential negative effects of demographic change, policies that aim to increase labour market participation or labour productivity may be necessary. Considering the prominent role of human capital as a driver for economic growth described above, investment in human capital is one of the primary policy suggestions to address the effects of demographic change. The following sub-sections conceptualise the relationship between population ageing and human capital and discuss the existing empirical literature.

4.2.1 Demographic change and human capital accumulation

Demographic impacts on human capital accumulation have predominantly been analysed in the context of cohort-size effects on individual educational attainment. For instance, the large baby boom generation has been found to reduce the returns to education via increased competition on the labour market (Connelly, 1986; Welch, 1979). Fertig et al. (2009) apply this logic to the reverse problem of decreasing cohort sizes in Germany born between 1966 and 1986 and find that smaller cohorts are indeed associated with higher educational attainment. Although these individual-level studies provide relevant insights into the relationship between demographics and human capital, they have limited applicability to the question of aggregate availability of human capital, especially on a regional level.

Demographic change will affect the level and type of human capital by changing the size and composition of the working-age population. On the one hand, assuming stable participation rates, smaller young cohorts will not be sufficient to replace the retiring older generations. There are concerns that retirement of large cohorts (e.g. baby boomers), could lead to knowledge loss if not managed effectively (Hipp & Verworn, 2011). The increasing average age of the labour force may also impede updating of human capital because only a small share of new graduates enters the labour force. This emphasises the need for continuous on-the-job and life-long learning to ensure that the human capital stock is continuously renewed. On the other hand, labour market entrants are on average more highly educated than retirees. This is due to the global trend of expansion in secondary and tertiary education (Santiago, Tremblay, Basri, & Arnal, 2008; Schofer & Meyer, 2005).

Potential reasons for this education expansion could be supply-driven societal factors such as the democratisation of access to higher education (Schofer & Meyer, 2005) or changes in the labour demand in the context of skill-biased technological change (see e.g. Katz & Autor, 1999). In this framework, the effect of technical changes on the task content of occupations, as documented by the seminal work of Autor, Levy, and Murnane (2003) on the computerization of routine tasks, causes shifts in the skill distribution of human capital over time. For West Germany, Spitz-Oener (2006) shows that changes in the task content of occupations account for up to 36% of the increase in the share of high-skilled employees between 1979 and 1999. More generally, such changes have been linked to patterns of labour market polarization (Goos, Manning, & Salomons, 2014). Additionally, education expansion has been an explicit policy goal for the European Union in the context of the Lisbon Strategy and Europe 2020, which benchmarks a goal of 40% of 30–34 year-olds having completed tertiary education (European Commission, 2010).

Considering the trend of education expansion for younger cohorts, a theoretical link between human capital and the population age composition can be established: the degree of ageing affects the impact of education expansion on the availability of human capital. We would thus expect that regions with an older labour force have relatively lower levels of human capital, ceteris paribus. In terms of composition, this would suggest that the labour force of regions that are ageing strongly would be relatively more strongly shaped by lower educational attainment than by tertiary education.

4.2.2 Regional human capital, migration, and convergence

The relationship between population ageing and human capital availability is especially relevant on a regional level because demographic and labour market developments differ across space. Differences in interregional and international migration, previous demographic structure, and fertility rates lead to a large degree of variation across regions (Gans, 2006; Swiaczny, 2015; Swiaczny et al., 2008). Moreover, given the relevance of human capital for regional development processes, any potential effect of ageing on human capital availability could have consequences for future economic growth as well as for the degree of regional disparities.

As described above, regional studies of human capital need to account for the higher degree of internal rather than international mobility (Faggian & McCann, 2009). Indeed, when considering the effect of population ageing on human capital, it is important to note that migration may be selective both in terms of the age- and skill-levels of migrants. In general, migration propensity is higher among the young and well-educated (see e.g Borjas, 2015; Bucher & Heins, 2001). Skill-selective migration has been shown to react to both wage premia (Borjas, Bronars, & Trejo, 1992) as well as employment differentials (Arntz, 2010; Arntz, Gregory, & Lehmer, 2014), and the determining factor may differ among age groups, e.g. with young Germans being more sensitive to wages and less sensitive to unemployment rates than older workers (J. Hunt, 2006). In the context of the theoretical prediction outlined above, such skill- and age-selective migration would imply a sorting of individuals across regions, which will simultaneously affect regional age and human capital levels. This chapter does not attempt to isolate migration effects but rather considers migration as a driving factor for regional population ageing: the age composition of internal migration across regions directly affects the average age of the population.

Through its effect on regional age structures and human capital availability, migration is also influential in terms of regional disparities and convergence processes. In particular, in line with the notion of human capital externalities discussed above, highly-skilled human capital tends to concentrate in urban areas (Faggian & McCann, 2009; Glaeser & Maré, 2001). Additionally, highly-skilled workers may cluster specifically in places with high initial human capital, e.g. due to learning externalities (Peri, 2002) or because highly-skilled entrepreneurs hire skilled labour (Berry & Glaeser, 2005). This could lead to patterns of regional divergence in human capital, which has been supported by some empirical studies for the US (e.g. Berry & Glaeser, 2005; Wheeler, 2006). In general, even if the attracting factor for human capital is not initial human capital but rather some other agglomeration force (e.g. Betz, Partridge, & Fallah, 2016), the outcome may nevertheless be an increasing polarisation of human capital between regions. If human capital availability is indeed a crucial factor for regional economic development as suggested by theory and empirics, such divergence and polarisation could lead to a deepening of regional disparities in economic terms.

For Germany, several empirical studies have tested the question of convergence in human capital. Bade and Schönert (1997) present a literature review that largely predates German reunification and emphasises rural-urban as well as North-South differences in the share of employees with higher education. Their own analysis suggests that peripheral West-German regions were converging to urban regions between 1976 and 1996. Similarly, Südekum (2008, 2010) finds that highly-skilled Western regions saw faster employment growth overall, but that high-skilled employment is characterised by convergence. In a broader analysis of human capital, Tarazona (2007, 2010) suggests a human capital index that is also implemented in this chapter, and presents mixed evidence for regional convergence in human capital: convergence among East and West Germany may coincide with divergence within West Germany. In particular, convergence seems to be driven by the reducing human capital levels in East Germany, which is supported also by literature on skill-selective East-West migration for Germany (Brücker & Trübswetter, 2007; Melzer, 2013; Schneider, 2005). Thus, in contrast to the US, the process of education expansion in Germany seems to be accompanied by regional convergence rather than divergence in human capital levels.

This section has outlined the relevance of human capital in economic development, the current and projected demographic changes in Germany as well as why these shifts in the population age structure may affect the availability of human capital. Despite some evidence of a convergence trend in human capital for German regions, the role of demographic change remains unclear. In particular, if population ageing decreases aggregate human capital due to the smaller extent of education expansion in the labour force, and the extent of population ageing is unequally distributed, demographic change could undermine convergence processes in human capital availability or even lead to regional polarisation. Further, due to the role of human capital in regional economic development, disparities in human capital could also affect regional disparities in income more broadly. For instance, Anger and Plünnecke (2010) illustrate that due to the demographic structure and migration patterns in the East of Germany, projected education expansion for universities barely covers the replacement demand for retiring academics, which could affect East-West economic convergence.

The existing empirical literature on regional human capital patterns pays limited attention to the role of demographic structure. Tarazona (2007) calculates a regional age-specific index of human capital for 2001 and concludes that age structure does not explain regional disparities. Brunow and Hirte (2009a) consider the age structure of regionally available human capital and find age-specific differences in productivity but draw this conclusion from a cross-section thus not capturing the process of population ageing. Gregory and Patuelli (2015) present an exploratory spatial data analysis that suggests clustering and polarization between German regions in terms of age structure, share of creative professionals and innovative performance.

This chapter adds to the existing literature by investigating the link between labour force age and human capital on a regional level. We test the hypothesis that a stronger degree of population ageing is associated with lower human capital accumulation and examine consequences for regional disparities.

4.3 Conceptualising human capital

Due to its intangible nature, measurement of human capital is clearly imperfect. Proxies of human capital usually rely on measuring its accumulation, especially in the context of formalised education, which is more directly observable and measurable than more implicit activities such as on-the-job training (e.g. Schultz, 1961). However, even when relying on formal education, it remains unclear how to construct a measure. Two conceptually popular options are to consider the share of population with a specific educational attainment or the mean years of schooling (Lutz, Goujon, & Wils, 2008). However, although these measures are most easily available, formal education may not accurately represent the human capital that is actually employed in the labour market. Instead, task-based measures of human capital as suggested in the literature on skill-based technological change (Autor et al., 2003; Spitz-Oener, 2006) use occupational data to construct measures of human capital.

This section describes the measures of human capital used here. It first gives an overview of the German education system and the levels of educational attainment. It then illustrates different measures applied in this chapter before discussing the data source used.

4.3.1 The German education system

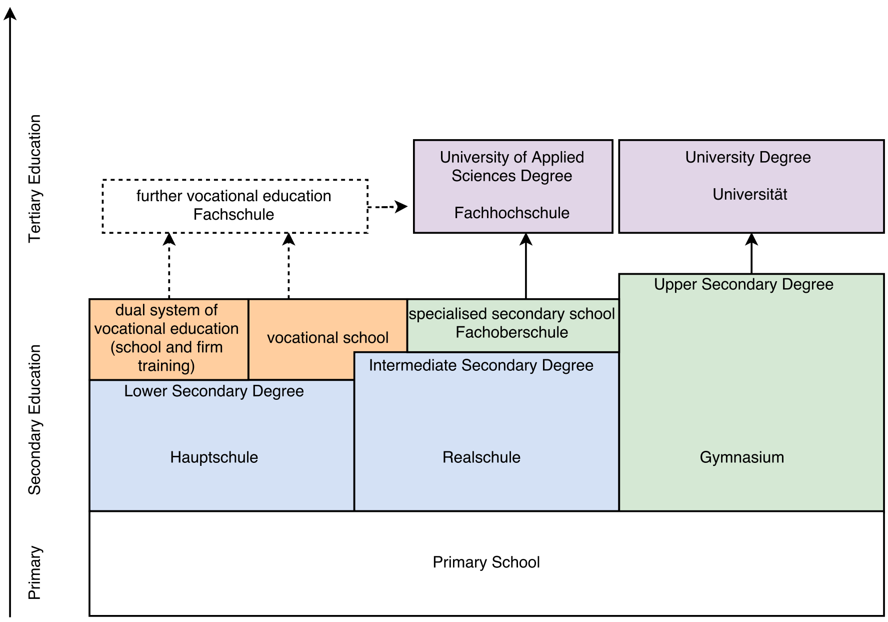
To analyse human capital in the German context, a short overview of the German education system is necessary. Figure 4.1 presents a simplified structure of the current educational system of Germany. After primary school, students enter secondary schools for one of three degree types: lower secondary degree (*Hauptschulabschluss*), intermediate secondary degree (*Realschulabschluss*) and upper secondary degree (*Abitur*). A lower secondary degree takes 5 years after which students may move towards vocational school or enter the dual system of vocational training[1]. An intermediate secondary degree takes 6 years and allows graduates to complete further secondary education, which gives access to tertiary education at a university of applied sciences (*Fachhochschule*) or in specific subjects at universities. The upper secondary degree (8–9 years of secondary schooling) is the only degree that grants direct access to tertiary education at universities. However, in some circumstances, a completed a vocational degree allows further vocational education (e.g. *Fachschule*), which can lead to a qualification that allows pursuing tertiary education.

It is important to note that education policy is a responsibility of the Federal States, which implies that details of the system differ within Germany, although these differences do not affect the comparability of qualifications[2]. Furthermore, although the

[1] The dual system of vocational training does not have any educational prerequisites. Thus, students who do not obtain any secondary degree are still eligible for vocational training.

[2] For a detailed description of the German education system, see the official documentation by the Standing Conference of the Ministers of Education and Cultural Affairs (KMK, 2015).

Figure 4.1: Schematic representation of German education system



current education system is similar to the structure of former West Germany, the German Democratic Republic had a distinct education system (see e.g. Köhler & Stock, 2004; Pritchard, 1999). This is relevant because a substantial share of employees in the observed time frame of 1996–2010 completed their education in the GDR. However, since the data does not allow tracing where individuals completed their education, we rely on the equivalence of vocational and educational qualifications that was set out in §37 of the reunification treaty and do not distinguish between educational degrees from the former East or West of Germany. Nevertheless, the different education systems are influential for the human capital composition in the former East and West of Germany, which is reflected for example in the fact that the share of observations with a university degree are higher in the East.

Vocational training takes on a prominent role in the German education system. *Dual vocational training* implies that students are trained both within a company and at a vocational school (*Berufsschule*). The combination of on-the-job training and both general and specialised vocational education are meant to equip apprentices with specific skills, a vocational qualification and job experience. Powell and Solga (2011) argue that the German prevalence of vocational training (rather than the Anglophone emphasis on higher education) is supported by cultural and normative values associated with the concept of vocation as well as risk aversion since vocational education can be more secure and less costly than tertiary education (because apprentices earn a salary during their training).

As a result, vocational training can be attractive even for students who could otherwise attend university. More than half of any age cohort begins vocational training and of those currently in training in 2012, 24% had previously obtained entrance qualifications for higher education (KMK, 2015, p. 139). The prevalence of vocational education and the segregated nature of the school system limit the size of the higher education sector with only 26% of 25–34 year olds having completed tertiary education compared to an OECD average of 38% in 2012 (OECD, 2012, p. 3). It should be noted here that, in contrast to other countries, university tuition fees play a limited role in the costs of tertiary education in Germany since university has traditionally been free[3]. Even in the period between 2007 and 2014 when universities in some Federal States charged tuition fees, the amounts were low in international comparison (usually €1000 annually) and research on the causal effects of German tuition fees generally does not find significant effects on enrolment behaviour (e.g. Bruckmeier & Wigger, 2014; Helbig, Baier, & Kroth, 2012) with the exception of Hübner (2012).

4.3.2 Educational attainment levels

Based on the outlined structure of the German education system, human capital can be broken down to the shares of six different qualification types (Figure 4.2). These qualification types are reported by employers for all employees covered by social security.

The six degree types are defined based on the highest level of education completed and distinguish between vocational and higher education. The first type (D1) is only primary, lower secondary or intermediate secondary education and no further qualification whereas the second type (D2) has a completed vocational education qualification. Similarly, the third type (D3) refers to only an upper secondary degree and no further qualification while the fourth type (D4) has both an upper secondary degree and a completed vocational degree. The fifth type (D5) refers to a completed degree from a university of applied sciences. The sixth type (D6) is a university degree. Note that the types increase with the implied level of education with the exception of D2 and D3 which cannot be ranked. For D5 and D6, an upper secondary education degree (or equivalent) is not recorded but implied, since it is a requirement for higher education. However, no information on vocational education is available for those with higher education because only the highest level of qualification is recorded.

These six qualification types allow more detailed insight into the composition of human capital than a dichotomy of high- and low-skilled based on tertiary education. However, the information is clearly still relatively broad since no information about the precise type of degree within the categories is available. For instance, completed vocational training can imply a basic apprenticeship but also having obtained qualification as a

[3]Tuition fees were banned by Federal law until 2005. As of 2014, all states that had imposed fees since then have abolished them again. Some Federal States charge fees for long-term students or Master's degrees (up to €650 per semester) and most universities charge a small contribution to administration costs (usually around €50).

Figure 4.2: Six qualification types of German human capital

	Primary/ Lower/ Intermediate Secondary Education	Upper Secondary Education	Completed Vocational Training	Higher education
D1	✓			
D2	✓		✓	
D3	✓	✓		
D4	✓	✓	✓	
D5	✓	or equivalent*	-	University of Applied Sciences
D6	✓	or equivalent*	-	University

*The SIAB7510 dataset does not record secondary school attainment or vocational training for individuals with higher education. Upper secondary or an equivalent degree (*Fachabitur*) is a prerequisite for higher education

master craftsman (*Meisterprüfung*). Similarly, there is also some variation within the education types over time. Before implementing reforms in the context of the Bologna Process in the early 2000s, German university degrees were *Diplom* or *Magister* degrees comprising 4–5 years of university education, which have since mostly been transformed into a system of Bachelor's and Master's degrees. However, since any higher education degree represents a distinct type of education, the specific obtained degree is arguably less relevant. In terms of the human capital composition, the six education types should thus be understood as exemplary and relative categories rather than a representation of skill content.

4.3.3 Data source: SIAB7510 Regional File

The data source used to calculate regional human capital levels is the Sample of Integrated Labour Market Biographies 1975–2010[4] denoted as SIAB7510 (for the full data description see vom Berge et al., 2013). The dataset provides a 2% sample of the administrative social security database with micro-data on gender, age, educational attainment, occupation, employment status as well as region of workplace. The data reflects private sector employees only and does not consider civil servants, the self-employed, and students because these groups do not fall under the compulsory social security cover (*versicherungspflichtige Beschäftigte*).

[4]Data access was granted via a Scientific Use File supplied by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB).

For measures of human capital, the education data was imputed based on the strategy suggested by Fitzenberger, Osikominu, and Völter (2006). The implemented imputation (IP3) only imputes information judged as reliable based on whether the employer frequently revises information and is thus relatively conservative, but it addresses a number of inconsistencies for instance by ensuring that qualification levels can only rise and not fall for an individual over time. The first employment spell per individual and year was then aggregated to the regional level and used to calculate the human capital measures described below.

The education data only consider individuals of at least 30 years. This is due to the fact that the skill composition for individuals in their twenties does not seem to be representatively captured in the SIAB7510 file. Since the dataset is based on those employed, there is selection bias with respect to education in the sample because the observed individuals chose to work instead of continuing education. As a consequence, only a very small share of under 30 year olds in the dataset have attained a university degree (e.g. 2.6% compared to 7.6% for above 30-year olds in 1996). Comparing this age group to the older ones thus introduces bias and is not implemented here. After imputation and excluding observations with missing education and location, the underlying micro data set comprised 7.1 million observations on 800 000 individuals between the ages of 30 and 62[5] for 1996–2010.

The micro data was aggregated by region and year for the district regions identified in the SIAB7510 regional file. For reasons of anonymity, each region needs to have a population of at least 100 000, which is why the SIAB7510 regions combine some smaller districts to a district region, whereas larger districts appear as independent regions. The 332 SIAB regions are thus based on, but do not perfectly correspond to, the 412 administrative districts in Germany.

The proportions of employees by educational attainment, mean age, and gender shares from the aggregated SIAB7510 file were combined with data on regional socio-economic characteristics from the Regional Database Germany (Federal Statistical Office and Statistical Offices of the Länder, 2014) and from INKAR, the database of the Federal Institute for Research on Urban Affairs and Spatial Development (BBSR, 2016). Due to missing data, the final dataset covers 326 regions for the time period 1996–2010. A full list of variable descriptions is presented in Appendix 4.A.2.

4.4 Population ageing and human capital availability

4.4.1 Aggregate measures of human capital

Share of tertiary education According to the literature review above, the share of employees with higher education seems to be the most frequently used measure of

[5]Retirement age in Germany was 65 years in the relevant time period. However, due to data protection reasons, the Scientific Use File of the SIAB7510 censors data for individuals older than 62.

Table 4.4.1: Educational attainment and duration in years (Tarazona, 2010)

Educational attainment	Duration
1: primary, lower/intermediate secondary degree, no vocational training	9
2: primary, lower/intermediate secondary degree, completed vocational training	12
3: upper secondary degree, no vocational training	13
4: upper secondary degree, completed vocational training	15
5: degree of university of applied sciences	17
6: university degree	19

human capital. By design, it captures the most highly-skilled portion of the human capital composition and the one that is most closely reflected in theories of the relevance of human capital for innovation and economic growth. In line with the common definitions in the literature, we consider the share of employees with tertiary education as a measure of highly-skilled human capital in the region. This includes graduates from both universities (D6) and universities of applied science (Fachhochschulen) (D5) in the German education system.

Average years of schooling The second human capital measure we implement is a measure of mean years of schooling but derived from educational attainment. Tarazona's (2010) human capital index (HK) uses the average years spent in education by level of educational attainment ($i = 1, ..., 6$) (see Table 4.4.1) and weighs them by the prevalence of this educational attainment in the region.

$$\text{HK} = \sum_{i=1}^{6} \text{years of education}_i * \text{share of employees with education}_i \tag{4.1}$$

Tarazona's (2010) recoding of educational attainment to duration of education is theoretical rather than empirical and relies on a classification by Ostermeier and Blossfeld (1997). It should be noted that the duration of secondary education is relatively accurate, due to the formalised schooling requirements to obtain such degrees[6]. However, for vocational training as well as higher education, the duration is more difficult to approximate due to larger variance in individual educational biographies as well as recent changes in educational institutions. For instance, prior to the reform of higher education in the context of the Bologna Process, a university degree would indeed refer to roughly 19 years of education but university graduates entering the labour market in the late 2000s may have a shorter duration of education. However, since the HK index is used to compare regional differences in human capital and these institutional changes were made on a national level, the confounding effect should be limited.

[6]Secondary school organisation still differs by Federal State, with an upper secondary degree traditionally comprising a total of 13 years of schooling in most Federal States. More recently, school reforms have reduced the duration to 12 years. These changes by one year do not have a large impact on the calculation of the index and are therefore ignored here.

Complex human capital The educational data in the SIAB7510 file shows a distinctly higher share of tertiary education for regions in the former East of Germany. This is in line with differences in the education systems in the FRG and GDR prior to reunification (e.g. Köhler & Stock, 2004; Pritchard, 1999). Upon reunification, the former East adopted the West German education system and the reunification treaty ensured formal equivalence of degrees (Jarausch & Welsh, n.d.). However, Brunow and Hirte (2009a) argue that the shock of reunification pushed highly-educated East-Germans into jobs with lower educational requirements. Although such overeducation could in principle be transitional (Groot & Maassen van den Brink, 2007), Brunow and Hirte suggest that highly-educated East Germans may permanently work in lower-skilled jobs thus making their human capital unavailable to the labour market. Therefore, considering educational attainment for East German regions may provide a biased (and optimistic) view of the actually available human capital.

To avoid this issue, human capital can also be evaluated via occupational tasks as e.g. in the literature on skill-biased technological change (Autor, Katz, & Kearney, 2006; Gathmann & Schönberg, 2010; Spitz-Oener, 2006). Brunow and Blien (2015) identify occupations using "complex" skills, i.e. a high proportion of non-routine analytical work, based on the German Qualification and Career Survey. We apply their categorisation of occupations to calculate the share of employees working in occupations requiring complex skills. See Appendix 4.A.1 for an overview of the types of occupations considered to apply complex skills according to Brunow and Blien (2015) .

4.4.2 Ageing indicators

The explanatory variable of interest should capture the degree of ageing in the region. The preferred indicator here is mean age of the employed labour force as sampled in the SIAB7510 dataset described above. Mean age is preferred over median age here because it is a continuous measure thus offering a larger extent of cross-sectional and time variation than median values. The mean age is calculated from the entire dataset, i.e. not excluding individuals younger than 30 years. It is a continuous and simple measure of relative age across district regions but it only captures the age structure of the employed labour force. Since we also only analyse human capital for the employed labour force, this choice is reasonable.

In principle, the role of ageing could also be analysed using population-wide mean age. However, accurate mean age requires data on population by age-year rather than by 5-year age group. If 5-year age groups are used (e.g. population aged 30 to 35 rather than aged 30, 31, 32...) we would need to make an assumption on the distribution of ages within the age group (e.g. 1/5 of the population between 30 and 35 is actually 30 years old). Mean ages from population age-groups are therefore less precise and also offer less variation than those from age-year data. For districts, age-year data is only available after 2003, which is why we limit the analysis to the mean age calculated from the SIAB7510. However, this measure is highly correlated to population mean age from

2003 although it is a little lower due to the upper bound of 63 years in the SIAB7510 sample.

4.4.3 Estimation method

The relationship between regional age structure and the availability of human capital is analysed through a cross-sectional growth regression. To acknowledge that changes in both human capital and demographics are relatively slow processes, both the dependent variable and the explanatory variable of interest are specified as a difference for the entire time period 1996–2010.

Note that the dependent variables of the share of employees with tertiary education and the share of complex skills are defined as proportions (see section 4.4.1). The estimated model is thus based on simple differences for these dependent variables:

$$\begin{aligned}\Delta\text{tertiary}_{r,1996-2010} = \beta_0 + \beta_1\text{tertiary}_{r,1996} + \beta_2\Delta\text{mean age}_{r,1996-2010}\\ + \beta_3\text{RC}_{r,1996} + \varepsilon_r \quad (4.2)\end{aligned}$$

$$\begin{aligned}\Delta\text{complex}_{r,1996-2010} = \beta_0 + \beta_1\text{complex}_{r,1996} + \beta_2\Delta\text{mean age}_{r,1996-2010}+\\ \beta_3\text{RC}_{r,1996} + \varepsilon_r \quad (4.3)\end{aligned}$$

For the average years of schooling, we follow Tarazona (2010) in specifying the model in logarithms. This facilitates interpretation and comparison across the different dependent variables.

$$\ln\left(\frac{\text{HK}_{2010}}{\text{HK}_{1996}}\right)_r = \beta_0 + \beta_1 \ln \text{HK}_{r,1996} + \beta_2\Delta\text{mean age}_{r,1996-2010} + \beta_3\text{RC}_{r,1996} + \varepsilon_r \quad (4.4)$$

As conventional in growth regressions, the initial level of human capital is included as a control. We also control for a set of initial regional characteristics (RC). These include GDP per capita, unemployment, the share of the service sector in value added, the share of women in the employment sample and population-weighted net migration (across district boundaries), as well as dummies for whether a region is an urban area or in former East Germany.

It is worth emphasising that equations (4.2), (4.3) and (4.4) provide purely correlational evidence of the relationship between population age and human capital availability. In particular, the discussed relevance of migration for both population age and human capital levels implies that age is likely to be endogenous in the estimation. Age- and skill-selective migration implies that individuals may sort according to either of these characteristics, leading to issues of reverse causality. However, for the present analysis, we are interested only in the existence of a relationship and not in proving its causal effects. The presented analysis is thus descriptive.

Table 4.4.2: Descriptive statistics of human capital and age indicators

Variable	mean	st.dev	min	max
mean age 1996	37.51	0.89	34.6	39.3
Δ mean age	2.88	0.99	-0.2	5.4
share tertiary 1996	9.18	4.50	2.4	30.0
Δ share tertiary	3.62	2.42	-4.9	11.1
average years of schooling 1996	12.37	0.41	11.6	13.9
Δ average years of schooling	0.49	0.21	-0.2	1.0
share of complex skills 1996	19.84	5.33	10.1	40.4
Δ share of complex skills	0.46	2.37	-7.9	10.3

4.4.4 Results

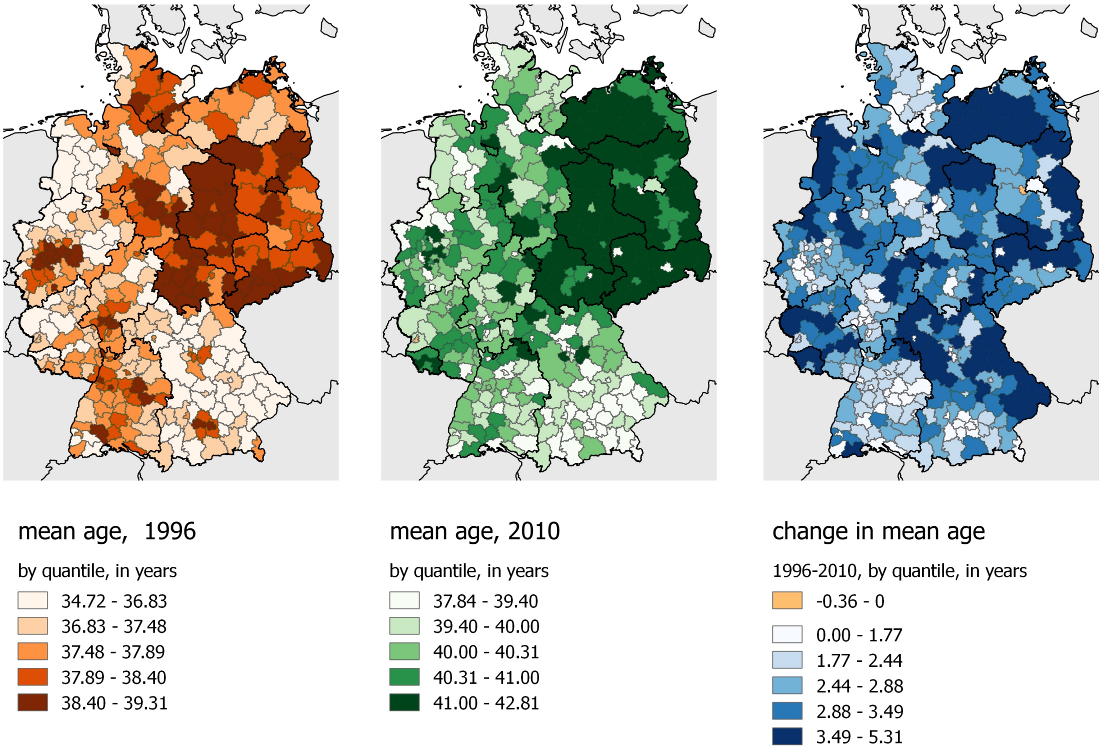
Descriptive analysis

Analysing labour force age illustrates the trend of population ageing for Germany, with the national mean age increasing by almost 3 years between 1996 and 2010. Mean age increased in all German regions but one: the city of Potsdam, capital of the Federal State Brandenburg and adjacent to Berlin, is the only region that recorded a lower average age in 2010 than 1996 (39.0 and 39.3 respectively). Despite the fact that ageing is a national trend, the spatial distribution of the age structure clearly shows a concentration of relatively old regions in the East of Germany, especially in 2010 (mid-panel of Figure 4.3). Nevertheless, there are also smaller clusters of old regions in the West, especially in Saarland and the Ruhr area, i.e. regions affected by deindustrialisation. Moreover, the degree of population ageing (Figure 4.3, right) is considerably less concentrated: Strongly ageing regions are located throughout Germany and more in the west and south-east than the regions of the former GDR.

Table 4.4.2 shows national level summary statistics of the key variables. As expected from the discussion about education expansion, the average share of employees with tertiary education increased by 3.6 percentage points across Germany. Similarly, the average years of schooling increased by half a year. In comparison, the change in the share of employees categorised as working in occupations with complex skills increased only by 0.46 percentage points on average. Moreover, for all three human capital measures, there are regions that experienced a decrease in human capital rather than the national trend of increasing human capital.

Figure 4.4 illustrates the regional variation in the different human capital measures as well as the changes in the time period. Three main observations emerge. First, by construction, the geographical distribution of the share of employees with tertiary education is quite similar to the average years of schooling measure. The simple correlation between these two measures is 0.93. In contrast, the measure of complex skills via occupations shows a distinct geographical pattern and the correlation with aver-

Figure 4.3: Mean age of employed in 1996, 2010 and change 1996–2010



age years of schooling and tertiary education is much lower (0.53 for both). Second, both tertiary education and average years of schooling show relatively high values for regions in former East Germany in 2010, as is to be expected from the strong emphasis on tertiary education in the institutional framework of the GDR. When considering the change in these measures, it is clear that the East of Germany experienced slower increases in human capital and some regions even saw decreases. Thus, the fact that there still seems to be a high-skilled cluster of human capital in the East of Germany in 2010 indicates the type of East-West convergence in human capital that has been documented e.g. by Tarazona (2010). Moreover, it is clear that within former West Germany, regions experiencing the largest increases in human capital seem to be located in the South and around large agglomerations such as Munich, Stuttgart, Frankfurt and Cologne/Düsseldorf.

Third, the share of complex skills clearly differs from the measures based on educational attainment. This is in line with its purpose, as Brunow and Blien (2015) suggest the measure primarily to address concerns that high educational attainment in the East may misrepresent human capital availability. Indeed, the share of complex skills in 2010 is less shaped by an East-West divide but still seems to be concentrated in urban areas and agglomerations in the South and West. However, the change in this measure shows that a substantial number of regions (134, i.e. 41% of all regions) record a fall in the share of occupations using complex skills. This includes most rural regions in the East as well as in the North and West of Germany. Increases in complex skills between 1996 and 2010 are largely concentrated in the South (especially Bavaria). It is difficult to reconcile the apparent decreases in the share of complex skills with the general trend of education expansion. Indeed, even if educational attainment does not match available skills for East Germany due to overeducation (as suggesed by Brunow & Hirte, 2009a), this should apply to a smaller degree to West Germany. However, for West Germany, 87 regions (of 268) record an increase in the share of employees with tertiary education but a decrease in the share of complex skills according to Brunow and Blien (2015). This would indicate that the education expansion in these regions does not actually increase the supply of high-skilled human capital and illustrates a potential drawback of using occupation-based human capital measures to analyse changes in availability over time.

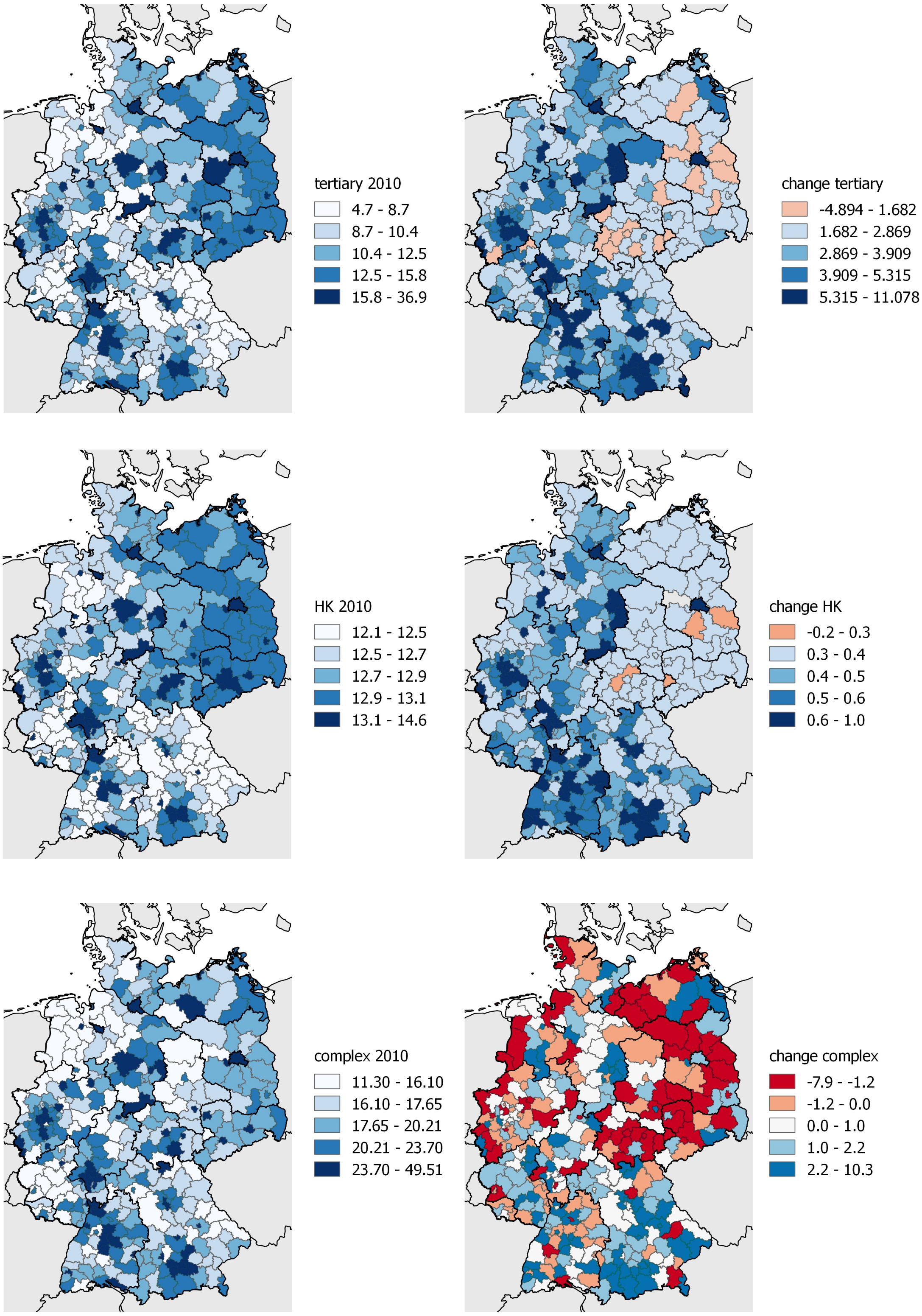
Regression results

Table 4.4.3 shows the results of the baseline regression for the three different human capital measures both with and without control variables. As expected from the theoretical discussions, we indeed find that regions with an older demographic structure on average have lower human capital availability across all specifications. Average age of the labour force is negative and highly significant for the share of employees with tertiary education as well as for average years of schooling. In particular, when controlling for regional characteristics, increasing average age by one year is associated with a decrease in average years of schooling of 0.3% and decrease in tertiary education by 0.42 percentage points. The specification using the share of complex skills (column 6) also yields a negative coefficient but it is just below significance at conventional confidence levels (p-value 0.107).

The initial value of the dependent variable (i.e. the value in 1996) is negatively significant for average years of schooling and the share of complex services, while the coefficient for initial share of tertiary education is insignificant. This suggests convergence in the former two measures when controlling for the regional age structure and other characteristics. In contrast, when testing for simple beta-convergence in human capital (see Appendix 4.A.3), we find that only the average years of schooling measure shows a clear convergence trend. For both tertiary education and the share of services, the insignificant coefficient of the initial value suggests that neither regional convergence nor divergence occur.

Initial GDP per capita is significantly positive for all specifications, suggesting that regions with higher GDP in 1996 saw a larger increase in human capital. Although there is a risk of endogeneity when considering the relationship between GDP and human capital in this framework, the results are in line with the interpretation that regions with higher GDP per capita may attract or produce more highly skilled human capital. Initial unemployment is insignificant for average years of schooling and share of tertiary education but significantly negative for the share of complex skills. The relevance of unemployment for the share of complex skills but not the education-based human capital measures could be related to the fact that the share of complex skills is

Figure 4.4: Human capital measures in 2010 and change between 1996–2010.



based on a region's occupational composition, which could change in response to and jointly with unemployment rates. In terms of the industry structure, we would expect regions with a higher share of the service sector in value added to have higher human capital availability, since many highly-skilled jobs constitute part of services. However, the share of services is only significant for tertiary education at a confidence level of 10% (p-value: 0.064). The share of female employees in 1996 is significantly positive for the change in average years of schooling but not the other human capital measures.

Controlling for the volume of net migration, i.e. net migration as a share of population in 1996, does not yield a significant result. Thus, regions with relatively large in- or out-migration in 1996 do not see significantly different developments in their human capital availability. While controlling for the size of net migration helps account for the fact that human capital is shaped by migratory movements, it does not solve the issue of potential reverse causality. Even if immigration and outmigration are of equal size, thus leading to a small migration balance, the migrants may still be self-selected on the basis of age and skills. Accounting for these aspects of migration would require modelling the migrants' characteristics, which goes beyond this aggregate analysis.

For the dummy variables for urban regions and regions in former East Germany, the coefficients are again insignificant for the share of complex skills but highly significant for the other two human capital measures. As expected from the strong connections between human capital and city growth (e.g. Glaeser et al., 1995; Simon & Nardinelli, 1996), urban regions see a larger increase in human capital availability in the time period 1996–2010 than rural regions. Indeed, urban regions' average years of schooling increase by 0.4% and the share of tertiary education by 0.55 percentage points more than rural regions, ceteris paribus. In contrast, and in line with the observations above, regions in former East Germany experience a 0.19% decrease in the years of schooling and 1.8 percentage point lower change in the share of tertiary education than the West. It should be emphasised that these results are conditional on the initial values of the human capital measure in 1996, thus illustrating that urban and rural as well as East and West German regions seem to experience different trends in the accumulation of human capital in the observed time frame.

To further analyse the relevance of these rural-urban and East-West differences with respect to demographics, Table 4.4.4 shows the results of introducing interaction terms between the degree of labour force ageing and the respective dummy variables. The interaction terms for the urban dummy are insignificant across all specifications, illustrating that population ageing seems to affect urban and rural regions similarly. The interaction term for the East dummy, however, is significantly positive at least for average years of schooling and the share of tertiary education. Thus, ageing is associated with a decrease in human capital but this decrease is larger in West German regions than East German ones. Indeed, comparing the point estimates of the relationship between labour force age and the share of tertiary education suggests that the overall correlation between labour force age and tertiary education may even be positive for East Germany but negative for West Germany. In this sense, the regions that are

Table 4.4.3: Baseline Regression Results

dep.var.	(1) $\ln\left(\frac{HK_{2010}}{HK_{1996}}\right)$	(2) $\ln\left(\frac{HK_{2010}}{HK_{1996}}\right)$	(3) Δ tertiary	(4) Δ tertiary	(5) Δ complex	(6) Δ complex
Δ mean age	-0.010***	-0.003***	-1.406***	-0.420***	-0.780***	-0.267
	(0.0007)	(0.0008)	(0.1220)	(0.1408)	(0.1560)	(0.1652)
HK_{1996}	-0.240***	-0.085**				
	(0.0265)	(0.0342)				
tertiary_{1996}			-0.097***	-0.022		
			(0.0350)	(0.0414)		
complex_{1996}					-0.149***	-0.192***
					(0.0424)	(0.0641)
ln GDP p.c.		0.015***		2.838***		2.705***
		(0.0028)		(0.5428)		(0.8041)
unemployment		-0.000		0.003		-0.106**
		(0.0002)		(0.0422)		(0.0530)
net migration		-0.000		0.058		-0.250
		(0.0009)		(0.1590)		(0.1837)
services		-0.000		0.024*		-0.000
		(0.0001)		(0.0129)		(0.0211)
female		0.000***		0.018		0.015
		(0.0002)		(0.0294)		(0.0358)
urban		0.004***		0.555**		0.153
		(0.0013)		(0.2187)		(0.3164)
east		-0.019***		-1.861***		-0.174
		(0.0032)		(0.5937)		(0.6999)
Constant	0.673***	0.202**	8.563***	-5.823**	5.660***	-2.478
	(0.0669)	(0.0826)	(0.5452)	(2.3434)	(1.1367)	(2.6411)
Observations	326	326	326	326	326	326
R-squared	0.400	0.669	0.264	0.541	0.081	0.240

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

ageing most in West Germany seem to be disadvantaged in terms of human capital accumulation, whereas East German regions that age more quickly may actually see larger increases, at least in tertiary education.

All in all, the regression results for the human capital measures based on educational attainment show that regions that aged more severely between 1996 and 2010 saw smaller growth in human capital. However, a considerable degree of regional variation remains. For instance, Figure 4.5 shows the share of employees with tertiary education by quantiles based on the value in 1996. The right panel shows the distribution in 2010 and illustrates that there is some mobility between the quantiles (45% of regions are in a different quantile in 2010 than 1996). However, the regions with the highest share of tertiary education in 1996 overall still have the highest shares in 2010 (71% of regions in the highest quantile in 1996 are still in the highest quantile in 2010). The only exception are predominantly regions in the East of Germany who have in some cases even seen their share of graduates fall. A further interesting point to note in Figure 4.5 is the fact that the quantile with the highest share of tertiary education in 1996 represented some of the oldest regions in Germany. In contrast, by 2010, these regions are some of the youngest ones. Thus, the relationship between labour force age

Table 4.4.4: Interaction Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)
dep.var.	$\ln\left(\frac{HK_{2010}}{HK_{1996}}\right)$	$\ln\left(\frac{HK_{2010}}{HK_{1996}}\right)$	Δ tertiary	Δ tertiary	Δ complex	Δ complex
Δ mean age	-0.002**	-0.004***	-0.337*	-0.583***	-0.076	-0.338*
	(0.0011)	(0.0009)	(0.1810)	(0.1434)	(0.2218)	(0.1756)
Δ mean age*urban	-0.002		-0.170		-0.393	
	(0.0014)		(0.2423)		(0.2813)	
Δ mean age*east		0.004***		0.730***		0.296
		(0.0012)		(0.2298)		(0.3691)
urban	0.010**	0.004***	1.088	0.550**	1.385	0.158
	(0.0046)	(0.0013)	(0.8307)	(0.2166)	(0.9690)	(0.3160)
east	-0.018***	-0.029***	-1.840***	-4.023***	-0.185	-1.014
	(0.0033)	(0.0041)	(0.5950)	(0.8178)	(0.6884)	(1.3140)
HK_{1996}	-0.090**	-0.086**				
	(0.0346)	(0.0342)				
tertiary_{1996}			-0.027	-0.015		
			(0.0425)	(0.0419)		
complex_{1996}					-0.200***	-0.193***
					(0.0642)	(0.0634)
ln GDP p.c.	0.014***	0.013***	2.738***	2.473***	2.481***	2.583***
	(0.0029)	(0.0029)	(0.5688)	(0.5545)	(0.8137)	(0.7956)
unemployment	-0.000	-0.000	0.000	-0.026	-0.109**	-0.118**
	(0.0002)	(0.0003)	(0.0425)	(0.0449)	(0.0518)	(0.0549)
net migration	0.000	-0.001	0.067	-0.068	-0.228	-0.302
	(0.0009)	(0.0009)	(0.1586)	(0.1708)	(0.1830)	(0.1940)
services	-0.000	0.000	0.025*	0.029**	0.001	0.002
	(0.0001)	(0.0001)	(0.0130)	(0.0131)	(0.0210)	(0.0210)
female	0.000**	0.000**	0.014	0.002	0.006	0.008
	(0.0002)	(0.0002)	(0.0296)	(0.0299)	(0.0363)	(0.0360)
Constant	0.215**	0.214**	-5.656**	-3.652	-2.048	-1.634
	(0.0839)	(0.0830)	(2.3749)	(2.4553)	(2.6344)	(2.7049)
Observations	326	326	326	326	326	326
R-squared	0.671	0.676	0.541	0.553	0.244	0.242

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

and highly-skilled human capital availability has reversed.

Although the regression results in the previous section give supportive evidence that labour force age may matter for human capital availability, they do not allow much insight into the processes at work in the regions. For instance, the regressions show that tertiary education in urban regions in Germany increased more strongly than in rural regions. But does this actually imply that human capital has not expanded in rural regions? Or has it maybe expanded in other directions? Using the average years of schooling helps account for the fact that human capital is not only tertiary education, but it still aggregates the different educational attainments into one number. This implies substitutability of skills across different degrees albeit accounting for the different duration of the education. It also disguises that expansion of human capital may take different forms in different regions.

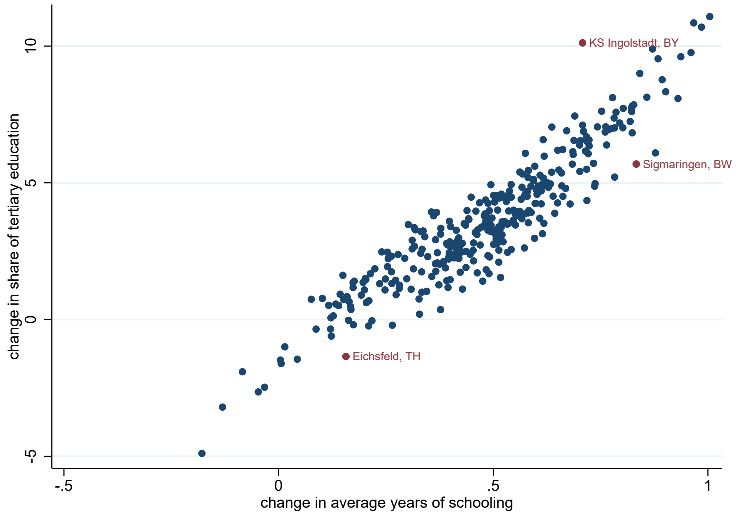
To illustrate, Figure 4.6 plots the change in the share of employees with tertiary edu-

Figure 4.5: Share of employees with tertiary education by quantile in 1996

cation versus the change in the average years of schooling. By construction, there is a strong positive association between these two variables but there is also a large degree of regional variation. For instance, the district of Eichsfeld in Thuringia is one of the regions that experienced a decrease in tertiary education between 1996 and 2010. In contrast to many other districts in former East Germany, Eichsfeld did not start out with particularly high tertiary education and both its tertiary education as well as the average years of schooling are considerably below national averages for the entire time period. Nevertheless, Eichsfeld did experience a small increase in the average years of schooling. Similarly, the example of comparing the city of Ingolstadt in Bavaria and the rural district of Sigmaringen in Baden-Württemberg shows that for regions with similar changes in the average years of schooling, the contribution of tertiary education can be very different. The analysis presented so far cannot determine the source of the increase in average years of schooling other than establishing that it is not due to tertiary education.

Thus, although the analysis presented here shows that there is a conceptual and empirical relationship between regional demographic structure and human capital availability, a closer look at different levels of educational attainment is necessary. The primary focus in economic studies of human capital in developed countries is on tertiary education, which has been identified as a driver for innovation and economic development. In contrast, human capital investment in other forms, e.g. an upskilling of the labour force by reducing the share of the population with low educational attainment, has largely been ignored. Especially in the context of Germany, a country with a traditionally large role for vocational training, this focus on tertiary education is limiting. A natural extension to the presented analyses of human capital availability via educational attainment is therefore to consider the composition of human capital in more detail.

Figure 4.6: Change in tertiary education and change in average years of schooling



4.5 Population ageing and human capital composition

Section 4.2.1 discussed the theoretical background why population ageing may affect human capital and argued that there is an ambiguous effect of smaller but more highly educated cohorts entering the labour market. While this may affect the availability of human capital as examined in the previous section, it may simultaneously represent changes in the human capital composition. In particular, the prevalence of specific educational attainment may differ with age groups. Thus, regional differences in age structure may not only be reflected in changes to availability of aggregate human capital but also in the availability of specific types of human capital. This section tests whether human capital composition differs with the age of the labour force.

4.5.1 Method

To investigate the relationship between mean age and the composition of human capital, a measure of human capital needs to account for its diversity. Rather than aggregating human capital into average years of schooling or the share of tertiary education, this section uses the relative shares of the 6 types of educational attainments (as described in section 4.3.2) directly. We calculate the relative share of each degree type $D(i)$ with $i = 1, 2, 3, 4, 5, 6$ in region r. In contrast to average years of schooling, this approach does not assume substituability across human capital types and in contrast to focusing on the share of tertiary education, it accounts for the strong presence of vocational training in Germany. While this approach is entirely based on educational attainment and thus neglects other sources of human capital, it also yields a comprehensive and clear framework for analysing compositional changes.

Differences in the share of a specific degree type (e.g. a university degree (D6)) may be caused by two channels. First, as we already pointed out above, education expansion means that a university degree is relatively more common among younger people than older people. Thus, purely by composition, an older labour force would suggest a smaller aggregate share of individuals with university degrees than a younger labour force. However, second, there may be other channels transmitting a regional difference in the human capital composition. If an individual's educational attainment depends on the regional age structure or if there is skill-and age-selective sorting of individuals, there may still be differences in the share of university degrees even when conditioning out the compositional age effect. To test the latter point, we consider the share of each degree type by age group. We define three age groups: 30 to 39 years, 40 to 49 years and above 50 years[7].

$$D(i)_{a,r,t} = \frac{\sum \text{degree } (i) \text{ in age group } (a) \text{ and region}(r)}{\sum \text{employed in age group } (a) \text{ in region}(r)} \tag{4.5}$$

While this approach avoids the generalisation of an aggregate index, it also implies that regressions for all six degree types need to be run separately. Although each individual regression on the share of a specific degree type is separately valid, it should be noted that, due to the nature of using relative shares as dependent variable, the coefficients across the six regressions will add up to zero. This is because an average increase associated with an independent variable for one relative share needs to be accompanied with a corresponding decrease in another share.

Considering that trends in demographic and educational structure work relatively slowly over time, we investigate their relationship in a cross-sectional growth specification:

$$\begin{aligned} \Delta D(i)_{a,r,1996-2010} = \beta_0 + \beta_1 D(i)_{a,r,1996} + \beta_2 \Delta \text{mean age}_{r,1996-2010} \\ + \beta_3 RC_{r,1996} + \varepsilon_r \end{aligned} \tag{4.6}$$

The model is estimated for each education share per age group separately. As in the previous section, the initial level of the respective educational share and controls for the same set of regional characteristics (RC) are included. These include GDP per capita, unemployment, the share of the service sector in value added, the share of women in the employment sample and population-weighted net migration (across district boundaries), as well as dummies for whether a region is an urban area or in former East Germany. As described in section 4.4.2, ageing is measured using the mean age of the SIAB7510 sample.

[7]Due to the ages covered in the SIAB7510 sample, this implies 50 to 62 years.

4.5.2 Results

Descriptive analysis

Considering the human capital composition at the national level (Figure 4.7) the effect of education expansion is clearly visible. For all age groups, the share of the two lowest educational degrees fell between 1996 and 2010, whereas the share of the remaining degrees increased. Additionally, education expansion is also visible when comparing age groups: for both years, the share of employees with higher education decreases with age. The share of D1 (only primary, lower or intermediate secondary education) increases when comparing the youngest to the oldest age group, although the middle age group shows the overall lowest share of D1 in 2010. Thus, the data confirms the notion that young cohorts entering the labour market are, on average, more highly educated than the previous cohorts. Moreover, the skill composition also illustrates the comparatively large role of vocational training in Germany. Although the share of D2 decreases over time and age groups, it remains the single most common degree. The share of university degrees is increasing but remains significantly lower than estimates for the entire population with tertiary education in Germany. This is at least partially caused by the fact that the used data source is employees covered in the social security database, which excludes current (unemployed) students as well as the self-employed and public servants many of which have completed tertiary education.

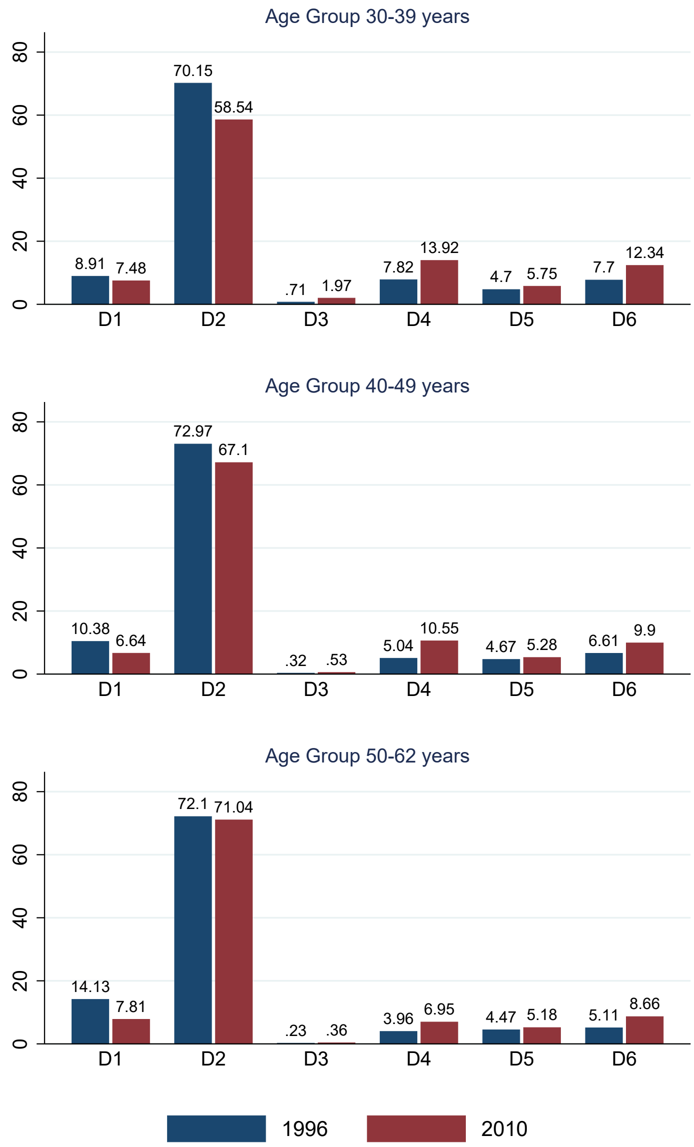
Regression results

The results of the growth regressions for each of the six degree types (D1–D6) and each of the three age groups (30–39, 40–49, 50+) are presented in Table 4.5.1.[8] Across all regressions, change in mean age emerges as a significant coefficient for many (but not all) degree types and age groups. Change in mean age is significantly negative for D6 especially for the age groups 30–39 and 50–62. For the age group 40–49, the coefficient is only significant at a confidence level of 10% (p-value 0.083). A negative coefficient for the change in mean age implies that regional labour force ageing is associated with a lower share of D6. In particular, a one year increase in mean age is associated with a 0.676 percentage point reduction in the share of university degrees among 30–39 year olds and a 0.451 percentage point decrease for 50 to 62 year olds. In this sense, regions with an older age structure seem to have labour forces that are relatively less shaped by university education.

Ageing is insignificant for D1 across all age groups, indicating that population ageing does not seem to be related to changes in the share of employees with the lowest educational attainment. In contrast, ageing is consistently and highly significantly positive for the change in D2, i.e. employees with primary, lower or intermediate secondary education and a completed vocational degree (column 2). The coefficient

[8] Additionally, the results for estimating equation (4.6) without regional controls are presented in Appendix 4.A.4. The results are qualitatively similar to the models with controls presented here.

Figure 4.7: Human capital composition by age group



sizes are also comparably large, with a one year increase in mean age associated with an increase in D2 by over 1 percentage point for all age groups. Thus, the results suggest that regions with an older age structure on average have lower shares of employees with university degrees and a higher share of employees with traditional vocational training degrees (D2).

The results for degrees D3, D4, and D5 are less clear. Change in mean age is significantly negative for D3 in age groups 30–39 and 40–49 but insignificant for the oldest age group. D4 is insignificant for the youngest age group but significantly negative for the other two. D5 is insignificant for 40–49 year olds but negative for the other two age groups. It is difficult to derive a consistent conclusion from these results other than the fact that ageing does not seem to be positively associated with either of these degrees.

The initial level of the respective degree type is negatively significant for all specifications but D6 in the age group 30–39. This indicates that, conditional on the other regional characteristics as well as ageing, the regional prevalence of each specific degree type do not seem to diverge. The results are thus in line with the findings of section 4.4.4 as well as other studies on human capital convergence in Germany, which find trends of convergence (e.g. Südekum, 2008) especially when considering both former West and East German regions (Tarazona, 2010).

With respect to other regional characteristics, GDP per capita in 1996 is significantly positive for degrees D4, D5, and D6, and significantly negative for D2 for all age groups. Similarly, initial share of services is negative for D2 for all age groups and positive for D3, D4. These results illustrate that regions' economic structures are relevant for changes in the skill composition as would be expected if human capital development follows labour demand. In this sense, it could be argued that the expansion in D3 and D4 corresponds to demand for service occupations, which require these types of degrees. It is interesting to note that the results are opposite in sign for degrees D2 and D4, which are only differentiated by D4 including an upper secondary degree. However, the occupations demanding D4 versus D2 may be quite different, e.g. vocational degrees in business services rather than traditional vocational degrees in manufacturing sectors.

The dummy for urban regions is significantly positive for D1,D3,D4, and D6 and significantly negative for D2 in all age groups. This indicates that urban areas experienced larger increases than rural areas in both tertiary education but also the degree type with the lowest educational attainment. In contrast, rural areas rely relatively more strongly on traditional vocational degrees (D2) than urban areas and the effect sizes are quite large. For instance, for the age group 30–39, the share of D2 decreased by 3.3 percentage points more between 1996 and 2010 in urban than in rural regions, ceteris paribus. Comparing regions of the former East and West of Germany, regions in the East have significantly lower shares of traditional vocational degrees (D2) for the age group 30–39 and above 50 years. However, the sign is reversed for the 40–49 age group. Moreover, the dummy for East German regions is insignificant for university degrees across all age groups.

In summary, these results show that the differences in human capital availability by a region's age structure may manifest in a lower share of tertiary education and a higher share of vocational training. This is in line with the results from the previous section and helps explain the considerable degree of regional variation in human capital. Interestingly, the effects of regional age structure on the share of D2 and D6 hold while conditioning out the compositional effect of the work force: all age groups have higher shares of D2 in regions with an older age structure, which thus cannot be caused by differences in the size of the age groups within the region. Instead, the results suggest that other channels of transmission are at work. Migration is clearly relevant as the results could indicate skill-selective movement across regions, although testing this hypothesis is beyond the scope of this analysis. Alternatively, processes of human capital accumulation could in principle differ as well, for instance if educational attainment is dependent on individuals' locations.

Table 4.5.1: Human capital composition regressions by age group

			Age group 30-39			
1996-2010	Δ D1	ΔD2	ΔD3	ΔD4	ΔD5	ΔD6
Δ mean age	0.246	1.035***	-0.147**	-0.287	-0.558***	-0.676***
	(0.1571)	(0.3525)	(0.0708)	(0.1834)	(0.1220)	(0.1999)
$D(i)_{1996}$	-0.575***	-0.143**	-0.563***	-0.375***	-0.620***	-0.074
	(0.0579)	(0.0565)	(0.1206)	(0.0697)	(0.0758)	(0.0700)
ln GDP p.c.	-0.167	-6.223***	0.899***	1.178*	1.111**	3.025***
	(0.4755)	(1.1426)	(0.2506)	(0.7048)	(0.4911)	(0.7001)
unemployment	0.050	-0.267**	0.008	0.212***	-0.093**	0.085
	(0.0498)	(0.1080)	(0.0211)	(0.0616)	(0.0371)	(0.0676)
net migration	0.274*	-0.888**	0.055	0.506**	0.123	-0.148
	(0.1507)	(0.4151)	(0.0758)	(0.2421)	(0.1147)	(0.2301)
services	0.038*	-0.188***	0.049***	0.060***	-0.004	0.016
	(0.0213)	(0.0342)	(0.0098)	(0.0197)	(0.0140)	(0.0210)
female	-0.125***	0.181**	-0.044**	-0.032	-0.059**	0.051
	(0.0370)	(0.0812)	(0.0181)	(0.0490)	(0.0256)	(0.0431)
urban	1.170***	-3.375***	0.353***	2.303***	0.010	0.586*
	(0.2914)	(0.7029)	(0.1193)	(0.3668)	(0.2220)	(0.3325)
east	-0.896	-3.350***	0.307	0.670	0.898*	-1.127
	(0.6752)	(1.2147)	(0.2456)	(0.6720)	(0.4728)	(0.8232)
Constant	4.889*	27.896***	-2.785**	-1.202	5.258***	-7.565**
	(2.5137)	(7.8390)	(1.1632)	(3.2674)	(1.9540)	(3.4441)
Observations	326	326	326	326	326	326
R-squared	0.503	0.391	0.351	0.237	0.300	0.314
			Age group 40-49			
1996-2010	Δ D1	ΔD2	ΔD3	ΔD4	ΔD5	ΔD6
Δ mean age	-0.165	1.151***	-0.064***	-0.498**	-0.102	-0.273*
	(0.1642)	(0.3491)	(0.0232)	(0.2001)	(0.1194)	(0.1571)
$D(i)_{1996}$	-0.666***	-0.375***	-0.638***	-0.338***	-0.776***	-0.258***
	(0.0384)	(0.0625)	(0.0847)	(0.1181)	(0.0529)	(0.0739)
ln GDP p.c.	-1.232**	-5.730***	0.099	1.236*	1.668***	3.982***
	(0.4878)	(1.1646)	(0.1009)	(0.7058)	(0.3661)	(0.6300)
unemployment	0.120***	-0.335***	0.014**	0.213***	-0.129***	0.003
	(0.0397)	(0.0884)	(0.0070)	(0.0462)	(0.0340)	(0.0513)
net migration	0.049	-1.137***	0.080***	0.631***	-0.075	0.099
	(0.1401)	(0.3193)	(0.0278)	(0.1784)	(0.1242)	(0.2277)
services	0.015	-0.212***	0.006**	0.069***	-0.004	0.071***
	(0.0215)	(0.0369)	(0.0029)	(0.0222)	(0.0120)	(0.0208)
female	-0.128***	0.212***	-0.000	-0.032	0.002	-0.011
	(0.0429)	(0.0742)	(0.0061)	(0.0393)	(0.0285)	(0.0387)
urban	1.166***	-4.694***	0.130***	1.576***	0.810***	1.225***
	(0.2762)	(0.5593)	(0.0445)	(0.2882)	(0.1988)	(0.2761)
east	-2.842***	3.497***	-0.245***	-4.040***	2.040***	-0.165
	(0.5113)	(1.0545)	(0.0796)	(0.5534)	(0.4990)	(0.6929)
Constant	9.809***	49.316***	-0.433	-1.795	-0.062	-12.093***
	(2.5188)	(7.7201)	(0.4487)	(2.9786)	(1.8399)	(3.0038)
Observations	326	326	326	326	326	326
R-squared	0.727	0.576	0.343	0.495	0.498	0.474

Table 5 (continued)

			Age group 50-62			
1996-2010	Δ D1	ΔD2	ΔD3	ΔD4	ΔD5	ΔD6
Δ mean age	0.044	1.183***	-0.001	-0.328**	-0.338***	-0.451***
	(0.1541)	(0.2991)	(0.0233)	(0.1396)	(0.1266)	(0.1522)
$D(i)_{1996}$	-0.695***	-0.687***	-0.941***	-0.762***	-0.642***	-0.439***
	(0.0291)	(0.0444)	(0.0684)	(0.0851)	(0.0770)	(0.0670)
ln GDP p.c.	-0.317	-6.839***	0.306***	1.506***	1.530***	3.057***
	(0.4754)	(0.9963)	(0.0864)	(0.4440)	(0.3508)	(0.5555)
unemployment	0.043	-0.070	0.003	0.063*	-0.054	0.034
	(0.0427)	(0.0872)	(0.0060)	(0.0379)	(0.0384)	(0.0430)
net migration	-0.085	-0.147	0.054**	0.381**	-0.266	0.102
	(0.1455)	(0.4258)	(0.0236)	(0.1714)	(0.1859)	(0.1856)
services	-0.020	-0.096***	0.009***	0.031**	-0.006	0.071***
	(0.0164)	(0.0293)	(0.0023)	(0.0145)	(0.0157)	(0.0145)
female	-0.074**	0.091	-0.001	0.012	-0.014	-0.011
	(0.0311)	(0.0574)	(0.0053)	(0.0266)	(0.0243)	(0.0337)
urban	0.727***	-3.205***	0.086**	1.070***	0.235	0.877***
	(0.2677)	(0.4891)	(0.0411)	(0.2209)	(0.1925)	(0.2404)
east	-3.304***	-1.702*	-0.130**	-0.417	2.344***	1.036
	(0.5640)	(0.9310)	(0.0636)	(0.4598)	(0.5575)	(0.6965)
Constant	8.239***	73.198***	-1.294***	-1.939	0.760	-8.109***
	(2.4686)	(5.8594)	(0.4292)	(2.0209)	(1.7158)	(2.5834)
Observations	326	326	326	326	326	326
R-squared	0.829	0.644	0.454	0.514	0.445	0.495

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.6 Shift-share decomposition

The results of the previous two sections showed that increases in labour force age are associated with lower human capital availability, higher shares of vocational training degrees with only primary, lower secondary or intermediate secondary degrees (D2), and lower shares of university degrees (D6). The presented analysis does not allow judgement on the causality of these effects because population ageing and human capital could be jointly determined, e.g. via age- and skill-selective migration. However, the previous section showed that ageing seems to be related to differences in human capital even when controlling for the compositional effect of the work force by splitting the analysis into age groups. This section takes the opposite approach and instead focuses on the compositional aspect of regional human capital. It aims to assess how much of the observed changes in the human capital composition can be attributed to changes in the age-structure of the employed labour force alone.

4.6.1 Decomposition of human capital changes

The theoretical framework for compositional changes suggested in section 4.2.1, conceptualizes changes in the skill composition as driven by effects of demographic change on the one hand, and education expansion on the other. While demographic change

Table 4.6.1: National decomposition of changes in human capital composition

Share of degree type	D1	D2	D3	D4	D5	D6
observed 1996	10.8	71.6	0.5	5.9	4.6	6.7
observed 2010	7.3	66.1	0.9	10.2	5.4	10.1
actual change 1996-2010	-3.5	-5.5	0.4	4.3	0.8	3.4
projected 2010	11.3	71.9	0.4	5.4	4.6	6.4
residual change[1]	-4.0	-5.8	+0.5	+4.8	+0.8	+3.7
contribution demographic change[2]	+0.5	+0.3	-0.1	-0.5	0.0	-0.3

[1](observed 2010 - projected 2010) [2] (projected 2010 - observed 1996)

reduces the size of the cohorts entering the labour market (quantitative effect) education expansion changes the relative skill content of these cohorts (qualitative effect). The regressions presented in the previous section analysed the aggregate change in the skill composition in a reduced form but cannot distinguish between the relative contribution of the two counteracting trends. Thus, in order to gain an understanding of the relative relevance of demographic change versus education expansion, a decomposition of changes in the skill composition was implemented.

The decomposition is an accounting exercise resembling shift-share methodologies (e.g. Loveridge & Selting, 1998). It relies on projecting the human capital composition solely based on demographic shifts and comparing the projected changes to the actual ones. We calculated the relative shares of the six degree types for each age group in both 1996 and 2010. To project a human capital composition without education expansion or other trends, we assume that the relative shares of degrees per age group are constant over time, i.e. if 14% of the age group above 50 years recorded D1 in 1996, we assume that this will also apply in 2010. However, due to demographic change, the sizes of the age groups change between 1996 and 2010. We thus apply the education shares from 1996 to the age group sizes in 2010 to obtain a predicted human capital composition that is based on demographic shifts only and not influenced by educational expansion.

As an illustration, Table 4.6.1 shows the results of decomposition for the national average shares (across all age groups). Demographic change in the absence of education expansion would have increased the shares for D1 and D2 while decreasing the other shares relative to the 1996 values. However, when comparing the projected shares in 2010 with the actual ones, it is clear that the contribution of demographic change suggests opposite trends to those actually experienced between 1996 and 2010. Thus, if we attribute the residual change between the actual and projected value in 2010 to education expansion, the decomposition suggests that the changes in the human capital composition are less shaped by demographic developments than general education expansion. Indeed, in comparison to the relatively large changes in the degree shares, the portion explained purely by demographic shifts is small.

However, this national average decomposition neglects the large regional diversity in

Table 4.6.2: National decomposition of changes in human capital composition

	9272: Freyung-Grafenau, Regen						9184: City of Munich					
Share of degree type	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
observed 1996	22.0	72.6	0.2	2.2	1.7	1.3	7.8	61.0	0.7	8.7	7.6	14.2
observed 2010	10.8	80.6	0.1	3.8	2.3	2.3	4.5	48.4	1.6	12.8	8.8	23.9
actual change 1996-2010	-11.2	8.0	0.0	1.6	0.6	1.1	-3.3	-12.6	1.0	4.1	1.2	9.7
projected 2010	25.1	69.6	0.2	2.1	1.9	1.1	7.8	62.5	0.6	8.1	7.4	13.6
residual change[1]	-14.3	+11.0	0.0	+1.7	+0.4	+1.2	-3.3	-14.1	+1.1	+4.7	+1.4	+10.2
contribution dem. change[2]	+3.0	-3.0	0.0	-0.1	+0.2	-0.1	+0.1	+ 1.5	-0.1	-0.6	-0.3	-0.6

[1](observed 2010 - projected 2010) [2] (projected 2010 - observed 1996)

both demographic and education structures, which is visible when implementing the decomposition for all 332 district regions in Germany. As an example, Table 4.6.2 shows two regions in the State Bavaria, which experienced notably different skill development. In the combined region of Freyung-Grafenau/Regen, a rural district in the east of Bavaria, demographic change would predict a decrease in the share of D2. Instead, the region experienced an increase in D2 by 2010, illustrating that education expansion implied a decrease in the share of labour force with only primary or secondary education in favour of those with at least primary, lower or intermediate secondary degree and completed vocational training. In contrast, the demographic structure in Munich, the Federal State's capital, would predict an increase in D2 but the region instead experienced education expansion towards the higher degrees, most notably university graduates. This example illustrates that even regions within the same Federal State experience not only different changes in their skill composition but also differences in the degree to which these changes are dampened or attenuated by the demographic structure.

The decomposition also provides an opportunity to classify regions according to the observed and projected changes to the human capital composition. We distinguish four cases[9] (Table 4.6.3). Type A and B refer to regions where the share of the degree increases either in line with demographic changes (Type A) or despite them (Type B). Type C applies if negative demographic changes coincide with a negative realised trend. Finally, Type D implies that the demographic composition of the labour force would suggest an increase in a given degree but the realised change was negative. Thus, for Types B and D, trends of education expansion are sufficient to counteract demographic trends.

4.6.2 Geographical patterns in decomposition types

The four decomposition types (Table 4.6.3) are mapped out for each educational level in Figure 4.8. For D1 (primary, lower/intermediate secondary degree without vocational

[9]The types are defined as greater or equal to zero to account for the fact that some regions experience zero changes in D3, which would leave them uncategorised otherwise.

Table 4.6.3: Decomposition types

Type	Actual Δ	Projected Δ	Description
A	≥ 0	≥ 0	Increasing share with positive demographic contribution
B	≥ 0	< 0	Increasing share with negative demographic contribution
C	< 0	< 0	Decreasing share with negative demographic contribution
D	< 0	≥ 0	Decreasing share with positive demographic contribution

training), the dominant trend is a decreasing share despite the fact that demographics alone would predict an increase. There are a total of six observations with increasing shares in D1, four in the East German Federal State Brandenburg and two in North Rhine-Westphalia's Ruhr area.

There is more regional variation in the types for D2 (primary, lower/intermediate secondary degree with vocational degree). Despite the national trend of a decreasing share of D2, a substantial number of regions experience opposite changes. For instance, a total of 67 regions (20.1%) saw an increasing share of D2 and often despite a negative contribution of the demographic structure (light green in Figure 4.8). These regions are mostly located in the South of Germany, especially Bavaria. A closer look at the human capital composition and its changes over time for these regions shows that they experienced above average decreases in D1 as well as below average increases in D6. This indicates that the human capital composition is more markedly expanding in terms of traditional vocational training degrees rather than tertiary education. Indeed, when considering human capital availability in terms of increases in the share of university graduates, regions such as Freyung-Grafenau would seem to be falling behind. However, it could be argued that the expansion of traditional vocational training degrees is in line with these regions' characteristics as being predominantly rural, of low-density and ageing strongly. In this sense, these regions may represent an alternative path of increasing human capital investment that relies on vocational rather than tertiary education.

The trend towards higher secondary school attainment is clearly visible from the maps for D3 and D4. This is despite the demographic contribution being negative in large parts of the country. Although a few regions recorded a decrease in the share of D3, only two regions (city of Ingolstadt and Eichstätt in Bavaria) saw the share of degree 4 fall. It should be noted that for some regions, especially in the former GDR, the increase in both degrees 3 and 4 are actually supported by the demographic structure, whereas the West, types B and C (with negative demographic contribution) are more common.

For D5 (degree from a University of Applied Sciences), the geographical distribution is again relatively mixed. Based on demographic structure, most regions in the East would be predicted to see increases in D5 (Types A and D), whereas the West again predominantly exhibits a negative demographic contribution. This illustrates that the driving factor in the development of the human capital composition does not seem to be demographics, since both East and West German regions are exhibiting opposite trends to what demographics would predict.

University degrees again show a strong trend towards increasing shares whether along with or despite demographic contributions. However, a notable exception are 17 regions in the Federal States of Brandenburg and Thuringia as well as one in Baden-Württemberg, which experienced decreases in the share of university graduates between 1996 and 2010. In line with the relatively high level of tertiary education in the former GDR, most of these regions recorded shares of D6 above the national average in 1996 but fell below the national average by 2010. Across these regions, the trend seems to be a contraction of D6 in favour of D4 and D5 (see Appendix 4.A.5).

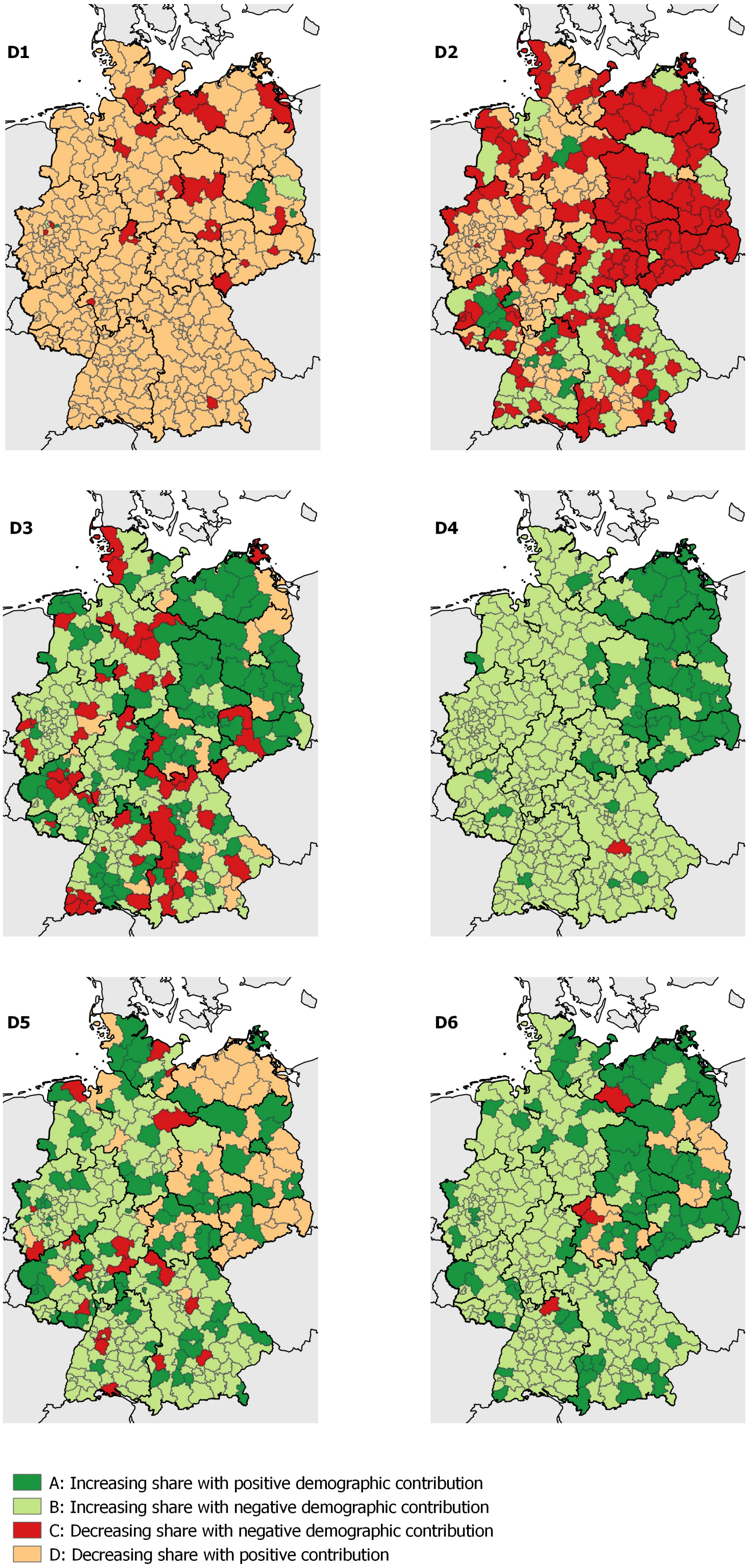
The decomposition suggests that demographic structure alone would have predicted an increase rather than decrease in the share of university graduates in all but 4 of these 18 regions. A possible explanation may be found in patterns of selective migration. The net-outmigration from East towards the West as well as rural-urban migration within the East is well-documented (e.g. Nelle, 2016; Sander, 2014; Sander & Bell, 2016; Schlömer, 2004) and considered to be a major factor in East Germany's demographic composition. However, the purely age-selective aspect of migration is implicitly considered in the decomposition as the calculation is based on the age group sizes in 2010. Nevertheless, if migration is not only selective with respect to age but also with respect to education, i.e. outmigration of skilled labour from the East to the West (Schneider, 2005), this will affect the human capital composition by changing the degree of education expansion, or could, e.g. in this case, lead to a contraction in the share of university graduates.

4.7 Discussion and conclusion

This chapter set out to investigate the relation between demographic change and regional human capital. The first empirical application of this chapter considered the role of population ageing in explaining regional differences in the availability of human capital using three different measurements. The regression analyses showed that, for human capital measures based on educational attainment, regions that aged more severely between 1996 and 2010 saw smaller growth in human capital. Moreover, human capital growth in East German regions was on average slower than in the West, leading to a trend of convergence across Germany. However, although East German regions have slower average growth in human capital, labour force age has a smaller effect in the East than the West.

In contrast, labour force age was not significant for Brunow and Blien's (2015) occupation-based measure of human capital with complex skills. Thus, while labour force age may be an influential factor in determining a region's average educational attainment, this does not necessarily feed back into its occupational structure. In this sense, the result that older regions do not have a lower share of occupations requiring complex skills,

Figure 4.8: Maps of decomposition types by degree type



shows that there are no apparent skill shortages nor changes in regional specialisation according to age structure. In this sense, while human capital availability may vary with a region's age structure, these demographic changes do not yet seem to systematically affect occupations.

A problem of using aggregate measures of human capital is that it neglects the structure of human capital itself. This is problematic especially in countries like Germany where the emphasis on vocational training implies that tertiary education may not be a good indicator of the actually available human capital. The second empirical section of this chapter therefore examined whether regional age structure is associated with shifts in the relative shares of educational attainment levels. Moreover, to condition out the effect of the composition of the employed labour force, we tested the effects of regional age structure on changes in education shares by age group. The results indicate that regions with an older age structure have lower shares of university degrees (D6) and higher shares of vocational training with only primary, or lower/intermediate secondary education (D2) for all age groups. Thus, even the the youngest cohorts, who benefit the most from recent education expansion, have relatively fewer university degrees in strongly ageing regions than in regions that did not age to the same extent between 1996 and 2010. These results suggest that demographic change may be associated with changes in the regional structure of human capital and that these are likely driven by factors other than mere population composition.

As a final step, we examined the relative contribution of demographic change to shifts in the human capital composition. By projecting a human capital composition based only on demographic shifts, we could compare the realised effects to a hypothetical scenario where only the population composition changed. The results suggest that, for the time frame 1996–2010, demographic shifts seem to have had only small effects on human capital on a national level. Instead, other factors, such as the general trend of education expansion outweigh demographic shifts. Nevertheless, on a regional level, the decomposition illustrated considerable geographical heterogeneity especially for degrees D2 and D6. In particular, the descriptive analysis shows not only that some regions experience opposite trends to the national average, but also that these regions seem to be geographically clustered. For instance, the majority of regions experiencing increases in D2 despite their demographic structure projecting decreases, are located in Bavaria and Baden-Württemberg. In contrast, most of the regions experiencing decreasing shares of D6 are located in East German Federal States.

As pointed out throughout this chapter, there are two core limitations to these results. First, the focus of the research presented here is descriptive and does not address causality issues. Endogeneity issues exist among human capital measures and age structure as the two variables are closely intertwined. Causality concerns are therefore clearly relevant in the interpretation of the results. Instrumental variable approaches could help support these results but instruments for the age structure are difficult to find, especially considering the limited data availability for regional data in Germany. Due to the lack of empirical studies on this topic, we argue that purely descriptive and correlational analyses such as the ones presented here at least present a starting point for discussion. In this sense, the purpose of this chapter was to examine the co-movements in human capital and population age structure rather than pinpoint the causal channels of influence.

Second, the role of migration is clearly relevant in explaining changes in human capital. Indeed, it is perhaps the most obvious source of endogeneity as it potentially affects both age structure and human capital. This concerns both internal and international migration, neither of which are easily measured at a small geographical scale. This chapter only considered migration superficially, i.e. by controlling for net migration in the regression analyses. Beyond that, migration is implicit in the analysis if it influences the regional age structure. Modelling migrant's contribution to both the age structure and the human capital composition explicitly could help disentangling these effects. An aspect of this problematic is further explored in Chapter 5 of this thesis.

Despite these caveats, the results jointly indicate that the regional age structure is associated with distinct patterns in human capital availability and composition already today. This is relevant because of human capital's status as a prime policy suggestion to address the potential effects of demographic change on productivity levels (e.g. Börsch-Supan, 2003; Kaufmann, 2005). If investment in education is meant to address issues of population ageing, the findings presented here, i.e. that ageing is associated with smaller increases in human capital, could be problematic at a regional level. The pace of education expansion seems to currently still outweigh demographic effects in most regions. As the relative size of cohorts entering and exiting the labour market further shifts, increasingly larger degrees of education expansion may be necessary to maintain increasing shares of, for example, university graduates. This may prove to be challenging especially for rural regions and regions in the east of Germany, which face outmigration of higher-skilled labour.

Moreover, the question emerges what kind of human capital investment would most effectively counteract the potential negative consequences of population ageing on productivity. Academic and political discussions emphasise tertiary education disproportionally, due to its role in innovation and thus economic growth. However, the regional heterogeneity in human capital composition illustrated here implies that education expansion may take different forms, with some regions expanding the share of traditional vocational degrees in addition to or even instead of expanding university education.

In the context of this analysis, no judgement on the consequences of this pattern can be made and it is likely that the impact on regional development depends crucially on the causes for different types of education expansion. Increasing shares of vocational qualifications rather than university degrees may be adaptive to regional economic structure and does not necessarily imply an economic disadvantage relative to regions expanding tertiary education. Similarly, decreasing shares of university graduates for regions in the former GDR may be a consequence of excess supply in the past, which is reduced as skill-mismatch and over-education decline. It could, however, also be a consequence of skill-selective outmigration, which could worsen regional disparities (e.g. Fratesi & Riggi, 2007). More generally, considering the regional heterogeneity in the composition of both age and human capital, benchmarking rates of university graduates (as in the Europe2020 goals) may not be effective in increasing human capital availability in regional labour markets. Instead, place-sensitive policy approaches that take into account regional characteristics in demographic-, human capital-, and industry structure may be more appropriate to address potential negative effects of demographic change.

4.A Appendix

4.A.1 Occupations with complex skills

The share of complex skills was calculated by classifying occupations in the SIAB7510 file as either complex or not complex. The occupational classification was provided by Brunow and Hirte (2009a) and refers to occupational groups in the German occupational classification KldB1988 (Klassifikation der Berufe 1988). Table 4.A.1 shows the groups of occupations classified as requiring complex skills.

Table 4.A.1: Occupation groups with complex skills (Brunow & Blien, 2015)

KldB1988 occupation group	
60	Engineers
61	Chemists, Physicists, Mathematicians
62	Technicians
63	Technical specialists
69	Bank specialists, Insurance representatives
70	Other services agents and related occupations
75	Management consultants, Organisors, Chartered accountants
76	Members of Parliament, Senior government officials
77	Accountants, Data processing specialists
81	Legal and related business associate professionals
82	Journalists, Interpreters, Librarians
83	Artists
84	Physicians, Pharmacists
87	Teachers
88	Humanities specialists, Scientists
89	Ministers of religion

4.A.2 Variable descriptions and summary statistics

Table 4.A.2: Variable descriptions

Indicator		Source
Δ mean age	change in mean age of employees 1996-2010	SIAB
tertiary	share of employees with tertiary education	SIAB
HK	average years of schooling following Tarazona (2010)	SIAB
complex	share of employees in occupations with complex skills according to Brunow and Blien (2015)	SIAB
human capital$_{1996}$	initial level of respective human capital indicator, i.e. HK, tertiary or complex in 1996	SIAB
D$(i)_{1996}$	initial share of degree (i) in 1996	SIAB
Δ D(i)	change in degree type (i) 1996-2010	SIAB
ln GDP p.c.	ln of GDP per capita	RDG
unemployment	unemployment rate	RDG
services	share of services in total value added	RDG
net migration	net migration normalised by population	RDG
female	share women in labour force sample	SIAB
urban	dummy for settlement type with 1=urban, 0 = rural	BBSR
east	dummy for regions of former GDR excluding Berlin	

Data Sources	
RDG	Regional Database Germany
SIAB	Regional File of the Sample of Integrated Labour Market Biographies 1975-2010
INKAR	Indicators and Maps for Spatial and Urban Development (BBSR, 2016)

Table 4.A.3: Summary statistics

variable	obs	mean	std. dev.	min	max
mean age 1996	326	37.511	0.889	34.649	39.273
Δ mean age	326	2.881	0.994	-0.211	5.387
HK_{1996}	326	12.374	0.410	11.581	13.850
$\ln\left(\frac{\text{HK}_{2010}}{\text{HK}_{1996}}\right)$	326	0.038	0.016	-0.014	0.075
tertiary_{1996}	326	9.179	4.504	2.381	29.953
Δ tertiary	326	3.622	2.422	-4.894	11.078
complex_{1996}	326	19.840	5.329	10.060	40.372
Δ complex	326	0.465	2.368	-7.938	10.254
ΔD1	326	-4.309	2.489	-12.092	1.552
ΔD2	326	-3.452	4.174	-14.669	7.991
ΔD3	326	0.267	0.361	-1.149	1.927
ΔD4	326	3.873	1.645	-1.009	8.538
ΔD5	326	0.801	1.052	-2.880	4.640
ΔD6	326	2.820	1.942	-2.880	9.679
D1_{1996}	326	11.532	4.846	1.155	23.865
D2_{1996}	326	73.801	5.407	54.698	86.446
D3_{1996}	326	0.340	0.307	0.000	1.951
D4_{1996}	326	5.149	1.612	1.751	11.450
D5_{1996}	326	4.016	1.666	0.701	12.465
D6_{1996}	326	5.163	3.170	0.719	20.637
GDP p.c.	326	21.376	8.148	10.752	65.293
unemployment	326	10.965	3.775	4.650	22.225
services	326	64.270	9.476	30.450	92.138
female	326	42.352	4.770	26.843	53.829
net migration	326	0.428	0.671	-2.567	3.690
urban	326	0.571	0.496	0.000	1.000
east	326	0.178	0.383	0.000	1.000

4.A.3 Beta convergence in human capital

	(1)	(2)	(3)
dep.var	$\ln\left(\frac{\text{HK}_{2010}}{\text{HK}_{1996}}\right)$	Δ tertiary	Δ complex
$\text{human capital}_{1996}$	-0.113***	0.055	-0.057
	(0.0337)	(0.0373)	(0.0353)
Constant	0.323***	3.120***	1.589
	(0.0843)	(0.2906)	(0.6696)
Observations	326	326	326
R-squared	0.052	0.010	0.002

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.A.4 Regressions by age group without controls

Table 4.A.4: Age group 30-39

1996-2010	Δ D1	ΔD2	ΔD3	ΔD4	ΔD5	ΔD6
Δ mean age	0.042	1.998***	-0.403***	-0.638***	-0.674***	-1.217***
	(0.1261)	(0.4030)	(0.0685)	(0.1721)	(0.0916)	(0.1644)
$D(i)_{1996}$	-0.450***	0.042	-0.186	-0.181***	-0.555***	0.036
	(0.0329)	(0.0474)	(0.1240)	(0.0571)	(0.0644)	(0.0514)
Constant	2.137***	-17.422***	2.092***	8.516***	5.094***	6.603***
	(0.5017)	(2.9059)	(0.2320)	(0.7814)	(0.4619)	(0.6920)
Observations	326	326	326	326	326	326
R-squared	0.412	0.153	0.135	0.042	0.231	0.202

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 4.A.5: Age group 40-49

1996-2010	Δ D1	ΔD2	ΔD3	ΔD4	ΔD5	ΔD6
Δ mean age	-0.206	2.884***	-0.113***	-1.228***	-0.487***	-1.393***
	(0.1347)	(0.3779)	(0.0209)	(0.1786)	(0.0966)	(0.1395)
$D(i)_{1996}$	-0.519***	-0.153**	-0.527***	-0.329***	-0.649***	-0.205***
	(0.0212)	(0.0675)	(0.0880)	(0.1186)	(0.0416)	(0.0710)
Constant	1.652***	-0.410	0.580***	9.822***	4.782***	7.670***
	(0.4108)	(4.7794)	(0.0716)	(0.8571)	(0.3791)	(0.6043)
Observations	326	326	326	326	326	326
R-squared	0.616	0.168	0.232	0.139	0.409	0.192

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

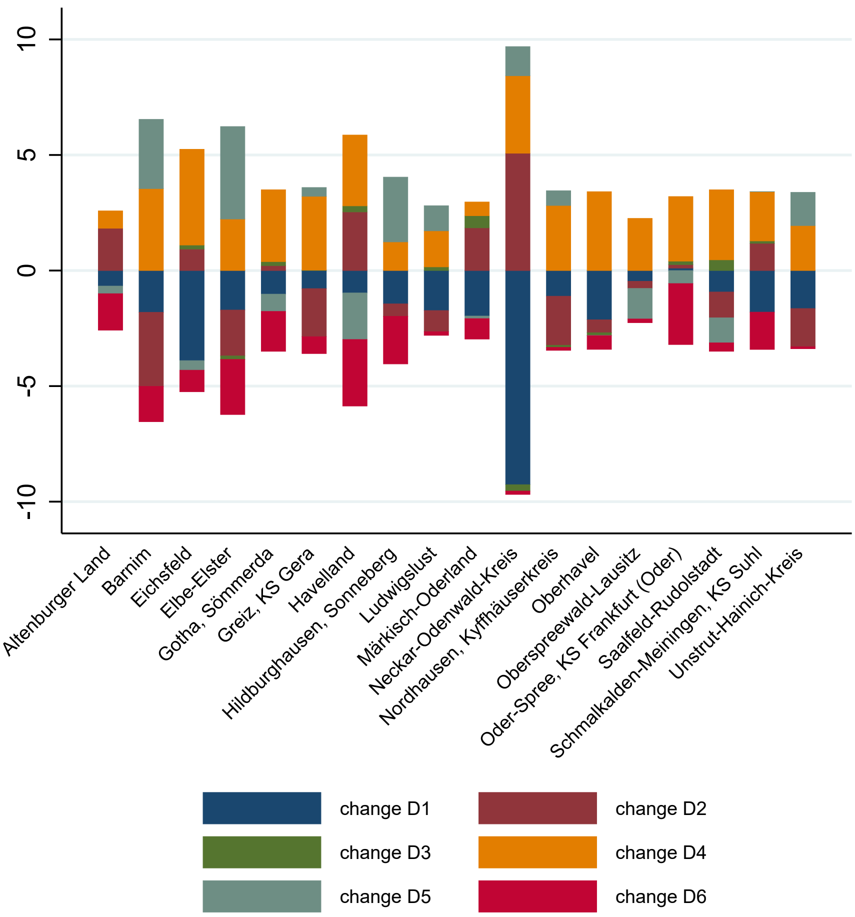
Table 4.A.6: Age group 40-49

1996-2010	Δ D1	ΔD2	ΔD3	ΔD4	ΔD5	ΔD6
Δ mean age	-0.183	3.189***	-0.093***	-0.873***	-0.533***	-1.223***
	(0.1142)	(0.2598)	(0.0200)	(0.1016)	(0.1038)	(0.1353)
$D(i)_{1996}$	-0.548***	-0.673***	-0.803***	-0.791***	-0.458***	-0.343***
	(0.0175)	(0.0519)	(0.0799)	(0.0700)	(0.0507)	(0.0427)
Constant	1.404***	40.536***	0.510***	8.127***	4.142***	8.089***
	(0.3934)	(3.8423)	(0.0659)	(0.4103)	(0.3638)	(0.4785)
Observations	326	326	326	326	326	326
R-squared	0.771	0.455	0.303	0.405	0.369	0.321

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.A.5 Human capital composition for type C and D, D6

Figure 4.9: Human capital composition for regions with type C and D for D6



Chapter 5

Population Ageing and Internal Migration Patterns

5.1 Introduction

Migration takes on a vital role in transmitting demographic changes. Population change is defined by net migration as well as the difference between births and deaths (Preston et al., 2001) and migration is therefore a fundamental determinant of both population size and composition. As described in Chapter 2, outmigration has historically been the dominant factor in causing regional population decline (e.g. Benke, 2004; Rieniets, 2009). Moreover, low fertility and increasing birth deficits associated with demographic changes mean that differences in migration increasingly explain population growth at a national and sub-national level (Bucher & Mai, 2008). Additionally, migration is selective along a variety of dimensions, e.g. age, gender, or skill-levels. Selective migration implies that movement of people is not only redistribution of population but also a sorting of population groups.

The relevance of migration in driving and shaping the processes of demographic change at a national and regional level is therefore clear and well-established in the theoretical and empirical literature. However, the reverse relationship, i.e. the effect of demographic change on migration patterns, has received much less attention. How does regional age structure affect the patterns, volume, and direction of migration flows? And will age-selective migration lead to a regional polarization of age structures? These are the questions addressed in this chapter, which focuses on how regional age structure interacts with determinants of migration flows and individuals' migration decisions. This chapter reviews the theoretical perspectives on the intersection of population ageing and migration from an individual and aggregate perspective to develop testable hypotheses on the relationship between regional age structure and migration patterns.

In the discourse on demographic change, regional population decline and ageing are frequently described as circular processes (e.g. Hoekveld, 2012; Schwarz & Haase, 2010). This implies that demographic change has qualities of cumulative causation, with strongly ageing and shrinking places becoming less and less attractive to migrants. The core mechanism of this circularity is that regional characteristics associated with population ageing or decline may stimulate outmigration and thus worsen the demographic situation. This could be the case e.g. if ageing regions offer reduced labour market opportunities (e.g. because they are less attractive firm locations) or inferior infrastructure provision. Moreover, strongly ageing regions may become less attractive especially for young people because they are adapting to serving a population with different consumption preferences and needs. This reasoning suggests that migration will lead to a regional polarization of demographic structures. Such concerns are inherent in the discussion of how to maintain the principle of equal living standards in ageing and declining regions and were mentioned also in Chapter 3. They may serve as justification for regeneration policies aimed at attracting immigrants to regions struggling with high outmigration.

However, there are also theoretical reasons why regional population ageing may lead to a slow-down of outmigration, which would contradict the notion of migration and ageing as mutually reinforcing. Decreasing propensity to migrate over the life course implies that older regions should see less outmigration simply because a larger part of the population is in their less mobile life stage. Similarly, the notion of "generational-crowding" suggests that mobility may increase with cohort size, which would indicate that small young cohorts have less incentive to migrate (Zaiceva & Zimmermann, 2014). Alternatively, an older regional age structure could imply more job openings due to retirement, which would act as pull factor to ageing regions. In this sense, migration could help clear regional labour markets by redistributing surplus labour and meanwhile even out regional age structures.

Even though concerns of circular ageing and decline are common in the political and academic discourse, there is only limited empirical evidence on migration as a consequence, rather than as a driver, of demographic change. Some insight can be drawn from studies on the role of primary school closures as drivers for depopulation (Barakat, 2015; Hyll & Schneider, 2011). The potential for migration to respond to demographic change is also implicitly addressed in some of the literature on East-West migration in Germany, especially when it considers the effect of migration on population concentration (e.g. Kemper, 2004; Kontuly, Vogelsang, Schon, & Maretzke, 1997), but also more generally the effects of selective migration on regional convergence (Granato, Haas, Hamann, & Niebuhr, 2015; J. Hunt, 2006; Kubis & Schneider, 2016). Nevertheless, the main focus of the empirical literature remains on how migration affects demographic change.

Migration is often automatically considered to be referring to international migration. This may be due to the steadily increasing scale of the phenomenon: the international migrant stock reached 244 million in 2015 with Germany hosting the second largest absolute number of migrants (12 million) worldwide, after the United States (47 million) (United Nations, 2016).[1] The scale of international migration as well as the fact that

[1]It is interesting to note that Germany already hosted the second largest number of migrants in 2010,

it represents an exogenous increase in population size and labour supply ensure that it will continue to play a large role in demographic developments. However, international migration will generally not be able to prevent or reverse the effects of population ageing in Europe (Coleman, 2006a, 2008).

Focusing on international migration neglects the effect of population redistribution between regions, i.e. internal migration, which also is an influential factor in driving demographic change on a regional scale. Research on internal migration patterns has receded with increasing prominence of international migration, despite the much larger absolute number of internal migrants[2] and the awareness that migration behaviour may differ by scale (Ellis, 2012; Wright & Ellis, 2016). An aspect of internal migration that makes it particularly interesting in the context of demographic change is that it represents a redistribution of population from one region to another. Thus, internal migration affects both the sending and receiving region, which is particularly relevant when considering the issue of potential cumulative causation in spatial distribution of population. In contrast to international migration, which only represents an addition of external population, internal migration flows illustrate the growth of some region at the cost of depopulating regions elsewhere. Additionally, because internal migrants are more similar to the resident population, institutional factors such as language and transferability of degrees are likely to constrain labour market access less than for international migrants.

The aim of this chapter is therefore to investigate the role of population age in explaining internal migration patterns in Germany in the time period 1996-2010. It adds to the existing literature on regional migration by emphasising population ageing as a contributor rather than only consequence of migration. The empirical approach tests the relevance of age structure in explaining migration both from a micro and a macro-level perspective. Using a sample of individual employment biographies (SIAB7510), we test whether regional age structure affects individuals' propensity to migrate as well as their destination choice. We complement these results with an origin-destination gravity model for district regions based on migration flows from the German Migration Database (Sander, 2014). This combined approach allows not only testing the overall trends in migration across ageing regions but also considering the interplay of regional age structure and individual characteristics of the migrants. While descriptive in nature, the analysis allows testing whether the patterns of migration are consistent with migration and population ageing as reinforcing or opposing processes, which is relevant in the discussion on policy responses to population ageing.

This chapter proceeds as follows. The next section discusses the theoretical background and empirical literature on ageing and (internal) migration. Section 3 describes the dataset and method for the analysis of individuals' migration propensity and destination choice among ageing regions. Section 4 summarises some descriptive statistics and

i.e. prior to the 2015 European refugee crisis (United Nations, 2016).

[2]For instance, the number of international immigrants entering Germany between 1997 and 2010 was on average 777 000 per year (with 675 000 leaving), while 2.5 million people change residence between districts in Germany each year (Destatis, 2016b).

section 5 presents the results on individual migration decisions. Section 6 implements a supplementary analysis of aggregate migration patterns based on a gravity model. The last section discusses the results and offers concluding remarks.

5.2 Background and literature

The patterns of migration have inspired a large literature starting with Ravenstein's (1885, 1889) empirical observation of the laws of migration, most of which, remarkably, still hold true to some degree today (Wright & Ellis, 2016). A complete review of migration literature is beyond this chapter[3] so we will focus on those aspects that are most relevant to the intersection between demographic change and migration. First, we demonstrate the relevance of migration in a context of demographic change before describing the literature on regional migration patterns in Germany. Then, the theoretical concepts linking population age structure to migration behaviour will be discussed.

In line with common definitions (Siegel & Swanson, 2004), migration is defined as a change in residence. *International migrants* are individuals who change residence between one country and another, whereas *internal migrants* change residence between sub-national regions within the same country. As we will focus on internal migration, we consider migrants to be internal unless otherwise stated.

5.2.1 Migration in times of demographic change

In a context of demographic change, i.e. low and decreasing fertility coupled with increasing life expectancy, migration becomes a fundamental determinant of population development. As the natural balance, i.e. difference between births and deaths, tends towards zero and eventually negative values, net migration becomes the driver of population growth. Bucher and Mai (2008) decompose population change into natural and migratory balance for 1500 regions in 34 European countries and show that migration is influential not only in population development but also as a driver of regional heterogeneity. On a national level, Germany's natural balance has been negative since 1972, indicating that all population growth since then has been exclusively due to net immigration. Applying the Webb classification (Webb, 1963) to German regions as discussed in Chapter 2 shows that there is more diversity on a regional level but migration clearly shapes population growth and decline. There is only one German region where a birth surplus is enough to compensate a migratory deficit whereas a positive net-migration outweighing a birth deficit occurs in 97 regions. Also, 14.94% of the population live in regions that shrink even despite positive net migration.

The increasing role of migration in shaping national and regional population development implies that both internal and international migration flows become relevant in

[3]See e.g. Molho (1986); Massey et al. (1993); White (2016) for reviews on migration theory in general and Etzo (2008); Greenwood (1997) for internal migration specifically.

determining demographic structure. International migration is particularly emphasised in this context as it represents a net inflow to a national economy rather than a redistribution of population. International immigration not only increases population size but may also shift the age structure, as migrants are generally relatively young. Thus, countries struggling with a decreasing working-age population may rely on international migration to bolster labour supply and increase human capital. Additionally, migrants from countries with higher-fertility levels may have more children, thus counteracting the trends of demographic transition.

However, international immigration is unlikely to solve issues of a declining population in the long-term and cannot prevent population ageing. Fertility levels of immigrants converge to those of the native population quite quickly (Mayer & Riphahn, 2000; Milewski, 2010) and migrants themselves, albeit initially younger, age in their host country. These issues coupled with the degree of population ageing already occurring in most industrialised countries imply that the necessary levels of immigration are unrealistic and unsustainable. As pointed out before, to maintain the German potential support ratio at its level of 1998, Germany would need a net gain of 3.4 million international immigrants per year until 2050 (United Nations, 2000). Although the United Nations (2000) suggests that the levels of migration needed to keep the population level constant or to maintain the size of the working-age population are more attainable (324 000 and 458 000 per year respectively), migration of this scale could have profound effects on the ethnic composition (Coleman, 2006b, 2008) and may be prevented by public opinion towards migration (Ceobanu & Koropeckyj-Cox, 2013). Moreover, if it is meant to address potential economic issues associated with a shrinking and ageing labour force, migration policy would need to be highly selective with respect to both age and skill-level of international immigrants (Fehr, Jokisch, & Kotlikoff, 2004). It should further be noted that even if international immigration may be able to slow down population ageing and decline on a national level, its effects on regional demographic structure entirely depend on where immigrants settle.

Thus, while migration patterns gain in importance especially when fertility decreases with progressing demographic change, immigration alone cannot solve the prospect of population ageing. This applies even more strongly to the case of internal migration, where each population gain is offset by population loss elsewhere. We now turn to describing the patterns of internal migration in Germany.

5.2.2 Regional characteristics and internal migration

As a spatial relocation, migration is clearly affected by the regional characteristics of both the origin and destination. The role of distance and economic factors were already emphasised as early as Ravenstein's (1885, p. 189) laws on migration, which observed that most migrants travel only short distances and that there are "'currents of migrants' setting in the direction of the great centres of commerce and industry which absorb the migrants". Stouffer (1940) proposed a theoretical framework that explained migration not by distance but by the number of opportunities available at each location. The concept of opportunities further inspired Lee's (1966) theory of migration, which identifies that factors influencing migration are those associated with the origin, those associated with the destination, "obstacles" between origin and destination, as well as personal characteristics (see e.g. Willekens, 2016).

These perspectives remain central to current theoretical and empirical study of migration and are reflected for example in the concepts of *push* and *pull factors* influencing the likelihood of individuals leaving or entering a specific region. These push and pull factors usually include economic conditions, such as wage-differentials and unemployment rates in the Harris-Todaro model of migration (Harris & Todaro, 1970). However, economic factors alone do not explain migration patterns, which illustrates the relevance of place characteristics such as amenities (e.g. Graves, 1976; Partridge, 2010; Rodríguez-Pose & Ketterer, 2012). Moreover, distance, while neither a push or pull factor, is an indicator of the cost of migration, both in terms of the physical costs of relocating but also in influencing aspects such as information flows or psychic costs of migration and remains a relevant factor in explaining migration (e.g. Cushing & Poot, 2004). A literature review on the empirical evidence for these respective types of push and pull factors is highly context-dependent and beyond the scope of this paper. We thus refer the reader to literature on internal migration more generally (T. Champion, Cooke, & Shuttleworth, 2018; Etzo, 2008; Greenwood, 1997, 2016) and in the following describe the trends in migration in the German context only.

In international comparison, German internal migration intensity is intermediate, with roughly 9% of the population changing residence per year (Sander, 2018). Although German mobility has decreased slightly between 2000 and 2010, it is overall remarkably stable (Berentsen & Cromley, 2005), which Sander (2018) attributes to a balanced settlement structure, relatively small economic disparities, and a housing market shaped by renting.

The historical context of division and reunification largely dominates the recent empirical literature. Wolff (2006) presents a literature review on East-West migration and estimates that 2.77 million people emigrated from the former GDR to West Germany between 1989 and 2002 with net migration constituting 7.5% (1.3 million) of the initial East German population. East-West migration is not only relevant due to its sheer volume but also due to its pronounced selective nature: migrants from the East to the West are relatively young and female (Kröhnert & Vollmer, 2012; Mai, 2006) as well as highly educated (J. Hunt, 2000; Schneider, 2005). Moreover, although it remains a defining trend, two waves of East-West migration have been documented: an initial one after reunification (1989-1991) and a second one from 1997 to 2001 (e.g. Heiland, 2004). Schlömer (2004) argues that these two waves of outmigration differ with respect to their destination regions: while the first wave went to regions close to the former border and was seemingly unaffected by economic opportunities, the second wave followed the usual pattern of internal migration within Germany and ended up in regions generally deemed attractive for economic reasons.

It should be emphasised that the issue of East-West migration is not simply a problem of outmigration but fundamentally also one of too little in-migration. Schlömer (2004) illustrates that the age group of 18-29 years is not more likely to leave East German regions than West German regions but that West German individuals of that age group are significantly less likely to move to the East. Although some cities in East Germany, especially university cities, have recently become more attractive (e.g. Köppen et al., 2007; Rink, Haase, Großmann, Couch, & Cocks, 2012) West-to-East migration remains less frequent (e.g. Mai, 2006). Indeed, in order to stimulate migration, East German regions have begun implementing policies to encourage former out-migrants to return, although the volume of such return migration remains small (M. Fuchs & Weyh, 2016).

Besides the strong focus on East-West migration in the literature, there is also a concern for the role of migration in shaping the regional settlement structure in Germany. A number of descriptive analyses distinguish migration to and from core agglomerations, urban areas, and rural areas (Mai, 2006; Schlömer, 2004). Sander (2014) analyses district-level migration flows and illustrates a trend of increasing concentration of population in urban core areas rather than suburbanization, especially for young age groups. Indeed, young adults (18-24) are increasingly undertaking longer-distance moves to large cities, whereas 30-49 year olds are becoming less likely to leave the urban core (Sander, 2018).

The pronounced patterns of migration between former East and West Germany but also internal migration more generally illustrate the need to consider the empirical evidence on which regional characteristics drive the migration flows in Germany. The relevance of economic circumstances, especially labour market opportunities, is well-documented. Specifically, both wage differences and unemployment differences have been found to motivate internal migration patterns in Germany (Decressin, 1994; Parikh & Van Leuvensteijn, 2002). J. Hunt (2006) shows that the decrease in emigration from East Germany in the mid-90s can be explained by rising wages and that unemployment differentials had smaller effects. Studies on migration behaviour of unemployed individuals show that local labour market opportunities increase mobility among the unemployed (e.g. Arntz, 2005; Fahr & Sunde, 2006). A related stream of literature studies the role of internal migration in facilitating economic convergence and generally finds that migration does not sufficiently support convergence (e.g Fendel, 2016; Kubis & Schneider, 2016) and may even lead to further divergence especially when migrants are high-skilled (Granato et al., 2015).

Although relevant, theory as well as empirical research confirm that economic factors alone cannot explain internal migration in Germany (e.g. Bierens & Kontuly, 2008; Buch, Hamann, Niebuhr, & Rossen, 2013; Goetzke & Rave, 2013). Regional amenities have been included in a number of studies, for instance via property prices (Goetzke & Rave, 2013) as well as directly by including aspects such as crime rates, childcare facilities or hotel capacity to proxy for attractive cultural or natural environments (Arntz, 2010). In a study on 71 German cities, Buch et al. (2013) show that besides labour market conditions, quality of life matters in explaining migration balances. Alfken, Vossen, and Sternberg (2017) also find significant roles for labour market conditions and living costs as well as a positive effect of cultural diversity but a negative one for a tolerance measure (based on foreign population, international marriages and civil unions) in the spirit of Florida's creative class (e.g. Florida, 2002). Culture may shape migration patterns even more intangibly, as historic dialect similarity from the 19th century is positively associated with today's gross migration rates, which could demonstrate the role of cultural borders in labour market integration (Falck, Heblich, Lameli, & Südekum, 2012).

A final stream of literature on German internal migration explicitly focuses on the role of self-selection. This perspective is valuable because the consequences of migration both for the sending and receiving regions crucially depend on who migrates. Selection effects are usually considered along two dimensions: age and education. As mentioned above, German East-West migrants for instance are generally found to be relatively young (e.g. Bucher & Heins, 2001; Mai, 2006) and female leading to a strongly skewed sex ratio in East Germany for some age groups (Kröhnert & Vollmer, 2012).

Skill-selective migration is often analysed in the context of the Roy model, which predicts that higher-skilled individuals are motivated by relative earnings and thus attracted to regions with a higher variance in the earnings distribution (Borjas, 1987; Borjas et al., 1992). Thus, an initially larger earnings inequality in West German regions could explain why East-West migrants are relatively highly skilled as well as why outmigration slowed when inequality in East Germany started to increase (J. Hunt, 2000, 2006). Brücker and Trübswetter (2007) also fit a Roy model and while they find that highly-skilled individuals do not have a higher propensity to migrate they find that East German migrants are positively selected on their earnings potential. Studies on internal migration in reunified Germany and West Germany show that high-skilled individuals may be more responsive to labour market conditions (Arntz, 2005, 2010). Additionally, higher-skilled workers may also be attracted to regions with both higher average wage and higher inequality in employment which demonstrates that skill-selective migration may continue despite wage convergence (Arntz et al., 2014). More generally, outmigration of the young and highly-skilled remains a challenge for East German regions (Nelle, 2016; Schneider, 2005) but could in principle affect any region especially if selective outmigration becomes self-reinforcing.

5.2.3 Age and migration behaviour

The previous section set out the literature on internal migration dynamics for Germany. We will now turn to discussing the role of population ageing in migration behaviour, first from an individual and then from an aggregate perspective.

Age and migration propensity

Economic theories of migration at an individual level assume that "migration results from forward-looking behaviour that aims to maximise an individual or household's expected well-being over some time horizon by means of relocation" (Cushing & Poot, 2004, p. 320). The predominant approach to model migration behaviour in economic studies is in the tradition of human capital theory (Becker, 1962; Schultz, 1961) and follows Sjaastad's (1962) seminal idea to consider migration an investment and evaluate its costs and benefits. Thus, migration from region r to region s occurs if the expected utility (EU) in region s less the costs of moving (C) outweigh the benefit of staying in region r. However, both expected utility and costs of moving vary over the life course and are therefore a function of an individual's age a:

$$EU(a)_s - C(a) > EU(a)_r \tag{5.1}$$

Factors that increase the expected benefit or decrease the costs of moving will make migration more likely. In general, improvements in the (economic) opportunities in the destination region increases the net benefit of migration, while improvements in the origin location decrease it. Moreover, an increase in the cost of migration decreases the net benefit (see e.g. Borjas, 2015; Greenwood, 2005, 2016). Also, migration costs can be non-pecuniary, such as the burden of being separated from social connections in the home region.

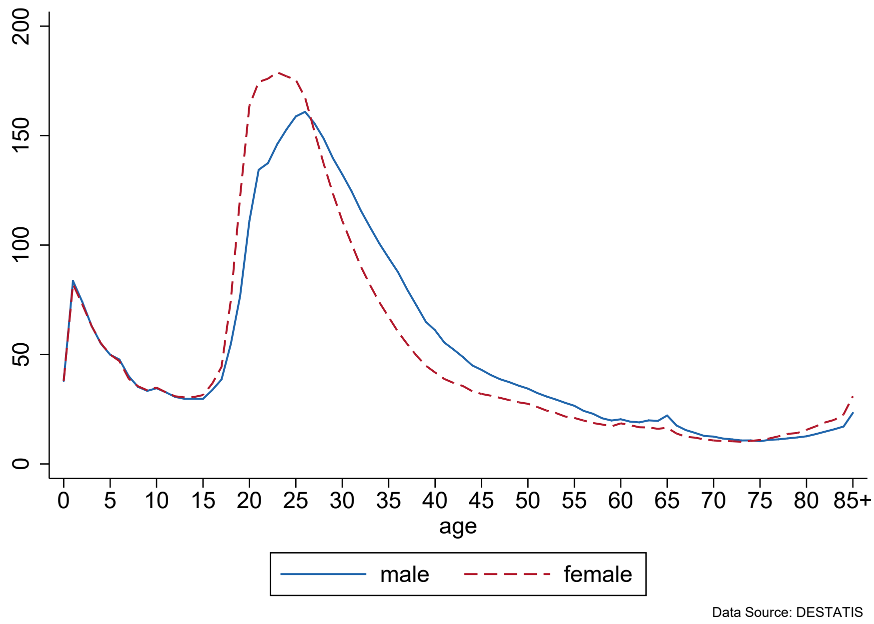
An individual's age influences the expected utility of moving because any differences in utility between the origin and destination region accrue over the lifetime. This is perhaps most obvious for wage differentials: With a fixed retirement age, a migrant will gain the wage difference between origin and destination over the remaining time horizon of their employment. Thus, a younger individual will have a longer period of activity remaining and experience the benefits of moving for a longer time than an older individual (e.g. Green, 2018). Additionally, the costs of migration may increase with age, e.g. because older individuals will have collected a larger amount of local social and human capital or face higher costs of job-search (Zaiceva & Zimmermann, 2014). Therefore, theoretical models along the framework of human capital theory predict that, ceteris paribus, moving will be more profitable and more frequent for a younger person than an older one.

The empirical literature is in considerable agreement in finding an inverse U-shaped profile with maximum propensity to migrate occurring in the early 20s (Zaiceva & Zimmermann, 2014). Simple descriptive analyses of migration rates by age group similarly show that migration propensity generally peaks in the early 20s for both genders (Bucher & Heins, 2001; J. Hunt, 2006). Figure 5.1 shows migration rates over the life course for migration across municipalities within Germany in 2010[4] and clearly indi-

[4]Due to data availability, figure 5.1 only considers the year 2010. However, the shape of the migration schedule is almost identical to similar graphs for previous years as well as internationally (see e.g. Rogers, Raquillet, & Castro, 1978; Rogers & Castro, 1979).

cates peak migration rates in the early 20s. Research using individual-level probability models of internal migration find similar effects for a variety of countries, e.g. in the UK (Böheim & Taylor, 2002) and China (Bodvarsson, Hou, & Shen, 2016). Moreover, migration propensity is also found to vary with other individual characteristics that increase either the benefits or the cost of migration, e.g. skill-level, employment as well as marital status (Etzo, 2008).

Figure 5.1: Migration rates (per 1000s) across German municipalities in 2010



Besides explaining migration in a human capital framework, the age-pattern in migration propensities can also be linked to transitional life events, such as entry or exit of higher education, entry in the labour force, or family formation (Bernard, Bell, & Charles-Edwards, 2014). Such life-course perspectives on migration yield persistently regular migration schedules illustrating peak migration propensity at young adult ages, when transitional life events occur more frequently (Rogers & Castro, 1979; Rogers et al., 1978). Additionally, some life-stages may inherently decrease mobility e.g. as individuals form families (see literature on family migration, e.g. Kulu & Milewski, 2008; Mincer, 1978), become homeowners (Dieleman, 2001; Hämäläinen & Böckerman, 2004; Van Leuvensteijn & Koning, 2000), invest in a local social network or generally settle down (Fischer & Malmberg, 2001).

Life-course differences in migration also motivate research into migration trends for specific life-stages, thus acknowledging that the benefits, costs, and motivations underlying migration may differ with age. For instance, the large literature on graduate mobility emphasises labour market factors as motivating migration propensity as well as destination (Abreu, Faggian, & McCann, 2015; Busch & Weigert, 2010; Faggian, McCann, & Sheppard, 2007; Iammarino & Marinelli, 2011; Krabel & Flöther, 2014; Smith & Sage, 2014). While graduate mobility may coincide with the peak-age for mobility, a secondary peak has been suggested to exists for retirement migration (Rogers et al., 1978), especially in cases of return migration (e.g. Cobb-Clark & Stillman, 2013; Constant & Massey, 2003). Indeed, Figure 5.1 also show a very slight increase at retirement age as well as a slowly increasing trend for very high ages (i.e. the open ended category 85+).

Age-specific destination choice

So far, we have found that age is an influential factor in determining whether someone is likely to migrate. However, age may not only influence the costs and benefits of relocation, but also which destination region maximizes the net gain. Since the push and pull factors that are most influential in shaping migration decisions may shift over the life-course, migrants of different age groups may choose different destination regions. For instance, as described above, labour market conditions are relevant for young migrants but individuals close to or after retirement will benefit less from wage differentials or employment opportunities. For retirees or workers towards the end of working-age, other regional characteristics, such as costs of living, access to health care and amenities, climate as well as proximity to relatives and friends may be more important (for overviews see A. Davies & James, 2011; Zaiceva & Zimmermann, 2014). Moreover, different age groups have different demands for public service provision, with, for example, school provision a crucial concern for families (e.g. Barakat, 2015; Hyll & Schneider, 2011; Slee & Miller, 2015) but less so for retirees. Migration thus allows individuals to sort spatially according to their preferences, for instance in terms of labour market conditions, amenities or public service provision.

For instance, Chen and Rosenthal (2008) show for US metropolitan areas that young households migrate to areas with good business environments whereas households near retirement move away from these places and instead towards places with a high level of amenities. For Germany, Goetzke and Rave (2013) find that young age groups (18–29 years) are relatively more motivated by amenities as they move towards regions with lower wages and high property prices whereas middle-aged workers (30-49) are attracted by employment opportunities and lower property prices. In contrast to the notion that costs of living are important in determining retirees' location decisions, Goetzke and Rave (2013) find that the elderly (above 65 years) are attracted to large cities with high property prices, arguing that this reflects a high value of amenities. J. Hunt (2006) presents evidence that young emigrants from East to West Germany between 1990 and 2000 were more sensitive to wage differentials, while older migrants were more sensitive to unemployment in the origin region. This illustrates that even for working-age migrants, the preferences for destination regions may differ with age.

The effect of age on destination choice is relevant from an individual and a regional perspective. If an individual's destination choice depends on their age, regions with specific characteristics will be more attractive for some age groups than others. Thus, migration can lead to a sorting of population across regions according to their age and change the demographic composition of both the origin and destination regions. If older regions are less attractive to young migrants, e.g. because of different preferences, migration will reinforce trends of population ageing, which could lead to a polarization of demographic structure across regions.

Age structure as a regional determinant of migration

Beyond age affecting an individual's migration propensity as well as destination choice, there are also potential aggregate effects of age structure on migration patterns. In particular, regional age composition may affect migration through compositional effects and cohort-size effects (see e.g. Plane, 1993).

The compositional effect of demographic change implies that with progressing population ageing, the younger age groups will be relatively smaller than the older age groups. As we have identified in the previous section, peak migration propensity occurs in the early twenties and generally falls with age. Thus, a region with an older age structure should see relatively less outmigration simply because fewer individuals are in the age groups that are most at-risk of migrating (Green, 2018). The compositional effect works on the aggregate rather than the individual level. It predicts that older regions should see less outmigration, but it does not offer any insight on an individual's propensity to migrate or on in-migration.

Beyond the compositional effect on migration, age structure could also indirectly affect propensity to migrate. Drawing on Easterlin's (1980) work on cohort size effects, Rogerson (1987) suggests that large cohorts have lower migration propensity. He argues that increased labour and housing market competition for large cohorts lead to an increased share of two-worker households, which are less likely to migrate. The large baby-boom generation could thus explain the reduction in internal migration rates for the US (Cooke, 2018; Plane & Rogerson, 1991; Plane, 1992). If only the large cohort itself is affected by reduced migration, mobility could in principle recover as smaller young cohorts enter the most mobile ages. However, "generational crowding" associated with the large baby boom cohort could also reduce labour and housing market opportunities for the following younger cohorts and thus reduce mobility for all age groups (Cooke, 2018; Zaiceva & Zimmermann, 2014). While these patterns seem to explain mobility changes in the US, Australia, where the baby boom has different characteristics, does not show reduced migration for the large baby-boom cohort (Sander & Bell, 2016).

These theoretical reasons suggest that the age structure of a region is influential in determining migration. This pattern has empirically been studied especially for international migration, e.g. to the US. For instance, Hatton and Williamson (2002, 2003) find that origin countries' shares of young population (15-29 years) are positively related to gross emigration rates although significance may depend on model specification (Belot & Ederveen, 2012; Clark, Hatton, & Williamson, 2007). Zaiceva and Zimmermann (2014) show that for immigration to Germany between 2000 and 2011 the share of population aged 15-29 years in the origin country is positively significant for migration from advanced economies only prior to 2008. In contrast, the share of young people is negatively significant after 2008 and insignificant for other countries. The results show that age structure, while potentially a driving factor of outmigration, interacts with other factors such as the economic situation in both the sending and receiving countries. On a regional level, Rodríguez-Pose and Ketterer (2012) conclude that young regions face relatively more outmigration. For Italian internal migration, Biagi, Faggian, and McCann (2011) find that the age group 20-39 years is especially relevant in explaining patterns of long-distance migration.

5.2.4 Hypotheses

The literature review has shown that, despite a vast literature on migration and an academic consensus on its relationship with demographic change, there is relatively little literature focusing on the interrelations between regional age structure and migration behaviour. Aggregate studies of migration often include the share of young population as a control variable for age structure (e.g. Biagi et al., 2011; Hatton & Williamson, 2002, 2003; Rodríguez-Pose & Ketterer, 2012) thus acknowledging its relevance but only superficially analysing its effects. In a US context, Plane and Rogerson especially contributed influential research on this relationship (e.g. Plane, 1992; Plane & Rogerson, 1991; Rogerson, 1987) but this literature addresses the effect of the large baby-boom generation entering their most mobile life stages. Current migration is likely still influenced by the role of this cohort, but the baby-boomers are now driving regional ageing and nearing retirement. Micro-level studies emphasise the relevance of an individual's age in determining migration propensity as well as destination choice (e.g. Goetzke & Rave, 2013; J. Hunt, 2006; Millington, 2000) but neglect the effect the regional age structure may have on individuals. Especially considering the potential cumulative causation inherent in demographic change and migration, age-selective migration patterns are clearly important and under-researched.

In the following, we will first address the role of the regional age structure in affecting individual migration behaviour. First we will test whether regional age structure affects individuals' migration propensities. The literature does not yield a clear prediction of whether an individual should be more or less likely to leave an older region, once we control for the individual's age. If regions with an older age structure are older because of amenities that are less attractive to all age groups, we would expect migration propensity to increase with regional age. However, since preferences differ by age group, the effect of regional age structure on individual migration propensity is not clear. We test for age-selective factors in migration propensity by testing interaction effects between regional age structure and individual characteristics.

Second, we test whether individuals' destination choices depend on regional age structure. Again, it is not theoretically clear whether individuals will on average choose older regions, unless there is some feature of ageing regions that make them less attractive in general. However, if sorting by age exists, the effect of regional age structure should differ by individual age.

The micro data, while allowing to test for potential sorting effects, cannot account for the described aggregate pattern of population composition or cohort size effects. Instead, we analyse aggregate migration flows between German regions, to test if the patterns of the individual level also hold for aggregate population flows. If outmigration indeed increases with the size of the young age group as suggested by the composition effect (as shown for instance in Hatton & Williamson, 2002, 2003; Rodríguez-Pose & Ketterer, 2012), regions with an older mean age should see less outmigration. Similarly, cohort size effects would suggest that relatively old regions should see less mobility. In contrast, if older regions are less attractive, we would expect larger outmigration from older regions, which would be consistent with concerns of cumulative causation and older regions experiencing increasing ageing and depopulation.

5.3 Methodology

5.3.1 Data

Availability of micro-level migration data for Germany is limited. Germany does not maintain a regular census and the yearly microcensus as well as most surveys are not representative at small geographical units such as the districts considered here. In line with similar studies on regional-level migration in Germany (Arntz, 2005, 2010; Arntz et al., 2014), we instead use administrative labour force data to identify internal migrants by change of employment region.

The source for the micro data is, as in the previous chapter, the Sample of Integrated Labour market Biographies 1975-2010 (SIAB7510). To reiterate, the dataset is a 2% sample of administrative social security records, which contain information on individual characteristics such as age, gender, education levels[5], average hourly wage, occupation and district of employment. The dataset covers those enrolled in compulsory social security (*sozialversicherungspflichtig Beschäftigte*) and thus excludes the self-employed and public servants. Additionally, although the dataset contains unemployed individuals, we limit the sample to employment spells because we define migration based on employment location, which is missing for the unemployed.

One of the conceptual challenges of migration research is how to distinguish migration from temporary relocation (Willekens, 2016), which is why we implement a minimum duration of all spells to be 30 days. Therefore, a migrant in the sample is someone who changed region of employment at least once in the considered time frame and stayed in the new location for at least 1 month. We classify each observed individual as either migrant or non-migrant for each year. For non-migrants we use the first employment spell per year, while we use the first migration event for migrants. For all individuals

[5]Imputed for data quality using the strategy suggested by (Fitzenberger et al., 2006).

we include age, gender, education level and average daily wage for their current job (i.e. prior to migration).

The individual data is matched to regional characteristics obtained from the Regional Database Germany, which is compiled by the Federal Statistical Office and Statistical Offices of the Länder (2014) and thus represents official statistics for districts. Each individual is matched with the regional characteristics of their initial employment region (origin). For migrants, the regional characteristics of the destination region are also added. Due to data availability, we restrict the analysis to the years 1997-2010. A list of all variables, their definitions, and sources is presented in Appendix 5.A.1.

5.3.2 Ageing measures

As in the previous chapter, regional age structure is operationalised via the mean age of the employed labour force. This measure is calculated from the SIAB7510 dataset and represents a continuous and simple measure of the relative ages of districts. As discussed previously, accurate mean and median ages require population by age-year rather than by 5-year age group[6], which is only available for German districts from 2003. Thus, in place of population mean age, the mean age of the employed labour force offers a sensible and highly correlated approximation of the regional age structures. Furthermore, the mean age is preferred over median age here because it is a continuous measure thus offering a larger extent of cross-sectional and time variation than median values.

Migration studies frequently use the share of young population (e.g. younger than 25 years) as an indicator of age structure. Similarly, the share of population above retirement age (i.e. population above 65 years) represents an intuitive proxy of age. Both these measures are relevant but do not reflect the full extent of the age structure because two regions with the same share of young population may still have different population composition along the remaining age groups. This issue is avoided by using mean or median age rather than population shares. A further possibility is to calculate an indicator that uses age group sizes but combines them into a single index such as the *Billeter J* measure (see e.g. Mai, 2003).

$$|\text{Billeter J}| = \left| \frac{P_{0-14} - P_{50+}}{P_{15-49}} \right| \tag{5.2}$$

The Billeter J captures the demographic growth potential of a population based on the relative size of the reproductive age group. A positive Billeter J indicates a majority of pre-reproductive age groups, whereas a negative one shows a majority of

[6]Population data for sub-national units is often reported as population per five-year age group (i.e. population of age 40 to 45 rather than population at ages 40, 41, 42...). Calculating a median out of age group data yields the median age group (i.e. the median individual falls in age group 40-45). Calculating mean age out of age groups requires assumptions on the distribution of ages within the age group (e.g. 1/5 of the population in the age group 40-45 is in fact 40 years old). Both of these measures are imprecise and reduce variation in the sample because most regions will have a median age in the age group 35-40 for most years.

Table 5.3.1: Overview of ageing indicators used

Variable	Description
mean age	Mean age of the employed work force
young	Share of population younger than 25 years
elderly	Share of population above 65 years
$\lvert$Billeter J$\rvert$	Ageing indicator based on relative size of reproductive age group. Absolute value used, so $\lvert$Billeter J$\rvert$ increases with age
pop. by age group	Population by age group: 0-19, 20-29, 30-39, 40-49, 50-64 and 65+

post-reproductive age. For Germany, and as a consequence of the almost inverted population pyramid, the Billeter J is negative for all regions. To simplify interpretation, we therefore define and use the absolute value $\lvert$Billeter J$\rvert$ in all estimations, in which a larger value corresponds to an older population.

Instead of using shares or average ages, the age structure can also be captured by using the sizes of different age groups simultaneously. This approach has the benefit of representing the full age structure but may create problems of multicollinearity in regression, since age group sizes are relatively highly correlated with each other. For all following analyses, the mean age of the employed labour force remains our preferred indicator. However, we test robustness of our results to using the other four described measures of ageing (Table 5.3.1).

5.3.3 Method

We analyse individual-level migration behaviour in a separate framework for the initial migration decision and the destination choice. The first step considers the generation component usually associated with push factors, the second step investigates the distribution component, i.e. the role of pull factors (Willekens, 2016). A caveat of this approach is that it assumes separate and sequential decision of migration where, in reality, the decision whether or not to migrate may be interrelated with the destination choice. To accurately model migration behaviour, these decisions may thus need to be considered jointly, e.g. using a nested logit model with a degenerate branch (G. L. Hunt, 2000; Pellegrini & Fotheringham, 2002). Despite this acknowledgement, the literature on individual migration commonly models generation and distribution components separately as it is computationally and intuitively simpler (for migration propensity e.g. Finnie (2004); J. Hunt (2006) and for destination choice e.g. Jayet, Rayp, Ruyssen, and Ukrayinchuk (2016)).

As we are primarily interested in whether migration patterns are differentiated by regional age structures and not by the fundamental determinants of the migration decision we follow this approach and investigate the role of regional age structure separately among regional push and pull factors. The following subsections discuss the estimation strategy for both these approaches before presenting the results.

Propensity to Migrate

To examine the relationship between regional age structure and propensity to migrate, we estimate a model with a binary dependent variable of migration, which is either $y = 0$ (for non-migrants) or $y = 1$ for migrants. Although it is possible to formulate a linear model of migration propensity, linear probability models have well-known drawbacks such as non-normality and heteroskedasticity of the error terms as well as predictions of probabilities outside the bound of 0 and 1 (e.g. Wooldridge, 2008). For these reasons, we focus here on the results from a logistic regression model.[7]

The migration decision can be derived from an underlying latent variable model (e.g. Wooldridge, 2008):

$$y_i^* = \beta_0 + \beta_1 \text{Mean Age}_r + \gamma IC_i + \delta RC_r + e_i \qquad y_i = I[y_i^* > 0] \tag{5.3}$$

y_i^* is the unobserved latent variable for individual i. In line with the theoretical depiction of migration decisions as investment (Sjaastad, 1962), equation (5.3) could be considered a reduced form representation of factors influencing the relative utility of migration out of origin region r for individual i. Thus, the decision to migrate is influenced by the main variable of interest, regional age structure, a set of individual controls (IC_i) and a set of regional controls for the origin region (RC_r).

The individual controls are informed by the literature on migration propensity reviewed above and include individual age, age squared (to account for the non-linear shape of migration propensity), gender, education level, wage at the current job (i.e. pre-migration) and whether or not this individual has been observed migrating in a previous period. The regional characteristics are include population size, GDP per capita, the unemployment rate, the share of employees with tertiary education, the share of services in value added, and the number of hotel beds, as a proxy for other amenities. Dummies for urban and East German regions are also included (see Appendix 5.A.1 for descriptions and sources of all variables).

From equation (5.3), it follows that:

$$P(y_i = 1|x) = P(y_i^* > 0|x) = P[e_i > -(\beta_0 + \beta_1 \text{Mean Age}_r + \gamma IC_i + \delta RC_r)|x] \tag{5.4}$$

Assuming that e_i has a standard logistic distribution, we can thus estimate propensity to migrate using a logistic regression model and using maximum likelihood estimation.

$$P(y = 1|x)_{i,t} = \frac{\exp(\beta_0 + \beta_1 \text{Mean Age}_{r,t-1} + \gamma IC_{i,t} + \delta RC_{r,t-1})}{1 + \exp(\beta_0 + \beta_1 \text{Mean Age}_{r,t-1} + \gamma IC_{i,t} + \delta RC_{r,t-1})} \tag{5.5}$$

A concern in estimating (5.5) is the potential simultaneity of migration and regional characteristics. For instance, since each migrant contributes to the age structure, re-

[7] In addition to the results presented here, all estimations were also specified as a linear probability model. The results are robust to specification as either a linear or non-linear model.

gional mean age could be endogenous. To lessen the simultaneity, the regional-level characteristics (mean age and other control variables) enter (5.5) lagged by one year. For causal inference, an instrumental variable approach would be necessary but due to the interrelated nature of age structure and migration, such instruments are difficult to implement, especially for a panel dataset. This chapter does not estimate the causal effect of a region's age in influencing migration. Instead, it is likely that mean age captures the presence of age-specific amenities that lead to a sorting of individuals via migration. In this sense, the aim of this paper is to establish the direction of these effects rather than establish causality.

To account for unobserved period effects, equation (5.5) includes year dummies. The panel structure of the data means that individuals are observed multiple times and can therefore migrate more than once. Equation (5.5) is first estimated on the pooled dataset with clustered standard errors. This specification treats each migration event independently although we control for whether the individual has previously migrated. The panel structure also allows fitting (5.5) with individual fixed effects thus controlling for unobserved time-invariant heterogeneity among individuals. However, the fixed effects absorb most of individual characteristics (i.e. individual age, gender and education). Moreover, in the panel specification, the effects are identified from individuals changing from non-migrant to migrant and individuals who never migrate (or migrate each year) are dropped. As an extension to the model, interaction effects between the individual and regional characteristics are included to test whether the effect of the regional age structure varies across age groups and education levels.

Destination choice

The second empirical application addresses the question whether regional age structure is related to migrants' destination choices. For this purpose, the sample is restricted to migrants only, i.e. those who are not observed as changing region of employment are excluded. Every individual has a choice of each of the 331 district-regions (i.e. all but the origin region) and a dummy variable is computed to denote the region that gets chosen. Each observation includes the individual's characteristics as well as the regional characteristics of the potential destination region.

To estimate the destination choice, we restrict the dataset to yearly cross-sections for two reasons. First, multiple observations in the unbalanced panel dataset confound the analysis because some movers may be observed more than once, implying that their choice is taken into account more often than the choice of a single mover. Adequately addressing the issue of multiple moves would require modelling sequential moves directly, which is outside the scope of this analysis. Second, the choice model has large computational requirements as the dataset requires one row per potential destination (i.e. 331 rows) per individual. Thus, setting up the choice model for the 781 109 observed migration events, would require simultaneous analysis of 258 million rows of data. In the literature, repeated yearly cross-sections are sometimes applied instead of panel models in order to reduce the computational demands of destination choice models (P. S. Davies & Greenwood, 2001). Translating the analysis into a panel framework is therefore left for future studies and instead we estimate the choice model as a repeated cross-section by year. This reduces the data to manageable size and solves the issue of multiple movers as each individual is only recorded once per year.

In line with Sjaastad's (1962) conceptualisation of migration as an investment decision described in Section 5.2.3, the migration decision can be analysed in the context of the random utility model (e.g. McFadden, 2001). The utility of choosing region j for each individual i is given by a systematic part (V_{ij}) and an immeasurable one (ε_{ij}) :

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{5.6}$$

Utility maximization implies that region r gets selected if its utility exceeds the utility of all other options. The probability that individual i chooses region r is:

$$\begin{gathered}\Pr(y_i = j) = \begin{cases} 1 & \text{if } U_{ij} > U_{ik} \quad \forall k \in N, j \neq k \\ 0 & \text{otherwise} \end{cases} \\ \Pr(y_i = j) = \Pr[\varepsilon_{ik} < V_{ij} + \varepsilon_{ij} - V_{ik}] \quad \forall k \in N, j \neq k \end{gathered} \tag{5.7}$$

McFadden's (1974, 1978) conditional logit approach models V_{ij} as depending on a vector z_{ij} of characteristics of the alternatives:

$$V_{ij} = z_{ij}\beta \tag{5.8}$$

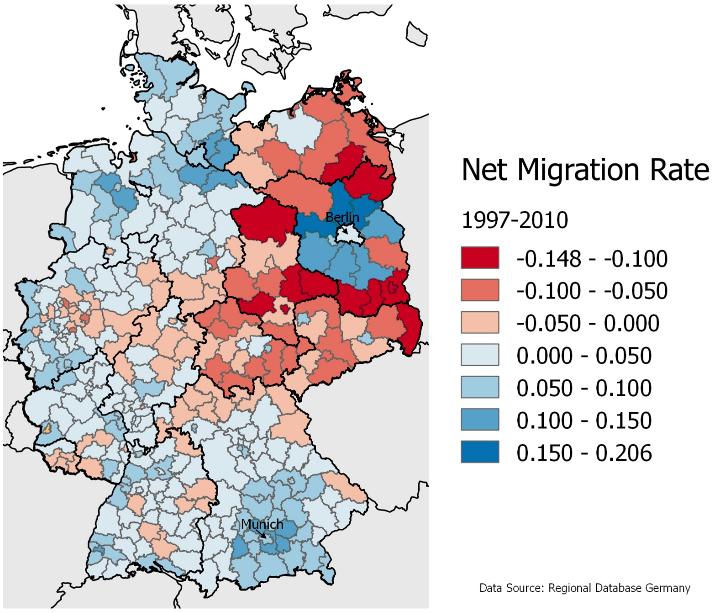
The probability of observing individual i choosing region j is then:

$$\Pr(y_i = j) = \frac{\exp(z_{ij}\beta)}{\sum_{k=1}^{N}\exp(z_{ik}\beta)} = \frac{\exp(\beta_1 \text{Mean Age}_j + \delta RC_j)}{\sum_{k=1}^{N}\exp(\beta_1 \text{Mean Age}_k + \delta RC_k)} \quad \forall k \in N, j \neq k \tag{5.9}$$

We estimate (5.9) by maximum likelihood estimation using mean age as our variable of interest and as separate cross-section per year. The same set of regional controls (RC_j) as in the other estimations is included as well as the distance between the individual's origin region and each potential destination region. As in the migration propensity model, reverse causality remains a concern: regional characteristics such as the age structure could change in response to destination choices by individuals. To address this issue, the characteristics of the alternatives are lagged by one year, which would imply that individuals are expected to make their destination decision on the basis of past rather than current regional characteristics[8]. The conditional logit model does not allow including individual characteristics directly as they are constant across alternatives. However, interacting individual characteristics with regional ones allows testing whether the effect of the regional age structure differs with an individual's age, education level, or gender.

[8]The results are robust to using lagged or current regional characteristics but only the results using lagged values are reported here.

Figure 5.2: Internal net migration rates 1997-2010



5.4 Descriptive statistics

Before presenting the regression results, we consider a few descriptive statistics to illustrate the trends of internal migration. Figure 5.2 shows the internal net migration rate for the entire time period, i.e. net-migration relative to the population in the initial year of the sample period[9]. Geographical patterns in net migration are clearly visible with regions in the East and centre of Germany largely showing net-outmigration, except for the regions surrounding Berlin (colloquially described as Berlin's *Speckgürtel*, literally "bacon belt", i.e. relatively well-off surroundings to the capital). Indeed, the largest German agglomerations, i.e. Berlin, Hamburg and Munich, all experienced positive net migration but to a smaller extent than the surrounding regions. This pattern is consistent with trends of suburbanization as well as the growth of "agglomeration hinterlands" (e.g. Kemper, 2004; Sander, 2014).

The individual-level dataset compiled from the SIAB7510 comprises 8.6 million observations for 995,790 individuals. Across all years, 781,109 moves are observed, corresponding to 9% of the full dataset. In line with the notion that the vast majority of migrations are of relatively short distance, the average distance for internal migrants in the dataset is 120.12 km and the median distance is 48.5 km. The distance of the individual-level moves is very close to the average distance of migration derived from aggregate migration flow data (average 124.8 km and median 54.2 km). Thus, the observed migration of employees covered in the Sample of Labour Market Biographies seems comparable in scale to population migration flows. Full summary statistics of the data are presented in Appendix 5.A.1.

[9] Net Migration Rate$_r$ = $\frac{\sum_{t=1996}^{2010}(\text{Immigration}_{r,t} - \text{Outmigration}_{r,t})}{\text{Population}_{r,1996}}$

5.5 Individual migration patterns

5.5.1 Results: propensity to migrate

The results of the baseline migration propensity estimation are presented in Table 5.5.1. The estimated coefficient on regional mean age is significantly positive both in the pooled specification and when including individual-level fixed effects. Individuals in older regions are more likely to leave than in younger ones. The average marginal effect of increasing regional mean age by one year is to increase the probability of migration by 0.53 percentage points in the pooled and 0.89 percentage points in the fixed effects estimation.

The individual-level explanatory variables show coefficients consistent with theory. As expected from the shape of migration propensity presented above, an individual's age is significantly negative for migration propensity, but the squared term is significantly positive. Women are significantly less likely to migrate than men. The education level uses the lowest educational attainment (only primary, lower/intermediate secondary degree) as base category. The coefficient for the second-lowest educational attainment (primary, lower/secondary degree with vocational training) is significantly negative and that of education 4 (upper secondary degree and vocational training) is insignificant. In contrast, tertiary education degrees are associated with a higher likelihood of migration. Average hourly wage at the current job is significantly negative, which is consistent with the notion that the relocation occurs to improve job prospects. Considering that the migration events are defined by changes in employment location, this result is not surprising. The dummy variable accounting for repeat migration is, as expected, significantly positive and quite large in magnitude, which implies that migration is more likely if an individual has previously relocated.

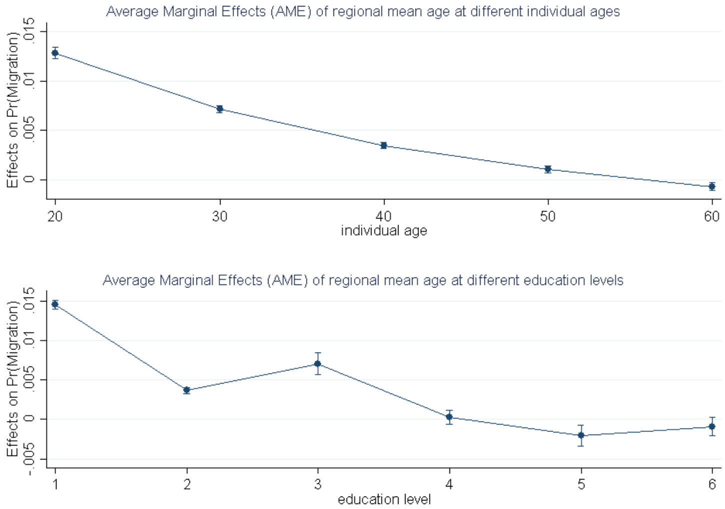
For the regional control variables, we find that population size is significantly negative for migration propensity, indicating that, ceteris paribus, large populations do not seem to act as a push factor. The coefficient on GDP per capita is significantly positive in the pooled model but negative in the fixed effect model, whereas unemployment is significantly negative. At first glance, a negative coefficient on unemployment seems counterintuitive as adverse labour market conditions should act as a push factor. However, the sample consists only of individuals who are currently employed and whose migration would be job-to-job migration (i.e. moving from an employer in the origin to another (or the same) employer in another region). Higher unemployment in their origin region may imply that the individual is comparatively well-off in their region and thus reduces their likelihood to migrate. The size of the service sector as well as the share of highly skilled employees are significantly positive. The coefficient on the number of hotel beds is significantly negative, which could indicate that individuals are less likely to leave regions with high amenity value. Finally, the dummy variables for urban regions supports the finding above: propensity of migration is higher for urban rather than rural regions. When including individual fixed effects (column 2) the

Table 5.5.1: Baseline results migration propensity

VARIABLES	(1) pooled logit	(2) panel logit
mean age	0.0775***	0.0444***
	(0.0024)	(0.0031)
age	-0.0683***	
	(0.0009)	
age^2	0.0004***	
	(0.0000)	
female	-0.2577***	
	(0.0030)	
education 2	-0.0984***	
	(0.0045)	
education 3	0.2915***	
	(0.0073)	
education 4	0.0051	
	(0.0065)	
education 5	0.1455***	
	(0.0088)	
education 6	0.3210***	
	(0.0073)	
wage	-0.0103***	-0.0099***
	(0.0000)	(0.0001)
repeat migrant	2.4624***	1.7043***
	(0.0029)	(0.0049)
ln population	-0.0561***	-0.0762***
	(0.0036)	(0.0053)
ln GDP p.c.	0.0265***	-0.0278***
	(0.0069)	(0.0089)
unemployment	-0.0127***	-0.0044***
	(0.0005)	(0.0007)
share high-skilled	0.0142***	0.0047***
	(0.0006)	(0.0008)
share services	0.0072***	0.0032***
	(0.0002)	(0.0002)
ln hotels	-0.1131***	-0.0437***
	(0.0025)	(0.0038)
urban	0.0360***	0.0135**
	(0.0046)	(0.0067)
east	-0.0464***	0.0491***
	(0.0078)	(0.0120)
constant	-1.8273***	
	(0.0944)	
$p > \chi^2$	0	0
pseudo R^2	0.205	0.0834
Year FEs	Yes	Yes
Individual FEs	-	Yes
Observations	8,667,376	3,753,891
Individuals	995,790	391,602

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5.3: Average marginal effects from pooled logit specification



dummy for regions in the East is significantly positive, which would support the notion of higher mobility for East Germany. However, the dummy is negatively significant for the pooled specification.

The baseline results show that individuals in older regions are more likely to leave their origin region. To investigate whether these individual decisions are consistent with selective migration, Table 5.5.2 presents results for interaction effects of individual characteristics. In particular, interactions between regional mean age and individual age, and education levels were added. Including these interaction terms does not substantially change the signs or significances of the remaining variables: the main term of mean age remains significantly positive. The interaction term between regional mean age and individual age, however, is significantly negative. Thus, although the probability of migration increases with the mean age of the origin region, its effect decreases with an individual's age. The average marginal effects of regional mean age at different individual ages are plotted in Figure 5.3 for the pooled model. The negative interaction term shows that young individuals are not only more likely to leave older regions; an increase in regional age also increases their probability to leave more than for older individuals. This finding is consistent with age-selective migration where younger people are more likely to leave regions with an older age structure, thus contributing to further ageing.

Columns 3 and 4 of Table 5.5.2 show the interaction results with regional mean age and individuals' education levels. The interaction term is negative for all education levels, again using the lowest educational degree as the base category. The average marginal effects of mean age at different education levels are illustrated in the lower panel of Figure 5.3. Compared to individuals with only primary or low/intermediate secondary education, more highly educated individuals are less sensitive to regional age structure. Thus, an increase in regional age will increase the probability of migration less for individuals with a university degree than for individuals with lower educational

Table 5.5.2: Interaction results migration propensity

VARIABLES	(1) pooled logit	(2) panel logit	(3) pooled logit	(4) panel logit
mean age	0.2017***	0.2040***	0.2096***	0.0333***
	(0.0051)	(0.0071)	(0.0039)	(0.0031)
age*mean age	-0.0036***	-0.0047***		
	(0.0001)	(0.0002)		
educ 2 * mean age			-0.1534***	0.0080***
			(0.0040)	(0.0002)
educ 3 * mean age			-0.1234***	-0.0093***
			(0.0091)	(0.0003)
educ 4 * mean age			-0.2058***	-0.0052***
			(0.0068)	(0.0003)
educ 5 * mean age			-0.2370***	-0.0118***
			(0.0092)	(0.0004)
educ 6 * mean age			-0.2206***	-0.0205***
			(0.0076)	(0.0004)
age	0.0699***		-0.0695***	
	(0.0052)		(0.0009)	
age^2	0.0005***		0.0005***	
	(0.0000)		(0.0000)	
female	-0.2578***		-0.2557***	
	(0.0030)		(0.0030)	
education 2	-0.0956***		5.8124***	
	(0.0045)		(0.1543)	
education 3	0.2931***		5.0474***	
	(0.0073)		(0.3509)	
education 4	0.0082		7.9440***	
	(0.0065)		(0.2620)	
education 5	0.1494***		9.2918***	
	(0.0089)		(0.3537)	
education 6	0.3259***		8.8292***	
	(0.0074)		(0.2915)	
wage	-0.0103***	-0.0102***	-0.0103***	-0.0095***
	(0.0000)	(0.0001)	(0.0000)	(0.0001)
repeat migrant	2.4671***	1.6944***	2.4693***	1.7065***
	(0.0029)	(0.0049)	(0.0029)	(0.0049)
$p > \chi^2$	0	0	0	0
pseudo R^2	0.205	0.0836	0.206	0.0862
Regional Controls	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Individual FEs	-	Yes	-	Yes
Observations	8,667,376	3,753,891	8,667,376	3,753,891
Individuals	995,790	391,602	995,790	391,602

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

attainment, ceteris paribus. In a context of patterns of selective migration, this results contradict the notion that the most highly educated are most likely to leave ageing regions.

As a robustness check, the regressions were repeated for alternative age indicators (Table 5.A.3). The baseline results are robust to measuring regional age structures in different ways. In particular, a higher share of elderly population (above 65 years) in the origin region is associated with a higher probability of migration. In contrast, employees in regions with a higher share of young population (under 25 years) are less likely to migrate, ceteris paribus. The Billeter J measure, which is a proxy of age structure more generally, is also significantly positive indicating that residents of regions with a lower population growth potential are more likely to leave. For the population groups, larger relatively young age groups reduce the probability of migration, whereas age groups between 30 and 64 increase the probability of migration. The fact that the baseline result can be replicated even when using population shares by age group or entirely different indicators of demographic structure, such as the Billeter J, shows that the findings are not an artefact of how regional age structure is operationalised.

5.5.2 Results: destination choice

Table 5.5.3 shows the conditional logit results of destination choice for internal migrants in Germany. As discussed above, the estimation was run for 15 separate yearly cross-sections using identical model specifications. The results are strikingly stable across time with estimated coefficients for all covariates except the urban dummy consistently estimated with the same sign and significances. The variable of interest, regional mean age, is negatively significant for all years. Figure 5.4 presents these coefficients graphically and illustrates that the results are not only clearly significantly negative but also remarkably similar across time, especially since 2001. These results imply that the probability of being selected as a destination region decreases with regional mean age: regions with an older age structure are significantly less likely to be selected than younger ones. If we understand the probability of being chosen as a destination region as a measure of regional attractiveness for migrants, this implies that older regions are significantly less attractive destination choices than younger ones, ceteris paribus.

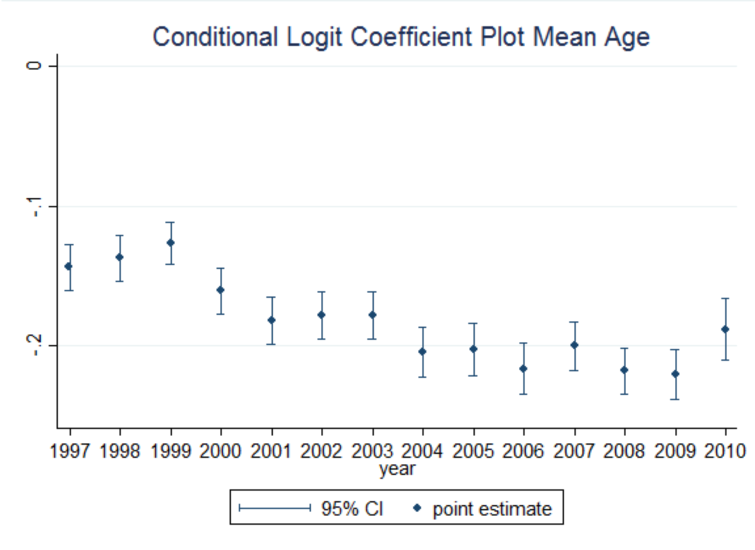
Besides the relevance of the regional age structure, the results in Table 5.5.3 also show other features of regional attractiveness. As expected from gravity-type migration models, distance is significantly negative, indicating that individuals are more likely to choose regions that are geographically close to their origin. The coefficients for GDP per capita, population size, the share of services, and the number of hotel beds are all significantly positive. Unemployment is significantly positive as well. As described above, due to the fact that all observations are based on employed individuals, we do not necessarily expect low unemployment to be a pull factor in this estimation. The share of high-skilled employment, however, is significantly negative.

Table 5.5.3: Results of conditional logit model of destination choice by year

	(1) 1997	(2) 1998	(3) 1999	(4) 2000	(5) 2001	(6) 2002	(7) 2003	(8) 2004	(9) 2005	(10) 2006	(11) 2007	(12) 2008	(13 2009	(14) 2010
mean age	-0.1433***	-0.1374***	-0.1263***	-0.1605***	-0.1821***	-0.1779***	-0.1779***	-0.2038***	-0.2024***	-0.2164***	-0.2000***	-0.2174***	-0.2202***	-0.1879***
	-0.0085	-0.0084	-0.0077	-0.0086	-0.0088	-0.0088	-0.0089	-0.0091	-0.0093	-0.0092	-0.0088	-0.0086	-0.0091	-0.0112
ln distance	-1.9019***	-1.8850***	-1.8822***	-1.8681***	-1.8581***	-1.8620***	-1.8532***	-1.8507***	-1.8556***	-1.8392***	-1.8435***	-1.8428***	-1.8475***	-1.8766***
	-0.006	-0.0059	-0.0053	-0.0051	-0.0051	-0.0052	-0.0053	-0.0053	-0.0054	-0.0053	-0.0052	-0.0053	-0.0056	-0.0076
ln GDP p.c.	0.6880***	0.6689***	0.6795***	0.7867***	0.6819***	0.6492***	0.5591***	0.6268***	0.5937***	0.6294***	0.6569***	0.5845***	0.5812***	0.7051***
	-0.0239	-0.0232	-0.0206	-0.0209	-0.0211	-0.0217	-0.0224	-0.0225	-0.0223	-0.023	-0.022	-0.0227	-0.0242	-0.0331
ln population	0.8824***	0.8770***	0.8758***	0.9136***	0.8932***	0.8981***	0.8898***	0.8732***	0.8776***	0.9024***	0.8772***	0.8979***	0.8714***	0.8626***
	-0.0128	-0.0126	-0.0113	-0.0109	-0.0111	-0.0117	-0.012	-0.0119	-0.012	-0.0119	-0.0116	-0.0117	-0.0126	-0.0169
unemployment	0.0095***	0.0072***	0.0089***	0.0039**	0.0087***	0.0195***	0.0192***	0.0226***	0.0227***	0.0184***	0.0124***	0.0190***	0.0250***	0.0203***
	-0.0022	-0.0021	-0.0018	-0.0018	-0.0018	-0.0019	-0.0019	-0.0019	-0.0018	-0.0015	-0.0016	-0.0017	-0.0019	-0.0028
share service	0.0080***	0.0084***	0.0081***	0.0060***	0.0059***	0.0050***	0.0056***	0.0048***	0.0071***	0.0049***	0.0047***	0.0050***	0.0060***	0.0040***
	-0.0006	-0.0006	-0.0006	-0.0005	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0009
share high-skilled	-0.0048*	-0.0046*	-0.0085***	-0.0164***	-0.0124***	-0.0149***	-0.0140***	-0.0155***	-0.0132***	-0.0153***	-0.0176***	-0.0192***	-0.0227***	-0.0328***
	-0.0025	-0.0024	-0.0021	-0.002	-0.0021	-0.0022	-0.0021	-0.0021	-0.0021	-0.0021	-0.0019	-0.0019	-0.002	-0.0026
ln hotels	0.1200***	0.1112***	0.1339***	0.1049***	0.1141***	0.1036***	0.1199***	0.1359***	0.1181***	0.1272***	0.1449***	0.1263***	0.1245***	0.1400***
	-0.0089	-0.0087	-0.0078	-0.0076	-0.0077	-0.0079	-0.0081	-0.0081	-0.0082	-0.0081	-0.0079	-0.0081	-0.0086	-0.0113
urban	-0.0061	0.0137	0.0247*	0.0179	0.0008	0.0135	0.0521***	-0.0021	-0.0122	-0.0621***	0.0006	-0.0245*	-0.0167	-0.0169
	-0.0164	-0.0164	-0.0147	-0.0139	-0.0139	-0.0145	-0.0147	-0.0148	-0.0152	-0.015	-0.0146	-0.0147	-0.0158	-0.0207
east	0.5792***	0.4740***	0.3748***	0.4322***	0.4046***	0.3547***	0.4372***	0.4371***	0.3557***	0.3985***	0.4069***	0.3739***	0.4532***	0.3856***
	-0.0293	-0.0305	-0.0266	-0.026	-0.0267	-0.0277	-0.0279	-0.0272	-0.0267	-0.024	-0.0225	-0.0224	-0.0237	-0.0317
Obs.	15,081,111	15,716,462	19,322,447	21,114,940	21,132,193	19,537,530	19,091,135	18,935,628	18,303,431	18,879,544	20,100,637	19,956,321	17,152,751	9,612,240
pseudo $textR^2$	0.328	0.328	0.329	0.326	0.322	0.322	0.317	0.316	0.321	0.317	0.317	0.317	0.316	0.318
$p > \chi^2$	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Figure 5.4: Coefficients and confidence intervals for baseline destination choice model



Interestingly, the dummy denoting alternatives in the East of Germany is significantly positive. Thus, regions in East Germany are significantly more likely to be selected as destination regions than West German regions. It should be noted that this does not contradict the observation of outmigration from the East to the West on an aggregate level. Rather it shows that, holding all else (e.g. economic and labour market factors) constant, East German regions are not inherently less attractive than those in the West. This corresponds to the notion that much of the East German outmigration is due to economic factors rather than some other preference for the West. Moreover, the positive East dummy could also be explained partly by the pronounced positive net migration rates experienced by Berlin's surrounding regions.

Table 5.5.4 shows the results of including interaction terms with individuals' ages and education levels in the conditional logit model. Signs and significances of the control variables are identical to the baseline case and omitted here for brevity. As in the previous results, the main term of regional mean age is significantly negative for all years. This indicates again that, ceteris paribus, migrants are less likely to move to regions with a relatively older age structure. The interaction term with individual age is significantly positive across all specifications, albeit only at 10% confidence level for 1998. Main and interaction term jointly indicate that the negative marginal effect of mean age on the probability of choosing a given region decreases with an individual's age. Stated differently, a hypothetical one-year increase in the mean age of a region r decreases the probability of choosing region r more for a young migrant than for an older migrant. Thus, the results suggest that younger migrants are more deterred by an old regional age structure than older migrants. This result is in line with a sorting of individuals by age where younger migrants are more likely to choose young regions rather than old ones, ceteris paribus.

In contrast to the age interaction effect, the results for education level are less conclusive. Up until the year 2000, the interaction terms with the different educational levels are usually positive. After 2000, the interaction with education levels 3, 4, and 6 are frequently significantly negative, while the interaction with education level 2 is significantly positive. A negative interaction term for any of the education levels would indicate that the deterring effect of regional mean age on the probability of destination choice is larger for more highly educated individuals than compared to the base category of only primary, lower/intermediate secondary education (education 1). Therefore, ceteris paribus, the effect of regional age on the probability of destination choice would be larger in absolute value (i.e. more negative) for someone with a university degree than for a comparable individual with education level 1. In this sense, we find some evidence for the notion that more highly educated individuals may prefer younger regions, which would be in line with patterns of selective migration based on education level. However, compared to the age interaction effects, there is more variability across the years, so the results are less conclusive and should be interpreted with caution.

The baseline choice model was also estimated using the alternative indicators for regional age structure (Table 5.A.4). The core result that regions with an older age structure are less likely to be selected as migrants' destination is robust to measuring age in different ways. For instance, the share of population over 65 years is significantly negative for all years, whereas the share of population under 25 years is significantly positive.

Table 5.5.4: Destination choice interaction model

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
age*mean age	0.0018***	0.0011*	0.0017***	0.0072***	0.0086***	0.0085***	0.0091***	0.0065***	0.0087***	0.0076***	0.0081***	0.0064***	0.0077***	0.0056***
	(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0006)	(0.0007)
mean age	-0.2020***	-0.1732***	-0.1831***	-0.3956***	-0.4642***	-0.4595***	-0.4830***	-0.4217***	-0.4980***	-0.4718***	-0.4741***	-0.4374***	-0.4894***	-0.3797***
	(0.0217)	(0.0226)	(0.0208)	(0.0243)	(0.0242)	(0.0238)	(0.0233)	(0.0239)	(0.0247)	(0.0242)	(0.0228)	(0.0219)	(0.0227)	(0.0277)
Observations	15,081,111	15,716,462	19,322,447	21,114,940	21,132,193	19,537,530	19,091,135	18,935,628	18,303,431	18,879,544	20,100,637	19,956,321	17,152,751	9,612,240
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
pseudo R2	0.328	0.328	0.329	0.326	0.322	0.322	0.318	0.316	0.321	0.317	0.317	0.317	0.317	0.318
p> χ^2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
educ 2*mean age	0.0037	-0.0113	-0.0028	0.0889***	0.1130***	0.0776***	0.1445***	0.1449***	0.1191***	0.1099***	0.1407***	0.1266***	0.1647***	0.1153***
	(0.0167)	(0.0174)	(0.0156)	(0.0189)	(0.0191)	(0.0187)	(0.0183)	(0.0189)	(0.0199)	(0.0195)	(0.0183)	(0.0178)	(0.0186)	(0.0223)
educ 3*mean age	0.3791***	0.3857***	0.3403***	0.0679*	-0.1817***	-0.2748***	-0.2426***	-0.2845***	-0.3761***	-0.4838***	-0.4549***	-0.4763***	-0.3959***	-0.4733***
	(0.0425)	(0.0417)	(0.0363)	(0.0371)	(0.0374)	(0.0368)	(0.0368)	(0.0375)	(0.0392)	(0.0390)	(0.0367)	(0.0351)	(0.0372)	(0.0467)
educ 4*mean age	0.2314***	0.2308***	0.2043***	0.1628***	-0.0015	-0.0609**	-0.0753***	-0.0121	-0.0723**	-0.1426***	-0.1235***	-0.1419***	-0.1181***	-0.1200***
	(0.0279)	(0.0290)	(0.0264)	(0.0289)	(0.0293)	(0.0287)	(0.0283)	(0.0287)	(0.0299)	(0.0295)	(0.0283)	(0.0267)	(0.0277)	(0.0335)
educ 5*mean age	0.1127***	0.1822***	0.1942***	0.2215***	0.0957**	-0.0433	0.0667	0.0366	-0.0163	-0.1116**	-0.0400	-0.0433	-0.0437	-0.1322***
	(0.0366)	(0.0362)	(0.0369)	(0.0430)	(0.0416)	(0.0426)	(0.0435)	(0.0409)	(0.0419)	(0.0437)	(0.0395)	(0.0376)	(0.0397)	(0.0465)
educ 6*mean age	0.4271***	0.4151***	0.3161***	0.1528***	-0.0715**	-0.1149***	-0.0396	-0.0893***	-0.0818**	-0.2224***	-0.2713***	-0.3218***	-0.2929***	-0.2743***
	(0.0339)	(0.0327)	(0.0302)	(0.0318)	(0.0318)	(0.0323)	(0.0322)	(0.0322)	(0.0339)	(0.0334)	(0.0309)	(0.0304)	(0.0313)	(0.0381)
mean age	-0.2036***	-0.1965***	-0.1817***	-0.2459***	-0.2350***	-0.1931***	-0.2382***	-0.2648***	-0.2362***	-0.2183***	-0.2189***	-0.2197***	-0.2544***	-0.1869***
	(0.0160)	(0.0164)	(0.0143)	(0.0168)	(0.0169)	(0.0166)	(0.0163)	(0.0170)	(0.0180)	(0.0176)	(0.0166)	(0.0163)	(0.0173)	(0.0206)
Observations	15,081,111	15,716,462	19,322,447	21,114,940	21,132,193	19,537,530	19,091,135	18,935,628	18,303,431	18,879,544	20,100,637	19,956,321	17,152,751	9,612,240
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
pseudo R2	0.328	0.329	0.329	0.326	0.322	0.322	0.318	0.316	0.321	0.318	0.318	0.317	0.317	0.319
p> χ^2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

5.6 Aggregate migration patterns

The results so far showed that individuals' migration behaviour is in favour of younger regions. Individuals are more likely to leave and less likely to move to a region with an older age structure, ceteris paribus. While these results allowed controlling for individual characteristics such as age and education, they are based on a sample of employees rather than the entire population. Moreover, the individual analysis does not allow testing the composition and cohort-size effects since these depend on the population as a whole. This section analyses the relationship between regional age structure and migration from an aggregate perspective, using migration flows for the entire population.

5.6.1 Method

Data on migration flows stem from the German Internal Migration Database (GIM) developed and described in Sander (2014). It is an origin-destination flow matrix of residence changes from the German population register in the years 1995-2010, adjusted for changes in district definitions and corrected for the effects of resettlement of ethnic German migrants (Spätaussiedler)[10]. The n x n GIM matrix yields the migration flows between origin-destination pairs but does not capture intra-district migration (zero on the diagonal). This is because the population register only records moves across district borders. Moreover, the definition by district borders means that the matrix only represents internal migration. International migration (i.e. migration across the national border) is not considered. After aggregating regions upwards to correspond to the district definitions of the SIAB7510 file and excluding regions with missing data, the resulting dataset represents interactions between 320 regions. We denote migration from region r (origin) to region s (destination) as M_{rs}.

Our empirical framework follows traditional gravity migration models (e.g. Greenwood, 2016; Poot, Alimi, Cameron, & Maré, 2016). The inherent logic of gravity models was already expressed by Ravenstein (1885, 1889): there will be more migration the bigger the origin and destination regions are and the closer to each other they are located. The classical form of the gravity model estimates migration flow M_{rs} as a function of population in origin (r) and destination (s) as well as the inverse distance between them.

$$M_{rs} = \frac{aP_rP_s}{D_{rs}} \tag{5.10}$$

[10] Ethnic German migrants and asylum seekers from Eastern European countries were hosted in specific districts (*Grenzdurchgangslager or border transit zones*) where the legal process of naturalization was initiated. The move to these districts was recorded as international immigration (since the migrants were not German citizens). However, when these migrants later migrated, their move was recorded as internal migration, implying that some German districts saw a large artificial surge in in-and outmigration due to their role as transit zone(see Sander, 2014). These large flows have been identified as a confounding factor in analyzing internal migration in previous studies (e.g. Berentsen & Cromley, 2005).

Logarithmic transformation of (5.10) yields the simple gravity model:

$$\ln M_{rs} = \ln a + lnP_r + \ln P_s - \ln D_{rs} \tag{5.11}$$

In order to capture the effects of migration push and pull factors beyond simple gravity, other factors can be included in a so-called modified or extended gravity model (Greenwood, 2016). We thus include our main variable of interest, regional mean age at the origin and destination as well as a range of regional control variables including population size (RC).

$$\begin{aligned} \ln M_{rst} = \beta_0 \ln a + \beta_1 \ln \text{Mean Age}_{r,t-1} + \beta_2 \ln \text{Mean Age}_{s,t-1} \\ + \beta_3 \ln D_{rs} + \gamma \text{RC}_{r,t-1} + \delta \text{RC}_{s,t-1} + \text{OD}_{rs} + \tau_t \end{aligned} \tag{5.12}$$

The panel structure of the data allows estimating (5.12) while controlling for time-invariant unobserved heterogeneity in regional characteristics. We experiment with regional fixed effects for origin and destination separately as well as origin-by-destination fixed effects. While the latter subsumes the distance measure (as it does not vary by origin-destination pair), it also controls for the relationship across region-pairs such as for example differences between migration that occurs within the same federal state versus migration across state borders. To account for unobserved trends in migration across time, we also include year fixed effects.

As above, there may be simultaneity between migration and age structure. Different migratory trends by age group could substantially change the age structure of both sending and receiving regions. Thus, reverse causality, i.e. migration affecting regional age rather than the other way around, is a possibility. To ensure that current migration does not directly affect age structure we lag the right-hand side of (5.12) by one year.

A further methodological issue with (5.12) is commonly denoted as the *zero-flow problem*: The log-transformed dependent variable $\ln M_{rs}$ is not defined for zero-flows which are a common occurrence (especially in migration and trade data) and themselves hold relevant information about the nature of migration. Aggregating across time or spatial units may decrease the incidence of zero-flows but also discards relevant information. Here, the number of zero flows is 184 118 out of 1 207 162 (15.3%) yearly observations across district regions. A simple and commonly applied solution (e.g. in Poot et al., 2016) is to add a small constant (usually 1) to the migration flows before the logarithmic transformation, which is the approach taken in the baseline results here. However, the chosen constant may itself affect the estimates (Burger, van Oort, & Linders, 2009) and this transformation neglects the discrete nature of a migration flow occurring or not occurring (LeSage & Pace, 2009). To test the robustness of the results with respect to the zero-flow problem, the baseline results using $\ln(M_{rs} + 1)$ are presented alongside a specification with $\ln(M_{rs})$ as dependent variable, which thus excludes all zero-flows.

Other inherent issues with the log-normal OLS estimation of the gravity model have been documented and emphasised in the literature (Burger et al., 2009; Flowerdew

& Aitkin, 1982; Santos Silva & Tenreyro, 2006). Log-normal OLS estimates may be biased as they under-predict large flows. Moreover, it is likely that the assumption of homoscedasticity does not hold thus affecting efficiency and potentially consistency of the estimator. To avoid these issues as well as the zero-flow problem, it is suggested to estimate the specification as a count model using the Poisson distribution (Burger et al., 2009; Santos Silva & Tenreyro, 2006). This implies stating that the observed migration flow between region r and s follows a Poisson distribution with conditional mean λ_{rst} as a function of the independent variables. Following Allison's (2009) notation, the probability that flow $M_{rst} = m$ is then given by:

$$\Pr[M_{rst} = m] = \frac{\lambda_{rst}^{m} e^{-\lambda_{rst}}}{m!} \qquad m = 0, 1, 2... \tag{5.13}$$

With the conditional mean λ_{rst} an exponential function of the independent variables:

$$\begin{aligned}\lambda_{rst} = \exp(&\beta_0 + \beta_1 \ln \text{Mean Age}_{r,t-1} + \beta_2 \ln \text{Mean Age}_{s,t-1} \\ &+ \beta_3 \ln D_{rs} + \gamma \text{RC}_{r,t-1} + \delta \text{RC}_{s,t-1} + \text{OD}_{rs} + \tau_t)\end{aligned} \tag{5.14}$$

We estimate (5.14) with conditional maximum likelihood and standard errors clustered on the panel variable, i.e. origin-by-destination pairs.

5.6.2 Results

Table 5.6.1 presents the results of fitting the described modified gravity model using the mean age of the employed labour force as indicator of regional age structure. Across all specifications, mean age in the destination region is significantly negative, indicating that older regions on average receive smaller migration inflows. Mean age of the origin region is significantly negative in a pooled model controlling for regional characteristics and year fixed effects. However, when we model the panel structure of the data and include regional fixed effects, mean age in the origin region changes sign. In all fixed effects specifications, older origin regions are estimated to experience larger migration outflows than younger ones.

Columns 4 and 5 show that the results are very similar whether including separate origin and destination fixed effects or a single fixed effect for the origin-destination-combination. The coefficients of column 5 suggests that a 1 percent increase in an origin's mean age is associated with outmigration increasing by 0.35%. In contrast, destination regions with a 1 percent increase in mean age on average experience 1.3% less internal immigration, which is a relatively large effect size. Dropping all zero-flows (column 6) and the Poisson regression specification (column 7) also show positive coefficients on origin age. The Poisson model suggests that the elasticity of migration with respect to origin mean age is 1.4 whereas it is -3.2 with respect to destination age. Thus, while the Poisson model yields results comparable to the OLS models in sign and significances, the estimated effect sizes are larger in magnitude.

Table 5.6.1: Baseline results gravity model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep.Var.	$\ln(M_{rst}+1)$	$\ln(M_{rst}+1)$	$\ln(M_{rst}+1)$	$\ln(M_{rst}+1)$	$\ln(M_{rst}+1)$	$\ln(M_{rst})$	M_{rst}
Regional Age							
ln mean age O	2.605***	-1.579***	-1.766***	0.341***	0.349***	0.217***	1.404***
	-0.0634	-0.0655	-0.086	-0.0565	-0.0564	-0.0648	-0.2553
ln mean age D	-3.990***	-3.673***	-3.860***	-1.317***	-1.301***	-1.841***	-3.216***
	-0.0635	-0.0652	-0.0865	-0.0582	-0.058	-0.0667	-0.2022
Origin Characteristics							
ln population O	0.896***	0.728***	0.723***	1.235***	1.251***	1.352***	1.025***
	-0.0042	-0.0046	-0.0046	-0.0272	-0.0272	-0.0309	-0.1094
ln GDP p.c. O		0.155***	0.143***	0.0720***	0.0729***	0.0113	0.0748**
		-0.0078	-0.008	-0.0148	-0.0148	-0.0169	-0.038
ln unemployment O		0.112***	0.139***	0.133***	0.139***	0.165***	0.0417*
		-0.0051	-0.0058	-0.006	-0.006	-0.0068	-0.023
ln services O		0.326***	0.315***	0.195***	0.195***	0.166***	0.112**
		-0.0129	-0.0131	-0.0185	-0.0184	-0.0211	-0.0494
ln high-skilled O		0.229***	0.237***	0.0281***	0.0287***	0.0298***	-0.00239
		-0.0067	-0.0067	-0.0064	-0.0064	-0.0075	-0.0179
ln hotels O		0.119***	0.122***	0.0490***	0.0508***	0.0661***	0.0297
		-0.0025	-0.0025	-0.0054	-0.0054	-0.0062	-0.0233
Destination Characteristics							
ln population D	0.956***	0.702***	0.698***	-0.328***	-0.310***	-0.372***	-0.566***
	-0.0043	-0.0045	-0.0046	-0.0262	-0.0261	-0.0303	-0.1065
ln GDP p.c. D		0.274***	0.262***	-0.138***	-0.138***	-0.180***	-0.199***
		-0.0077	-0.0079	-0.0149	-0.0149	-0.0169	-0.0455
ln unemployment D		-0.0382***	-0.0109*	-0.0283***	-0.0230***	-0.0167**	0.0356**
		-0.005	-0.0059	-0.006	-0.006	-0.0068	-0.0152
ln services D		0.499***	0.488***	-0.191***	-0.189***	-0.232***	-0.454***
		-0.0126	-0.0128	-0.0184	-0.0184	-0.0208	-0.0644
ln high-skilled D		0.306***	0.315***	-0.0669***	-0.0658***	-0.0816***	0.0193
		-0.0066	-0.0067	-0.0065	-0.0065	-0.0076	-0.0325
ln hotels D		0.150***	0.152***	0.0298***	0.0313***	0.0332***	0.102***
		-0.0025	-0.0025	-0.0056	-0.0056	-0.0063	-0.0215
Origin-Destination							
ln distance	-1.158***	-1.176***	-1.177***	-1.365***			
	-0.0047	-0.0046	-0.0046	-0.004			
Rural-Rural flow		0.141***	0.140***				
		-0.007	-0.0071				
Urban-Rural flow		0.0250***	0.0248***				
		-0.0056	-0.0056				
Rural-Urban flow		0.0375***	0.0373***				
		-0.0055	-0.0055				
East-West flow		0.147***	0.125***				
		-0.0079	-0.0083				
West-East flow		-0.110***	-0.133***				
		-0.0079	-0.0083				
East-East flow		0.262***	0.216***				
		-0.0169	-0.0175				
Constant	-1.397***	9.700***			-7.020***	-4.627***	
	-0.2022	-0.2253			-0.6097	-0.7052	
Obs.	1,391,280	1,391,280	1,391,280	1,391,280	1,391,280	1,207,162	1,390,990
No. IDs				102,080	102,080	102,055	102,055
R2	0.601	0.656	0.657	0.731	0.006	0.007	
Origin & Dest FEs				Yes			
O-D FEs					Yes	Yes	Yes
Year FEs			Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

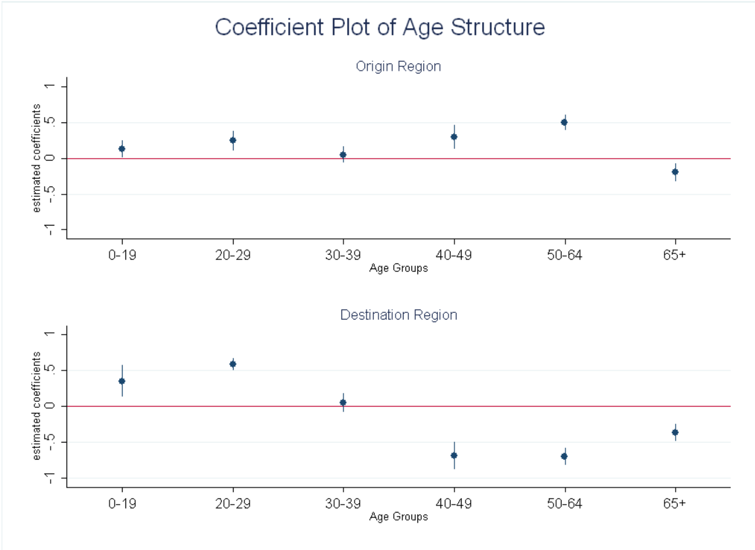
Beyond the core result of the role of regional age structure, the results are in line with theory and existing literature. Distance, as theory predicts, is significantly negatively associated with the volume of migration. The coefficient indicates that a 1 percent increase in the distance between origin- and destination region decreases the flow of migration by between 1.15% to 1.37%. Moreover, in the model without regional control variables, the coefficients on population size are very close to the theoretically expected value of unit elasticity (e.g. Greenwood, 2005).

Columns 2 and 3 include dummy variables for migration flows between settlement types as well as to/from regions of the former GDR. For settlement type, the excluded base category is urban-to-urban moves. The results show that rural-to-urban, urban-to-rural and rural-to-rural migration flows are all significantly larger than urban-to-urban movements. Also, rural-to-rural migration on average has the highest volume of migration. This may be due to the fact that density of urban regions allows avoiding a relocation, e.g. when changing a job, whereas low-density rural areas would require a change of residence and thus migration. For East-West migration, West-to-West moves are the base category. Reflecting a higher mobility from origin regions in the East of Germany, East-to-West and East-to-East migration flows are significantly larger than migration among West German regions. Moreover, West-to-East flows are significantly smaller than West-to-West migration, illustrating that movements from the West to the East are still comparably infrequent and much smaller than the reverse flows from East-to-West. This is in line with the literature on East-West German migration (M. Fuchs & Weyh, 2016; Schlömer, 2004).

The regional control variables are relatively stable across specifications. In line with the empirical literature, labour market conditions seem to be relevant in explaining migration patterns. Unemployment rates in the origin region are on average associated with larger outmigration flows, which would be consistent with unemployment acting as a push factor. Additionally, in all estimated OLS models, unemployment rates in the destination region are significantly negative, which would imply that unemployment also makes regions less attractive. In columns 4 and 5, population size, GDP per capita, and the share of the service sector are significantly positive for origin regions but negative for destination regions. This indicates that more outmigration occurs from relatively large and wealthy regions but also that these regions receive less inmigration. While this suggests that migration is not per se attracted to large and economically strong regions, it should be noted that we do not have data on price levels and thus cannot account for levels of real income, which could explain this result. The number of hotel beds, which is used here as a broad proxy of amenities, is significantly positive for both origin and destination regions, indicating that regions with high amenities may see larger turnover of residents.

Comparing the coefficients with separate origin and destination fixed effects (column 4) to the specification with fixed effects for each origin-destination pair (column 5) shows that the estimates are very similar. Although the similar results could indicate that controlling for origin and destination separately may be sufficient, the O-D fixed effects

Figure 5.5: Coefficient plot with 95% confidence interval per age group



ensure that factors such as the effect of moving between districts of the same state versus across federal states are captured as well. Although this specification does not allow including the distance measure (as it is constant across origin-destination pairs) we prefer this model for conceptual reasons.

The coefficients for the age structure of the destination region are robust to using alternative indicators of age (see Table 5.A.5). For origin regions, the results are more mixed. OLS estimation show that a younger age structure is, on average, associated with more outmigration, consistent with composition and cohort size effects. The same applies for Poisson estimation using the share of elderly population, which suggests that regions with a smaller population below retirement age experience more turnover of their population. However, the Poisson regressions using the share of young populaion or the Billeter J show the same pattern as in Table 5.6.1: older regions on average experience more out-migration and less in-migration than younger ones.

We also tested robustness to replacing population size with population size by age group. Figure 5.5 reports the coefficients from the age group specification graphically. Considering first the age structure of the origin region, larger young age groups (i.e. under 30 years) are associated with a larger volume of outmigration as predicted by theory. However, regions with larger age groups between 40 and 64 also seem to experience more outmigration. In line with the results for the share of population above 65 years, the effect of a large age group above 65 years is negatively significant for outmigration. For the destination region, the coefficient plot resembles the shape of the sine curve with young age groups estimated to be significantly positive and old regions significantly negative for the volume of internal in-migration. This pattern suggests that an older population age structure may indeed make regions less attractive destinations for migrants.

Across the different aggregate models, we find that an older age structure seems to be associated with more rather than less outmigration. A closer look at the demographic structure by age group revealed that population under 30 years seems to be correlated with larger migration flows into and out of regions. In contrast, regions with larger older population groups (especially 40-49 and 50-64) on average experience more outmigration and less in-migration. The results from the gravity-type origin-destination model thus seem to contradict the notion that population composition and cohort effects will lead to a slowdown of outmigration as population ages. Instead, older regions seem to lose population through outmigration while young regions attract more migrants. This is consistent with the micro-level results presented above, where individuals are more rather than less likely to leave ageing regions as well as less likely to choose old regions as destinations.

5.7 Discussion and conclusion

This chapter set out to investigate the relationship between population age and internal migration patterns. It started by reviewing the literature on the relevance of age in determining migration both in terms of individual ages and regional age structure. From this theoretical background, hypotheses were formulated and tested using a micro- and a macro-level analysis.

Controlling for individual and other regional characteristics, regional age of the origin region is significantly positively related to the probability of outmigration. Among migrants, the destination choice model showed that region alternatives with a higher mean age are less likely to get chosen as destination. We further tested whether the results are consistent with patterns of age- and skill-selective migration. Interactions between individual and regional ages were significant for both migration propensity and destination choice. This implies that younger individuals may be more sensitive to regional age structure both in deciding to leave a region and in choosing destination regions.

In contrast, we do not find compelling evidence to suggest education-specific effects in migration patterns across ageing regions. Indeed, individuals with lower educational degrees seem to be more likely to leave older regions than higher-educated individuals. After the year 2000, the choice model shows that more highly educated individuals may be more sensitive to regional age structure in their destination choice but these results are much less clear than for age-interactions.

The analysis of aggregate migration patterns supports the micro-level findings. The results of estimating a gravity migration model of a origin-destination matrix of district-to-district flows showed consistently that older destination regions experience smaller migration inflows. Additionally, and contradictory to the theoretical prediction of composition and cohort size effects, age of the origin region is, on average, associated with larger outflows.

With respect to the role of population ageing in shaping migration patterns, the results yield two core conclusions. First, age structure clearly matters in explaining migration trends. Even when controlling for a range of individual and regional characteristics, mean age was consistently significant in all estimations. Moreover, the fact that results were not sensitive to measuring age structure with alternative indicators lends further evidence for the notion that age structure is influential. Although the presented results do not address endogeneity concerns sufficiently to claim causality, the correlations show that relocations in a context of demographic change occur in a systematic manner.

Second, the direction of the estimated coefficients shows that, if anything, migration seems to reinforce rather than oppose the processes of demographic change. The presented results show that migration flows from relatively old to relatively young regions. Moreover, the identified interaction effects suggest that the migration flows may be selected based on age, with younger individuals more likely to leave older regions. If this is true, older regions do not only see an outflow of population but specifically an outflow of the younger age groups, which will increase the average age of the region further. Although we do not consider the net effect of the migration flows here, the findings illustrate that age-selective migration in Germany may indeed lead to a polarization of age structures.

Two important caveats to the presented analysis should be noted: the nature of the data used and the exclusive focus on internal migration. The micro-level analysis in this chapter was based on a reliable but restrictive data source. Although the information is of relatively high quality, the nature of the dataset only allowed us to identify the geographical location of employers, thus reducing the sample to those employed. It is not clear whether these employed individuals are representative of the broader population; unemployed individuals may for instance take into account a different set of factors to decide whether and where to move (see e.g. Arntz, 2005). Additionally, the aggregate flows in the gravity models cannot be disaggregated by age group, thus preventing any analysis on the composition of the migration flows.

The second caveat of the analysis is that international migration is not considered. Restricting the focus to internal migration allowed us to assume relative homogeneity of migrants and residents and thus ignore a range of factors that would be relevant for international migration. It also grants much more detailed and comprehensive information on migrants at a small spatial scale. However, considering only internal migration patterns limits external validity as it treats German interregional migration as if it were a closed system. In reality, foreign immigrants of course represent a relevant factor in shaping demographic structure. For the case of Germany, this has become abundantly clear with the large inflow of people in 2015, during what is often termed the European refugee crisis. 2015 was the year with the highest net immigration in the history of the Federal Republic: over 2.1 million immigrants and 998,000 emigrants were recorded across national borders leading to a net migration surplus of 1,139,000 (Destatis, 2016a). The scale of these population movements was so unexpected that the German Statistical Office decided to issue an update of its population projection until 2060 illustrating that, although long-term consequences of this development are not yet discernible, international migration has potentially profound effects on demographic structure.

With respect to the internal migration patterns examined here, the relevance of our discussion for migration more generally depends on whether international migrants' regional location decisions differ from internal migrants'. In particular, while the initial immigration decision may be distinct, subsequent relocations across district borders could follow the same patterns as internal migration. In this sense, while international migration clearly increases the population size on a national scale, regional-level effects could still be shaped by internal migration patterns. Assuming that international migrants are free to move[11], and if regional age structure indeed affects attractiveness of a place, we would expect both internal and international migrants to prefer younger over older regions. Thus, even a large population inflow may eventually end up in the same young and growing regions and further polarize the regional demographic structure. Policy suggestions to use international immigration to alleviate the issues of population ageing and decline on a regional level therefore need to take these issues into account.

The conclusions of this chapter's analysis tie into the broader question on policy making to address the consequences of demographic change. In terms of the patterns documented in this chapter, it seems that migration and population ageing are indeed reinforcing processes leading to polarization of demographic structure. These changes are, in turn, drivers of the economic and social consequences discussed in the previous chapters of this thesis. Contrary to some theoretical suggestions, population ageing does not seem to counteract outmigration, thus raising the question of whether policy should and can influence migration patterns directly.

Policy could aim to increase regional attractiveness, particularly for those age and skill groups most prone to outmigration, and some such attempts have been implemented especially for East Germany, albeit with limited effects (M. Fuchs & Weyh, 2016). Alternative policy approaches are those in line with the discussion of adopting a paradigm of shrinkage rather than growth (e.g. Grasland et al., 2008; Müller & Siedentop, 2004) and dealing with the consequences rather than the causes of the demographic shifts. Indeed, such policies, e.g. down-sizing of infrastructure, social innovations and repurposing built land to the environment may increase the liveability of ageing regions and thus hold a possible solution to curbing outmigration. The potential for success of such local policies also depends on the broader trends in demographic change, and especially international and internal migration, which can be very volatile. It is certain, however, that the location and mobility decisions as well as the consumption and retirement behaviour of the baby boom generation will be instrumental in shaping demographic change and migration on a national and regional level.

[11] It should be noted that the large German immigration surplus of 2015 is peculiar in this sense because of the very large share of asylum seekers among the migrants. In contrast to other migrants, asylum seekers are often subject to policies of dispersal, which implies a restriction of freedom of movement at least until refugee status has been granted (see e.g. Boswell, 2003).

5.A Appendix

5.A.1 Variable descriptions and summary statistics

Ageing Indicators		Source
mean age	Mean age of the work force	SIAB7510
young	Share of population younger than 25 years	RDG
elderly	Share of population above 65 years	RDG
|Billeter J|	$\lvert \text{Billeter J} \rvert = \left\lvert \frac{P_{0-14}-P_{50+}}{P_{15-49}} \right\rvert$	RDG
population by age group	Size of population by age group: 0-19, 20-29, 30-39, 40-49, 50-64 and 65+	RDG

Migration Indicators		
Mij	Migration flow from region i (origin) to region j (destination)	GIM
migration	Dummy variable for migration event	SIAB7510

Individual Characteristics		
age	age of individual	SIAB7510
female	Gender dummy	SIAB7510
education	educ 1: primary, lower/intermed secondary degree educ 2: primary, lower/intermed secondary degree and vocational degree educ 3: upper secondary degree educ 4: upper secondary and vocational degree educ 5: university of applied sciences degree educ 6: university degree	SIAB7510
wage	Hourly wage at current employment	SIAB7510
repeat migrant	dummy indicating whether individual migrated before	SIAB7510

Regional Characteristics		
ln distance	ln of distance between centroids in meters	
ln population	ln of population size	RDG
ln GDP p.c.	ln of GDP per capita	RDG
unemployment	unemployment rate	RDG
share services	share of services in total value added	RDG
share high-skilled	share of social-security insured employed with tertiary education	SIAB7510
ln hotels	ln number of hotel beds	RDG
urban	dummy for settlement type with 1=urban, 0 = rural	BBSR
east	dummy for regions of former GDR with Berlin coded as West	

Data Sources	
RDG	Regional Database Germany
SIAB7510	Regional File of the Sample of Integrated Labour Market Biographies 1975-2010
GIM	German Migration Database (Sander, 2014)

Table 5.A.1: Dataset for individual analysis (SIAB7510 data source)

Variable	Mean	Std. Dev.	Min	Max
migration	0.09	0.29	0.00	1.00
individual age	38.97	11.76	17.00	62.00
female	0.47	0.50	0.00	1.00
education	2.45	1.35	1.00	6.00
wage	66.19	43.71	0.00	180.00
repmig	0.17	0.38	0.00	1.00
mean age	38.65	0.94	34.72	42.49
elderly	0.18	0.02	0.11	0.27
young	0.26	0.02	0.19	0.35
|Billeter J|	0.46	0.11	0.10	0.98
age group 0-19	94958	119988	13343	690479
age group 20-29	64542	94371	9607	506652
age group 30-39	81069	117451	10268	648718
age group 40-49	76709	105375	12270	594666
age group 50-64	94262	130056	15896	681272
age group 65+	86871	110280	13491	658600
population	498412	673757	98773	3458763
GDP p.c.	28.96	13.03	10.75	83.52
unemployment	10.96	4.57	1.90	27.70
service share	68.62	10.70	27.98	94.63
share high-skilled	11.21	5.15	1.82	31.10
hotel beds	12379	15943	262	104483

Observations: 8,667,376

Table 5.A.2: Dataset for aggregate analysis (GIM data source)

Variable	Mean	Std. Dev.	Min	Max
Mij +1	23.47	139.27	0	14492
distance (km)	301.66	150.70	1.08	818.89
mean age	38.63	1.08	34.72	42.49
elderly	18.09	2.56	11.26	27.07
young	26.62	2.27	18.82	35.32
|Billeter J|	0.45	0.12	0.10	0.98
age group 0-19	51382	44272	13343	690479
age group 20-29	30131	33395	9607	506652
age group 30-39	38388	41751	10268	648718
age group 40-49	38879	37667	12270	594666
age group 50-64	47042	46595	15896	681272
age group 65+	45164	41373	13491	658600
population	250986	242445	98773	3458763
GDP p.c.	24701	9774	10752	83520
unemployment	10.34	4.55	1.90	27.70
service share	65.73	9.81	27.98	94.63
share high-skilled	9.13	4.19	1.82	31.10
hotel beds	7495	8788	262	104483

Observations: 1,391,280

5.A.2 Robustness checks

Table 5.A.3: Alternative ageing indicators propensity model

	(1) elderly	(2) elderly	(3) young	(4) young	(5) billeter	(6) billeter	(7) agegroup	(8) agegroup
share elderly	0.7058***	0.6067***						
	(0.0960)	(0.1386)						
share young			-2.6089***	-1.0287***				
			(0.0942)	(0.1336)				
|Billeter J|					0.4586***	0.3149***		
					(0.0186)	(0.0262)		
ln ages 0-19							-0.2987***	-0.0569**
							(0.0211)	(0.0289)
ln ages 20-29							-0.5733***	-0.3028***
							(0.0169)	(0.0209)
ln ages 30-39							0.2130***	-0.1007***
							(0.0317)	(0.0372)
ln ages 40-49							0.2950***	0.1867***
							(0.0318)	(0.0410)
ln ages 50-64							0.5627***	0.3337***
							(0.0252)	(0.0323)
ln ages 65+							-0.2715***	-0.1356***
							(0.0185)	(0.0260)
age	-0.0681***		-0.0681***		-0.0680***		-0.0683***	
	(0.0009)		(0.0009)		(0.0009)		(0.0009)	
age^2	0.0004***		0.0004***		0.0004***		0.0004***	
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
female	-0.2579***		-0.2578***		-0.2579***		-0.2575***	
	(0.0030)		(0.0030)		(0.0030)		(0.0030)	
education 2	-0.0995***		-0.1000***		-0.1000***		-0.0962***	
	(0.0045)		(0.0045)		(0.0045)		(0.0045)	
education 3	0.2896***		0.2885***		0.2903***		0.2988***	
	(0.0073)		(0.0073)		(0.0073)		(0.0073)	
education 4	0.0051		0.0044		0.0049		0.0076	
	(0.0065)		(0.0065)		(0.0065)		(0.0065)	
education 5	0.1446***		0.1449***		0.1445***		0.1499***	
	(0.0088)		(0.0088)		(0.0088)		(0.0088)	
education 6	0.3184***		0.3190***		0.3190***		0.3274***	
	(0.0073)		(0.0073)		(0.0073)		(0.0073)	
wage	-0.0103***	-0.0099***	-0.0103***	-0.0099***	-0.0103***	-0.0099***	-0.0104***	-0.0099***
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0001)
repeat migrant	2.4636***	1.7044***	2.4618***	1.7042***	2.4628***	1.7043***	2.4564***	1.7032***
	(0.0029)	(0.0049)	(0.0029)	(0.0049)	(0.0029)	(0.0049)	(0.0029)	(0.0049)
Constant	0.7980***		2.0165***		0.8556***		0.8900***	
	(0.0446)		(0.0582)		(0.0422)		(0.0461)	
Observations	8,667,376	3,753,891	8,667,376	3,753,891	8,667,376	3,753,891	8,667,376	3,753,891
Reg. Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind. FEs	-	Yes	-	Yes	-	Yes	-	Yes
pseudo R2	0.205	0.0833	0.205	0.0833	0.205	0.0833	0.206	0.0835
p>2	0	0	0	0	0	0	0	0
Number of IDs		391,602		391,602		391,602		391,602

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 5.A.4: Alternative ageing indicators for choice model

	(1) 1997	(2) 1998	(3) 1999	(4) 2000	(5) 2001	(6) 2002	(7) 2003	(8) 2004	(9) 2005	(10) 2006	(11) 2007	(12) 2008	(13) 2009	(14) 2010
share elderly	-4.1130***	-3.9417***	-3.3414***	-3.2970***	-1.9593***	-3.2873***	-3.5857***	-3.6951***	-3.8966***	-4.8574***	-4.1004***	-4.1910***	-3.8180***	-3.7966***
	(0.3465)	(0.3586)	(0.3305)	(0.3245)	(0.3203)	(0.3261)	(0.3320)	(0.3271)	(0.3314)	(0.3297)	(0.3131)	(0.3080)	(0.3262)	(0.4216)
share young	3.4650***	2.7753***	2.9021***	2.2891***	1.5030***	2.8897***	2.6887***	3.2335***	3.4932***	4.1713***	3.6794***	3.4486***	3.4243***	3.3335***
	(0.3388)	(0.3466)	(0.3167)	(0.3097)	(0.3144)	(0.3267)	(0.3361)	(0.3408)	(0.3566)	(0.3579)	(0.3554)	(0.3596)	(0.3898)	(0.5082)
|Billeter J|	-0.9784***	-0.9172***	-0.8825***	-0.7421***	-0.6280***	-0.8846***	-0.7979***	-0.9128***	-0.9390***	-1.1745***	-1.0243***	-1.0527***	-1.0255***	-0.9964***
	(0.0733)	(0.0732)	(0.0663)	(0.0640)	(0.0637)	(0.0649)	(0.0660)	(0.0658)	(0.0676)	(0.0674)	(0.0647)	(0.0632)	(0.0665)	(0.0853)
ln age 0-19	0.1060	-0.1000	-0.1398*	-0.2238***	-0.3344***	-0.2315***	-0.2608***	-0.1085	-0.0821	-0.0966	-0.0634	-0.1377**	-0.1860**	-0.1755*
	(0.0854)	(0.0875)	(0.0798)	(0.0757)	(0.0728)	(0.0734)	(0.0734)	(0.0729)	(0.0740)	(0.0719)	(0.0700)	(0.0698)	(0.0740)	(0.0965)
ln age 20-29	0.9298***	0.7631***	0.8979***	0.9472***	0.8993***	1.0735***	1.0876***	0.9939***	1.0688***	1.1477***	0.9236***	0.9017***	1.0002***	0.8767***
	(0.0921)	(0.0898)	(0.0817)	(0.0731)	(0.0677)	(0.0634)	(0.0608)	(0.0566)	(0.0551)	(0.0524)	(0.0486)	(0.0480)	(0.0505)	(0.0666)
ln age 30-39	0.2346*	0.6812***	0.5867***	0.6390***	0.8811***	0.7075***	0.3158**	0.5582***	0.4038***	0.3778***	0.2953***	0.3974***	0.3256***	0.4157***
	(0.1317)	(0.1320)	(0.1230)	(0.1198)	(0.1222)	(0.1262)	(0.1262)	(0.1208)	(0.1184)	(0.1090)	(0.1016)	(0.0972)	(0.1000)	(0.1295)
ln age 40-49	-0.2847*	-0.3861***	-0.3638***	-0.5800***	-0.6999***	-0.6985***	-0.4102***	-0.6706***	-0.6791***	-0.6676***	-0.2765***	-0.1746	-0.1553	0.0757
	(0.1480)	(0.1429)	(0.1287)	(0.1224)	(0.1190)	(0.1203)	(0.1146)	(0.1109)	(0.1108)	(0.1069)	(0.1055)	(0.1090)	(0.1182)	(0.1700)
ln age 50-64	0.2304**	0.1865**	0.0790	0.3961***	0.0948	0.1476	0.4394***	0.2944***	0.4493***	0.3978***	0.0250	-0.2166	-0.4826***	-0.8230***
	(0.0935)	(0.0868)	(0.0770)	(0.0780)	(0.0824)	(0.0920)	(0.1003)	(0.1100)	(0.1212)	(0.1292)	(0.1360)	(0.1391)	(0.1429)	(0.1842)
ln age 65+	-0.4020***	-0.3368***	-0.2310***	-0.3251***	0.0037	-0.1490**	-0.3262***	-0.2409***	-0.3218***	-0.2807***	-0.0370	0.1164	0.3676***	0.4823***
	(0.0601)	(0.0640)	(0.0607)	(0.0615)	(0.0627)	(0.0663)	(0.0696)	(0.0730)	(0.0782)	(0.0814)	(0.0821)	(0.0816)	(0.0826)	(0.1029)
Obs.	15,081,111	15,716,462	19,322,447	21,114,940	21,132,193	19,537,530	19,091,135	18,935,628	18,303,431	18,879,544	20,100,637	19,956,321	17,152,751	9,612,240

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 5.A.5: Alternative ageing indicators aggregate analysis

Dep. Var:	(1) OLS	(2) Poisson	(3) OLS	(4) Poisson	(5) OLS	(6) Poisson	(7) OLS	(8) Poisson
ln young O	0.596***	-0.267***						
	(0.0271)	(0.0884)						
ln young D	0.307***	1.493***						
	(0.0261)	(0.1535)						
ln old O			-0.447***	-0.246***				
			(0.0185)	(0.0682)				
Ln old O			-0.227***	-0.765***				
			(0.0183)	(0.0693)				
ln |Billeter J| O					-0.0338***	0.0980***		
					(0.0092)	(0.0251)		
ln |Billeter J| D					-0.280***	-0.549***		
					(0.0089)	(0.0332)		
ln age group 0-19 O							0.298***	0.141**
							(0.0230)	(0.0639)
ln age group 20-29 O							0.501***	0.246***
							(0.0140)	(0.0735)
ln age group 30-39 O							-0.0298	0.0312
							(0.0208)	(0.0608)
ln age group 40-49 O							0.260***	0.312***
							(0.0253)	(0.0972)
ln age group 50-64 O							0.242***	0.515***
							(0.0190)	(0.0570)
ln age group 65+ O							-0.222***	-0.182***
							(0.0185)	(0.0633)
ln age group 0-19 D							-0.0616***	0.352***
							(0.0226)	(0.1135)
ln age group 20-29 D							0.445***	0.586***
							(0.0134)	(0.0427)
ln age group 30-39 D							0.171***	0.0500
							(0.0204)	(0.0646)
ln age group 40-49 D							-0.222***	-0.686***
							(0.0244)	(0.0962)
ln age group 50-64 D							-0.404***	-0.700***
							(0.0192)	(0.0599)
ln age group 65+ D							-0.151***	-0.372***
							(0.0184)	(0.0617)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
O-D FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.007		0.007		0.007		0.010	
Obs.	1,391,280	1,390,990	1,391,280	1,390,990	1,391,280	1,390,990	1,391,280	1,390,990
No. IDs	102,080	102,055	102,080	102,055	102,080	102,055	102,080	102,055

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Chapter 6

Conclusion

> *'For in nature it takes thirty years for two hundred eggs to reach maturity. But our business is to stabilize the population at this moment, here and now. Dribbling out twins over a quarter of a century — what would be the use of that?'*
>
> Brave New World (Huxley, 1932, p. 5)

6.1 Summary of results

Demographic shifts are an undeniable force of change on a global, national, and regional level. They manifest themselves in the cumulative effect of decades of sub-replacement fertility and steadily increasing life expectancy, causing shifts towards smaller and older populations. Although regional population shrinkage has often been observed historically, its occurrence in a context of national-level population ageing and decline is unprecedented. Thus, as population ageing and shrinkage transform from exceptional cases to widespread trends, the questions of the consequences and possible policy approaches are becoming more pressing. This thesis investigated the regional consequences of demographic change using the case of Germany between 1996 and 2010. It aims to contribute to the growing empirical literature on how shifts in population size and composition will affect living conditions, local economic development, and regional disparities.

The empirical analyses in this thesis focused on three areas where regional effects of demographic change may occur. First, the issue of public service provision was examined using the example of primary school supply. The central challenge of demographic change for public service provision is to address the trade-off between cost effectiveness and adequate accessibility of public services. The results suggest that regions do adjust the supply of schooling when demand falls but that the degree of responsiveness depends on regional characteristics. More severe population shrinkage as well as disadvantageous economic conditions lead to larger changes in supply for a given change in demand. Moreover, the results illustrated a pronounced difference between regions in former East versus West Germany.

Chapter 4 examined the effect of demographic change on the availability and composition of human capital. Investment in human capital is usually presented as the core policy approach to compensate for an ageing and shrinking labour force. We find that regions that were ageing more severely between 1996 and 2010 also experienced less growth in human capital. Moreover, when considering the composition of human capital by educational degrees, we find that regional ageing is associated with a larger share of traditional vocational training degrees and a smaller share of tertiary education. Although demographic change seems to play a minor role in comparison with general education expansion, it nevertheless shows distinctly different geographical patterns in human capital expansion.

As a driving factor of population development on a national but especially on a regional scale, migration flows can both slow down and speed up processes of demographic change. However, the reverse issue, i.e. whether demographic structure may also influence migration patterns has so far received little attention. The results presented in Chapter 5 illustrate that migration behaviour on an individual and on an aggregate level are consistent with outmigration from older and towards younger regions. This finding supports the hypothesis that demographic change, at least on a regional level, may be shaped as a process of cumulative causation: if young people leave older regions, the regional age increases further, leading to a spatial polarization of demographic structures.

Jointly, the research presented in this thesis shows that there is a distinctly regional dimension to demographic change. This does not only apply to the regional variation in demographic structure and trends as documented in Chapter 2 but also in how these changes affect regions. Moreover, the presented results show that demographic change may indeed increase regional disparities in living conditions, labour market features and demographic structure. This heterogeneity in how regions respond to demographic change illustrates that policy aimed at issues of demographic change needs to be adapted to regional circumstances.

6.2 Limitations and extensions

In addition to the specific limitations to the research design noted in each of the chapters, some broader caveats should be highlighted. First, this thesis is largely exploratory and does not attempt to establish causal relationships. Clearly, population development is closely intertwined with other regional characteristics and the direction of causality likely goes both ways. However, for the purpose of understanding the challenges that regions will face with progressing demographic change, the precise causal channels of effects are perhaps secondary to first establishing the common correlational trends. In this sense, the presented results in the empirical chapters represent reduced form estimations, where the emphasis lies on how demographic structure and the dependent variable move together and not on establishing the underlying causal factor. Further research could, however, aim to address the issue of causality more directly, potentially by focusing on individual data or cases (such as e.g. the consequences on accessibility of schooling follwing the implementation of a legal minimum school size in the Federal State Saarland in 2005).

A second issue of this research is the choice of geographical units. The district-level was chosen to maximise sample size considering relatively strong limitations on data availability. Corresponding to NUTS 3 regions, German districts reflect a high degree of regional variation but they are administrative rather than functional regions. An inherent concern of the presented analyses is therefore the Modifiable Areal Unit Problem (MAUP) (Openshaw & Taylor, 1979). The MAUP refers to the fact that the size and shape of the statistical units used may affect the results of spatial analysis (e.g. Fotheringham & Wong, 1991) although Briant, Combes, and Lafourcade (2010) argue that MAUP is less problematic than other issues of mis-specification, especially for small geographical units. In order to address this concern, the analyses could be repeated for other geographical boundaries, e.g. labour market or spatial planning regions.

Using labour market regions could help ensure that commuting flows are accounted for. While this is unlikely to be an issue for the provision of primary education, human capital availability and migration trends could in principle be affected by individuals working and living in two different regions. The results in Chapters 4 and 5 are only based on individuals' places of employment, which are not necessarily the same as their residential locations. However, both labour market and spatial planning regions would require a considerable aggregation upwards, thus losing a large degree of regional heterogeneity and more than half of the observations. As the SIAB7510 is reported at an adjusted district-region level, where regions with less than 100 000 inhabitants are combined, the applied district definition of 332 regions does not always match up with labour market regions or spatial planning regions. Although repeating the analysis for other geographical units could establish robustness, the district definitions are nevertheless consistent across all presented empirical analyses, intuitive in a geographical sense, cover both rural and urban areas, and correspond to the administrative boundaries relevant for decision-makers on a local scale.

A final notable issue is the exclusive focus on the case of Germany. As discussed in the introduction, Germany represents a useful and natural case for analysis in Europe and restricting analysis to a single country allowed a more detailed and well-rounded investigation. However, demographic change is not only a national issue but also of concern for European-level policy making. It would thus represent an interesting extension to this research to implement a regional analysis on a European scale. Additionally, as Germany is relatively far-progressed in its demographic transition, it could be valuable to compare the results to other countries that have yet to age and shrink at a similar rate.

6.3 Policies for ageing and shrinking regions

Despite these limitations, the research presented in this thesis illustrates that demographic change has regional consequences that should be taken seriously. Furthermore, it offers empirical evidence on how demographic change already affects and will further affect German regions. The fact that the brunt of demographic changes is yet to come explains the relative scarcity of empirical results on its consequences. However, it could be argued that the lack of quantitative research even on the regional scale, where changes are already measurable, contributes to the uncertainty and apprehension surrounding our "demographic future". In this sense, quantifying the impacts of older and smaller populations on a regional scale, as attempted in this thesis, may help to demystify the process of demographic change. This may support policy makers, whose slow response in anticipating or at least reacting to demographic projections of population ageing and shrinkage is widely criticised among demographers (Birg, 2014; Kaufmann & Krämer, 2015).

Demographic policy is a value-laden subject, which may interfere with debates on this issue. Clearly, whether and how the state should intervene in people's decision to have children is a sensitive question. Dystopian scenarios, like that of Aldous Huxley's (1932) *Brave New World* quoted at the beginning of the chapter, come to mind: In Huxley's vision of the future, the government has taken over control of reproduction and achieves the aim of a stable population with efficiency and technology but at the cost of personal freedom[1]. This example resonates especially for the German case where population policy still carries connotations of its use in Nazi ideology, which may explain policy makers' hesitancy (Kaufmann & Krämer, 2015; Weipert, 2006).

Moreover, the sensitive discourse of demographic policy regularly veers from one extreme to the other (see e.g. Lengwiler, 2007). Historically, policies that promote population growth were desirable to increase economic and military power and central, but not exclusive, to nationalist ideologies. Similarly of course, concerns that population growth needs to be contained because it will otherwise outstrip agricultural production and use up scarce resources go as far back as Malthus (1798) but have frequently been reiterated upon and sometimes dramatised (e.g. Heinze, 2013). Fears of overpopulation motivated policy measures aimed at reducing fertility such as Japan's legalisation of abortion for economic reasons in 1952 (Coulmas & Lützeler, 2011) or China's One-Child-Policy in 1979 (Du & Yang, 2014). With the benefit of hindsight, these efforts seem misguided: Japan has the oldest population worldwide and is facing prospects of severe population shrinkage (Matanle & Sato, 2010; Matanle & Rausch, 2011). China is ageing rapidly (see e.g. Bloom & Luca, 2016) and repealed the One-Child-Policy in 2015. Whether this policy change will actually increase Chinese fertility in the face of global demographic change remains uncertain.

[1] In his 1958 essay Brave New World Revisited, Huxley (1932) expressed concern that overpopulation could be conducive to the emergence of such totalitarian governments and that the fast population growth of the 20th century was making this development more likely.

Keeping these general problems of population policy in mind, initiatives to address demographic challenges can take two forms: target the demographics or address the consequences. As discussed previously, immigration will generally not be able to prevent population ageing although it may slow down its effects (Coleman, 2006a). Moreover, the results of Chapter 5 of this thesis suggest that internal migration patterns may undermine attempts to use international immigration to counter regional-level population shrinkage and ageing. Pro-natalist family policy aimed at decreasing the monetary and non-monetary costs of parenthood could in principle increase fertility rates but are usually not very effective (see e.g. Birg, 2014; Huinink, 2015; Lutz & Skirbekk, 2005). Moreover, even increased fertility rates cannot reverse the effects of a fundamentally skewed population age structure. In particular, the cumulative effect of sub-replacement fertility implies that Germany but also Europe as a whole has now generated *negative population momentum*: even if fertility jumped to replacement level tomorrow the population will still decrease for several years until stabilising (Lutz, O'Neill, & Scherbov, 2003).

Considering the uncertain outcomes as well as long time-horizon needed for demographic policy, initiatives aimed at dealing with the consequences of changing population size and structure may be more promising. On a national level, restructuring pension systems, increasing labour market participation for all age groups, and continuous investment in human capital emerge as relevant aspects (e.g. Börsch-Supan, 2003). More radical suggestions aim to also address distributional equality between generations or between individuals with or without children. For instance, it has been suggested to tie tax or pension burdens in a pay-as-you-go system to parenthood: individuals without children would then have to compensate for the fact that they did not have children that will eventually pay into retirement funds (Sinn, 2015). Such measures would jointly address the demographics (by supporting families) as well as their consequences.

On a regional level, policy makers need to realise that population ageing and shrinkage are likely unavoidable and that these trends are in fact already occurring today. Empirical research, such as that presented in this thesis, has a valuable role to play in highlighting the progressing demographic changes as well as their measurable consequences. For most German regions, policy to address these consequences cannot rely only on attracting migrants through growth-oriented policies because population is shrinking at a national scale. Instead, regions will need to adjust to being smaller, older and less dense. Framing policy in a *paradigm of shrinkage* as an alternative to striving for expansion may support such pragmatic policy making (Müller, 2003; Müller & Siedentop, 2004). Policies could, for instance, involve expanding services for an elderly population, down-sizing and repurposing of infrastructure, supporting cooperation across sub-national units, and investing in human capital in a way that corresponds to the age-structure and demand of the local labour market. Further, regions with strong population decline and ageing may require significant investment in local social capital and communities and need to experiment with innovative approaches to ensuring accessible service provision.

The results of this thesis emphasise the regional heterogeneity in both demographic developments and their consequences. From a perspective of regional disparities, this heterogeneity clearly implies that policies need to be adapted to the local context. Moreover, it is possible that demographic change will increase regional disparities in demographic and economic structure. Regional policy in a paradigm of shrinkage does not imply neglecting lagging, shrinking or ageing regions but rather investing in targeted policies that safe-guard the local population from the most severe impacts of demographic change.

An aspect that is not often enough emphasised in discussions of demographic change is that population ageing and shrinkage are not per se problems but consequences of fundamentally beneficial developments. The share of elderly population is increasing because we live much longer and healthier lives. The number of children is low because social changes associated with gender equality and technological change empower us to control whether, when and how many children we have. The problem is not that population is ageing and decreasing, the problem is that the current institutional framework is designed for an out-dated demographic structure. Thus, dealing with demographic change implies adapting institutions to the new reality of older and smaller populations in a pragmatic manner. Although it holds many challenges, demographic change may become an impetus for restructuring and social change that is more sustainable and beneficial in the long term.

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