THE PRODUCTIVITY DYNAMICS OF THE UK ECONOMY: A MICRO DATA PERSPECTIVE

by
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I, Raffaella Sadun, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

This dissertation is dedicated to the memory of my grandmother Rina

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Abstract

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This dissertation analyzes two factors which may lie behind the recent productivity surge in the US, the lack of productivity growth in Europe and, ultimately, the persistence of significative differences in the levels of productivity across the two macro areas. First, we analyse the role played by Information Technologies (IT). Second, we study the impact of specific regulatory policies, focusing on the consequences of regulations which constrain the entry of large and peripheral retail stores ("big-boxes"). These issues are explored in the context of the UK economy, whose recent economic performance is consistent with the overall European picture of sluggish productivity growth (Basu *et al.*, 2003). Furthermore, the questions are approached from a micro data perspective, using a series of novel establishment and firm-level datasets drawn from Census data sources.

In the first two essays I focus on the role played by Information Technologies (IT), which appear to have played a substantial role in driving the recent productivity surge of the US economy. Chapter I sets out a theoretical and empirical context in which to study the impact of IT on productivity. Chapter II discusses the effects of IT on a

large panel of firms active in the UK economy, observed between 1995 and 2003. A key finding of the study is the apparent ability of US multinationals to obtain higher productivity than non-US multinationals (and domestic UK establishments) from their IT capital.

Chapter III, IV and V are dedicated to the study of the retail industry, which accounts for a large part of the European productivity gap vis a vis the US over the past decade. In particular, we study the effect of entry regulations against large retail stores ("big-boxes"). In Chapter III, it is shown that the recent introduction of entry regulations against large stores in the UK has paradoxically increased the competition faced by mom and pops retailers. Chapter IV show evidence that entry regulations have also significantly lowered the productivity of UK retail chains, forcing them to operate at a lower scale of retail activity. This result is set in an international context in Chapter V, where the market structure and the productivity dynamics of the UK retail industry with that of the US and Japan are compared using novel Census data sources.

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Introduction

One of the most remarkable stylized facts of the last decade has been the rapid growth of labour productivity in the US economy, represented in Figure 1. This has continued despite the high tech crash and the 9/11 terrorist attacks, and reversed a period of slow US productivity growth that set in after the Oil Shocks of the mid-1970s. Figure 1 also shows productivity growth in Europe. European productivity growth over the whole period since the Second World War has outstripped US productivity growth, generating a convergence in productivity levels. Since 1995, however, European productivity growth, unlike the US, has shown no acceleration, and productivity levels have started to diverge again.

There has been much discussion over this productivity difference between the US and Europe, but no consensus has emerged. Some authors claim it is simply a matter of time before Europe resumes the catching up process (Blanchard 2004) while others point to more long-term structural problems in Europe such as over-regulated labour and product markets (Gust and Marquez 2004).

This dissertation analyzes two factors which may lie behind the recent productivity surge in the US, the lack of productivity growth in Europe and, ultimately, the persistence of significative differences in the levels of productivity across the two macro areas. First, we analyse the role played by Information Technologies (IT).

Second, we study the impact of specific regulatory policies, focusing on the consequences of regulations which constrain the entry of large and peripheral retail stores ("big-boxes"). These issues are explored in the context of the UK economy, whose recent economic performance is consistent with the overall European picture of sluggish productivity growth (Basu *et al.*, 2003). Furthermore, the questions are approached from a micro data perspective, using a series of novel establishment and firm-level datasets drawn from Census data sources.

IT played a crucial role for the US productivity acceleration. The importance of IT intensive sectors for the US has been carefully quantified in a series of macro studies. For example, Jorgenson and Stiroh (2000) examine the sources of output growth in the 1974-90 period and the 1995-99 periods[1]. Output growth in the early period was 3.13 percentage points per annum. The contribution of IT was relatively small – about 0.37 percentage points per year or about 10 per cent (=.37/3.13) of the total. In the later period, the contribution made by IT is more prominent. Output growth rose to 4.76 percent per year, 20 per cent (1.01 per cent) of which was due to IT. Furthermore, there was a significant increase in Total Factor Productivity (TFP) growth from a third of a percent per year to just less than 1 per cent per year. Some of this TFP growth was concentrated in the IT producing sectors (semi-conductors, computers, etc.). Oliner and Sichel (2000, 2002) corroborate Jorgenson's results that IT made an important contribution to US productivity acceleration. By splitting the economy into

[1] The 1990-95 period covered a deep recession and therefore was not included; however, its inclusion does not have much effect.

IT producing and using sectors they found that there were important contributions made by IT in both sectors[2].

In comparison with the US experience, IT seems to have played a negligible role in Europe. This is illustrated in Figure 2, which depicts a comparison of productivity growth between sectors, when the economy is divided into IT producing sectors, IT using sectors (those that use IT extensively, for example, retail, wholesale, and finance), and the rest of the economy (excluding public administration, health, and education). The bars show the acceleration of productivity. In the US economy, illustrated on the left hand-side of the diagram, we can see that the productivity acceleration was strongest in the IT using sectors (up from 1.2 per cent per annum in the early 1990s to 4.7 per cent per annum after 1995). There is also a smaller acceleration in the IT producing sectors (up by 1.9 percentage points). Outside these sectors, there was a deceleration in productivity of about half a percentage point. The right hand side of the diagram shows the picture for the European Union (the 15 members pre-2004). Again, there is productivity acceleration in the European IT producing sectors, and a deceleration in the non-IT sectors, but unlike the US, no acceleration of productivity in the IT using sectors.

There is little doubt that the increased importance of IT in the US economy has been facilitated by the dramatic decline of IT prices since the early 90's onwards, when the technology cycle for semi-conductors appears to have speeded up, leading to a fall in quality-adjusted prices for IT goods (Jorgenson 2001). What is surprising, however, is that European economies seem to have somehow been unable to exploit the opportunities arising from falling IT prices. There are at least two broad classes of

[2] Some authors do not agree with the view that IT has played a crucial role for the US productivity growth. In a provocative series of articles, Gordon (2000, 2003) takes issue with the view that IT use played an important role in US productivity growth post 1995. He is skeptical about the ability IT to affect productivity growth and in Gordon (2000), he claims that outside the IT producing sector, productivity growth in the US economy was entirely cyclical. Despite the inherent problems of knowing exactly how to correct for the cycle, this view had some plausibility in the late 1990s. It seems very implausible at the end of 2005. The US economy has suffered some cyclical downturns with the stock market crash of 2000, 9/11, the Iraq War, high oil prices, etc. but productivity growth has continued to power ahead. Furthermore, Stiroh (2002a) produced econometric evidence based on industry data that there was significant productivity growth in the intensive IT using sectors, even after controlling for macro-economic shocks.

explanation of this puzzle. First, there may be some "natural advantage" to being located in the US, enabling firms to make better use of the opportunity that comes from falling IT prices. These natural advantages could be, for example, better access to risk capital, more educated or younger workers, larger market size or greater geographical space. A second class of explanations stresses that it is not the US environment *per se* that matters but rather the way that US firms are organised or managed that enables better exploitation of IT.

These explanations are not mutually exclusive. Nevertheless, one straightforward way to test whether the "US firm organisation" hypothesis has any validity is to examine the IT performance of US owned organisations in a non-US environment. If US multinationals export their business models outside the US then analysing the IT performance of US multinational establishments in Europe should be informative. Chapters I and II of this dissertation focus precisely on this task. Chapter I illustrates the main conceptual issues related to the estimation of the productivity impact of IT, and the measurement of IT assets. Chapter II analyses the productivity of IT in a large panel of establishments located in the UK, examining the differences in IT-related productivity between establishments owned by US multinationals, establishments owned by non-US multinationals and domestic establishments.

A key finding of the study is the apparent ability of US multinationals to obtain higher productivity than non-US multinationals (and domestic UK establishments) from their IT capital. This finding is robust to a number of tests, including an examination of establishments before and after they are taken over by a US multinational versus a non-US multinational. Prior to takeover by a US firm, the establishment's IT performance is no different from that of other plants that are taken over by non-US firms. After takeover, the American establishment's productivity of IT capital increases substantially (while the productivity of non-IT capital, labor, and materials does not).

Overall, these findings suggest that higher IT productivity in the US has something to do with specific characteristics of US establishments, which can be defined as their "internal organisation". Consistently with this idea, novel survey data relative to a large sample of manufacturing firms observed in Europe and the US shows that US firms are organised differently to non-US firms and that they can change their organisational structure more quickly.

What drives the organizational differences between US and European establishments? A possible explanation for these differences is that specific labor and product market regulation policies prevalent in certain European countries may have played a crucial role in determining the organizational structure of European firms and, therefore, their ability to exploit the full potential of IT assets. Consistently with this hypothesis, we show that establishments belonging to multinationals headquartered in countries with more restrictive labor market regulations tend to under invest in IT assets.

The importance of specific product market regulations is the main theme of Chapters III, IV and V, which study the effects of entry regulations in the retail industry. This sector accounts for a large part of the European productivity growth gap *vis à vis* the US over the past decade. According to Van Ark et al (2003), for example, the retail sector alone contributed approximatively 0.33 point less to aggregate productivity growth in Europe than in the United States. This represents slightly less than a third of the overall productivity differential of 1.1 percentage points between the US and the Europe from 1995 to 2000.

Several authors have argued that these startling productivity differences may be attributed to the restrictive entry regulations adopted by several European countries to protect small and urban retailers ("mom and pop stores") from the competition of large and peripheral stores - "big-boxes". These policies, it is argued, harm the efficiency of the retail industry. First, they may inhibit the exploitation of scale economies. Second, more generally, they may reduce the productivity gains arising from the reallocation of resources across firms[3].

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[3] Foster et al (2006) show that reallocation dynamics (entry and exit of stores) account for about 90% of the overall US labour productivity growth over the 90's.

The exceptional degree of variability shown by entry regulations in the UK allows us to study the validity of these claims with standard econometric tools. The main regulatory change occurred in 1996 when, after a long period of *laissez-faire* promoted by Mrs Thatcher, new and restrictive criteria of admissibility for retail stores above 2,500 square meters were introduced. Furthermore, the reforms delegated to local government bodies (Local Authorities) the implementation of the new planning rules. Local Authorities were encouraged to follow general guidelines, but could make their planning decisions in a regime of almost complete independence from the central government. This institutional setting generated variation in the restrictiveness of the new entry regulations both within and across Local Authorities. I use this variation to explore three specific questions. First, did the introduction of entry restrictions against big-boxes effectively protect the employment of small retailers? Second, did these regulations affect the productivity of UK chains? Third, more generally, did the regulations generate a divergence between the structure of the UK retail industry and that of other major developed countries?

Since the planning reform targeted exclusively peripheral big-boxes, it increased the attractiveness of alternative store strategies. In particular, the post-1996 period was characterized by an unprecedented diffusion of small and central stores belonging to national retail chains, and by a strong decline in the big-box openings (Griffith and Harmgart, 2005). Chapter III argues that the competitive effects generated by the substitution of peripheral big-boxes with small and urban chain stores was so strong to paradoxically accelerate the decline of "mom and pop" stores.

I illustrate this point with a unique dataset, which allows us to study the relationship between planning grants and mom and pop stores' growth at the Local Authority level between 1998 and 2004. In the estimation, I adopt an instrumental variable approach to abstract from the variation in planning grants determined by local demand conditions. Following Bertrand and Kramarz (2002), the involvement of locally elected politicians in the concession of planning grants is exploited to construct the instruments. In particular, I document that planning grants decrease with increases in the share of Conservative councillors in the Local Authority, even controlling for the time varying socioeconomic characteristics of the electorate, and looking both across and within planning boards over time. This finding is consistent with the fact that middle-class homeowners and small retailers enjoy a significant political weight in the UK Conservative party, which ends up influencing the planning decisions of Conservative councillors.

The key finding of the essay is that in Local Authorities where *more* big-boxes were allowed to enter in the post-reform period, mom and pop stores experienced *higher* rates of employment growth. The positive effect of planning grants on the employment of mom and pop stores holds both with OLS and when using changes in local political composition as an instrument to deal with the endogeneity of big-box entry. We decompose the positive effects of big-boxes along the different margins of adjustments (entry, exit and incumbents) of mom and pop stores, and show that most of the positive effect is driven by a reduction in exit rates. According to the estimates, the sharp decline in big-box entry - which followed the 1996 reform -accounts for about 8% of the decline experienced by independent retailers between 1998 and 2004.

Chapter IV investigates if the movement towards small stores had an impact on the productivity of UK retail chains. Several authors have emphasized the importance of scale economies for the activity of retail firms. Oi (1998), for example, discusses the role of fixed inputs such as parking and advertisement as sources of economies of scale at the store level. Others, like Holmes (2002) and Basker et al (2007) discuss the complementarity between store size with investments in bar codes and integrated distribution networks and, more generally, with the ability of retail chains to coordinate the activity of multiple stores.

I look at the relationship between store size and productivity using a series of micro datasets drawn from the UK Census, which provide detailed firm and store level information for a large sample of chains active in the UK, observed between 1997 and 2003. Detailed information on output, inputs and store characteristics is used to analyse the relationship between the TFP of retail chains and the typology of stores they own - as summarized by the median and the variance of their stores' distribution.

The analysis shows a consistent and statistically significant association between chain TFP and median store size, even controlling for a full set of firm level fixed effects. Interestingly, the relation is particularly strong in the Non-Specialised retail (SIC 521, supermarkets), the industry which accounts for most of the movement towards small stores in the aftermath of the reform. The coefficients suggest that the fall in within-chain shop sizes lowered annual TFP growth in retailing by 0.4%. This is, about 40% of the post-1995 slowdown in UK retail TFP growth of about 1% (as documented by Basu et al, 2003). This finding suggests that the introduction of tight planning regulations had a significant impact on the productivity of the UK retail sector, constraining the entry of high TFP outlets.

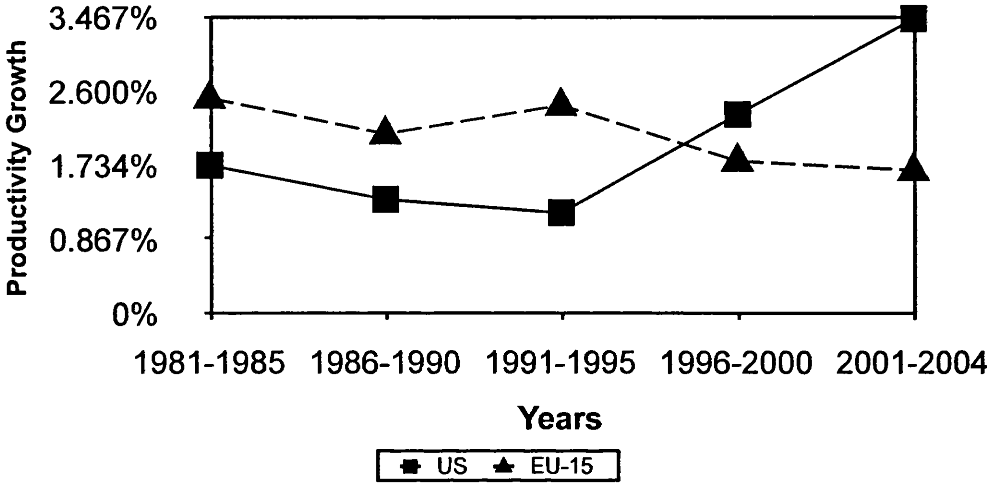
Chapter V studies the implications of the UK planning reform for retail market structure. For this purpose, comparable micro data on static and dynamic market characteristics of the retail sectors in Japan and the United States is assembled. This set of countries provides an ideal setting to analyse the importance of entry regulations, since Japan and the US are, respectively, characterized by stronger and weaker restrictive regulatory settings compared to the UK. A common research protocol is applied to confidential micro data on retail firms and establishments for all three countries. The data is collected by national statistical offices, which uses it in compiling the national accounts and other official statistics. The analysis is performed on comparable and disclosable aggregations of the national micro records, or in similar empirical exercises conducted at the firm or establishment level within each country for the 1997 to 2002 period.

The analysis reveals significant differences in terms of store frequency and average size across the three countries. Japan has a relatively large number (per head of the population) of small stores (10 per head), with the US many fewer (4) and the UK in between (5). In terms of store size, the US has bigger stores all round (average sizes are 13 in the US, 9 in the UK and 6 in Japan), and chains are bigger in the US at all points in the size distribution of stores within the chain. Moreover, between the mid-1990s and early-2000s, the median store size in a US supermarket belonging to a chain rose from about 140 to 155 employees, while in the UK it fell from about 80 to 40. Since the US is typically associated with milder regulatory restrictions against big-boxes. these differences are consistent with the idea that stricter entry regulations inhibit the diffusion of large retail stores, as discussed in Chapter IV.

Differences in terms of store and firms' dynamics are particularly stark. In the US, entrants either gain market share or exit. In the UK, they are much more likely to stick where they are, typically in the bottom of the market share distribution and not exit. Finally, in the US - as in the UK - the median store size of a typical retail chain is statistically associated with higher chain productivity. To the extent this is causal, this suggests that the UK trend to smaller stores within chains would have lowered UK retailing productivity and the US trend to larger will have raised it.

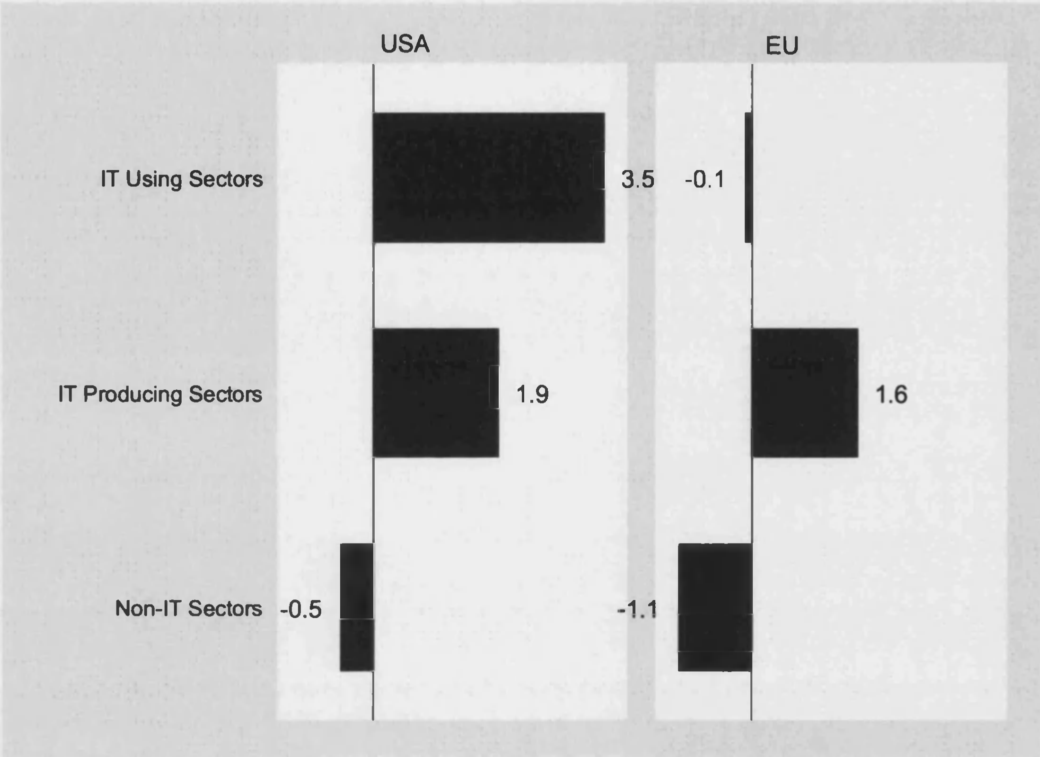
The overall picture emerging from the three essays focusing on the retail sector are consistent with the hypothesis that entry regulations have had a significant impact on the structure and the productivity of the UK retail industry. Interestingly, entry regulations appear to have induced significant distortions not only for retail chains, but also for mom and pop stores, which are generally considered among the beneficiaries of these policies. These findings suggest that a reduction in the regulatory restrictions against big-boxes which are currently in place in the UK and in several other European countries could generate important productivity and employment gains.

Figure 1: Annual Growth Rates of Real Output per Hour Worked



Notes: The graph shows the annual growth rates of real output per hour expressed in 2005 US $ PPPs. The countries included in the "EU 15" group are: Austria, Belgium, Denmark, Finland, France, Germany, UK, Greece, Italy, Ireland, Luxembourg, Portugal, Spain, Sweden and the Netherlands. Labour productivity per hour worked in 2005 US$ using PPPs. Source: Marcel P. Timmer, Gerard Ypma and Bart van Ark, "IT in the European Union: Driving Productivity Convergence?", Research Memorandum GD-67, Groningen Growth and Development Centre, October 2003, Appendix Tables, updated June 2005.

Figure 2: US and European acceleration in productivity growth (market sector)



Notes: The graph shows the change in annual growth rates in real output per hour between the 1990-1995 and the 1995-2001 periods. The countries included in the "EU 15" group are: Austria, Belgium, Denmark, Finland, France, Germany, UK, Greece, Italy, Ireland, Luxembourg, Portugal, Spain, Sweden and the Netherlands. Source: O'Mahony and Van Ark (2003). The ICT taxonomy is as follows (SIC92): 1. ICT Producing: Office machinery (30); Insulated wire (313); Electronic valves and tubes (321); Telecommunication equipment (322); Radio and television receivers (323); Scientific instruments (331); Communications (64); Computer & related activities (72). ICT Using: Clothing (18); Printing & publishing (22); Mechanical engineering (29); Other electrical machinery & apparatus (31- 313); Other instruments (33-331); Building and repairing of ships and boats (351); Aircraft and spacecraft (353); Railroad equipment and transport equipment nec (352+359);Furniture, miscellaneous manufacturing; recycling (36-37); Wholesale trade and commission trade, except of motor vehicles and motorcycles (51); Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52); Financial intermediation, except insurance and pension funding (65); Insurance and pension funding, except compulsory social security (66); Activities auxiliary to financial intermediation (67); Renting of machinery & equipment (71); Research & development (73); Legal, technical & advertising (741-3). 5. Non-ICT: Food, drink & tobacco (15-16); Textiles (17); Leather and footwear (19); Wood & products of wood and cork (20); Pulp, paper & paper products (21); Mineral oil refining, coke & nuclear fuel (23); Chemicals (24); Rubber & plastics (25); Non-metallic mineral products (26); Basic metals (27); Fabricated metal products (28); Motor vehicles (34); Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel (50); Hotels & catering (55); Inland transport (60); Water transport (61); Air transport (62); Supporting and auxiliary transport activities; activities of travel agencies (63); Real estate activities (70); Other business activities, nec (749); Agriculture (01); Forestry (02); Fishing (05); Mining and quarrying (10-14); Electricity, gas and water supply (40-41); Construction (45)

Chapter I: Information and Communication Technologies and Productivity: A Review of the Evidence[1]

I. Introduction

For many years 'we could see computers everywhere but in the productivity statistics'. Nobel Laureate Robert Solow (1987) made this remark in response to the simultaneous apparent widespread adoption of computers and slowdown in US productivity growth from the mid 1970s. Much research effort has been devoted since that time to addressing this 'Solow Paradox' and analysing the impact of information and communication technologies (ICTs) on productivity.

In recent years, a series of macro and micro studies have started documenting the importance of ICT for productivity. This explosion of research has involved academics, statistical agencies and international bodies. The work of private sector organizations and consultancies has also contributed significantly to the debate. In addition to the intrinsic interest of researchers in this question, the availability of very large longitudinal datasets following the same firms and industries over many years has enabled significant progress in research. These large electronic datasets would have been virtually possible to compile and analyse if the ICT revolution had not occurred.

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[1] This paper draws on joint work with Mirko Draca and John Van Reenen

This chapter offers a guided tour to some of the main aspects of ICTs and productivity. Section II discusses a neoclassical theoretical framework that has been extensively used (either explicitly or implicitly) by most of the studies surveyed in this chapter. Section III details some of the econometric issues involved in estimating the productivity of information technology (IT). This requires some consideration of the estimation of production functions, an area where there has been considerable econometric advance in recent years. Section IV discusses issues relating to the data; both ideal and actual. The final section discusses the results of the empirical studies covering econometric approaches at both the industry and firm level.

This chapter does not attempt to survey the large case study literature, which has thrown up some interesting insights on the role of organizational factors (for example, the McKinsey Global Institute studies). Furthermore, within the class of econometric studies, the focus is on the estimation of cross industry production functions. There are several econometric studies of particular types of IT in particular sectors, such as trucking (Baker and Hubbard 2004); emergency medical care (Athey and Stern 2002) and schools (Angrist and Lavy 2002; Machin, McNally, and Silva 2006).

II. Theory

II.A Basic approach

The basic neoclassical approach begins with a production function (F (.)), which relates output, Y, to inputs. One of these inputs is capital; the components of capital are IT capital (denoted C), and non-IT capital K (which includes, for example, buildings). There are also factors of production such as hours of labour L, and materials M[2]. The approach is compatible with different levels of efficiency, A (Hicks neutral technology). Consequently:

$$Y=AF(L,K,C,M) \qquad \text{(II.1)}$$

[2] Of course, we could consider multiple sub-divisions of the capital stock and other factors of production.

It is often assumed that the production function can be written in Cobb-Douglas form (although the results discussed are suitable for much more general forms of the production function). In natural logarithms the production function can be written as:

$$y=a+a_l l+a_k k+a_c c+a_m m \qquad \text{(II.2)}$$

where lower case letters indicate that a variable has been transformed into a natural logarithm (e.g. $y = lnY$). In discrete time, the growth rate of output can be written as:

$$\Delta y=\Delta a+a_l\Delta l+a_k\Delta k+a_c\Delta c+a_m\Delta m \qquad \text{(II.3)}$$

where β_t is Total Factor Productivity (TFP) growth and the other terms are the growth rates of the inputs. Usually, one can think of Δ as the first difference transformation (e.g. $\Delta y_t = y_t - y_{t-1}$) but it is also possible to consider longer differences (e.g. the average annual growth rate between 1995 and 2000 is $\Delta y = (y_t - y_{t-5})/5$). Equations II.2 and II.3 have often been used to analyse the impact of IT on productivity. In the next sections we discuss some of the possible extensions of the basic model which have been adopted in the literature to include the complementarity between IT and additional factors of production.

II.B Some extensions to the basic model

Complementary organizational capital and IT

There has been considerable discussion in the literature that the measured ICT may be only the tip of the iceberg. Successful implementation of an ICT project requires reorganization of the firm around the new technology.[3] Reorganization incurs costs, whether in the shape of fees paid to consultants, management time, or expenditure on the retraining of workers. There is much anecdotal evidence supporting this view, and it has been claimed that the total cost of an ICT project can be four or more times the

[3] Helpman and Trajtenberg (1998); Yang and Brynjolffson (2001).

amount paid for the equipment and software. Yang and Brynjolffson (2001, Table 2) cite evidence that the total start-up cost (that is, the costs incurred within the first year) of an Enterprise Resource Planning (ERP) suite is five times the cost of the hardware and software licenses. Based on econometric evidence of the effect on stock prices of ICT investment, Brynjolffson, Hitt, and Yang (2002) suggest that as much as $9 of total investment is associated with $1 of ICT investment. This additional expenditure could be interpreted simply as adjustment costs, which are perhaps particularly high in the case of ICT. These adjustment costs can be estimated econometrically.

More generally, a production function can be estimated, where there are interactions between organizational capital, *O*, and ICT capital (the previous discussion was in terms of perfect complementarity - a firm has to spend $9 extra on organization when it buys IT). One form of the production function could be (cf. Bresnahan, Brynjolfsson, and Hitt 2002)

$$y=a+\alpha_l l+\alpha_k k+\alpha_c c+\alpha_m m+\alpha_o o+\alpha_{oc}(c*o) \qquad \text{(II.4)}$$

where the hypothesis is $\alpha_{oc}>0$[4]. Note that this is different from the situation where the firm may simply have more organizational capital in general, and this is positively correlated with ICT capital ($\alpha_{oc}=0$, but $\text{cov}(C,O)>0$). In this case, the importance of ICT capital will be overestimated if organizational capital is not properly measured.

In another scenario, *O* is essentially fixed and exogenous to the firm. For example, entrepreneurs establish firms that have a distinctive managerial culture, which it is extremely difficult to change unless the firm (or plant) closes down or is taken over (for models of this type see Syverson 2004). A differenced version of this equation would be:

$$\Delta y=\Delta a+\alpha_l\Delta l+\alpha_k\Delta k+\alpha_c\Delta c+\alpha_m\Delta m+\alpha_{oc}(\Delta c*o) \qquad \text{(II.5)}$$

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[4] Note that finding a positive coefficient on the interaction is not sufficient to establish that the two factors are complementary in the Hicks-Allen sense. A positive coefficient makes Allen elasticity more likely, however.

There will be systematic variation in the ICT coefficient depending on whether firms have a high or low value of *O*. For example, if US multinationals have systematically greater organizational capital than non-US multinationals this implies a positive estimate of the interaction between ICT capital and a dummy for whether the firm was a US multinational (see Bloom, Sadun, and Van Reenen 2005 for evidence in favor of this hypothesis).

Skills

There is much evidence to show that technology and skills are complementary (for example, Chennells and Van Reenen, 2002, Machin and Van Reenen, 1998). Failure to account for skills in equation (II.2) could also bias upwards the estimated effects of IT, just as would the omission of organizational capital. Caroli and Van Reenen (2001) examine an extended version of the production function allowing for interactions between IT, organizational capital, and skills. They find that the complementarity between IT and organization is not significant when organization, skills, and the interaction between them are controlled for.

General purpose technologies and spillovers

It is frequently argued that ICT is a 'general-purpose' technology (GPT). This has several implications; first, adoption of a GPT entails experimentation that may lead to innovation by the adopting firms, which in turns shows up as TFP growth. Second, as well as innovating themselves, firms can learn from the (successful or unsuccessful) innovation efforts of others, so there are spillover effects (Bresnahan and Trajtenberg 1995). Thirdly, there may be network effects specific to the widespread use of ICT: ICT may be more effective when many firms in a region or industry are using similar levels or types of ICT.

These considerations cause researchers to look for spillovers from ICT in the same way that researchers looked for R&D spillovers. [5] The method generally employed is to augment the production function with a spillover term (denote this SPILL), which is the ICT of some of the other firms in the economy, i.e.:

$$y=a+a_l l+a_k k+a_c c+a_m m+\mu SPILL \qquad \text{(II.6)}$$

The object of interest is whether $\mu>0$.

The main problem here is how to construct the SPILL measure. In general, this requires the specification of weights or 'distances' (d_{ij}) between firms i and j. So in general $SPILL_i = \sum_{j,i\neq j} d_{ij} C_j$. The distances could be based on industry – for example, all the other firms in my industry are given a weight of unity (d_{ij}=1), while firms outside firm i's industry are weighted zero (d_{ij}=0). If spillovers come from forward or backward linkages, input-output matrices or trade matrices could be used. Alternatively, weighting can be based on geography or technology class.

It should be emphasized however, that IT, unlike R&D, is embodied, and therefore knowledge spillovers will be less likely. Network effects may be more important, but these might apply to specific forms of ICT (like operating systems or communication networks) rather than ICT in general.

III. Econometric models

There are many problems involved in estimating the production function for ICT. Some of these are generic issues related to the estimation of production functions. For instance, unobserved heterogeneity: there are many factors correlated with productivity that are not measured. If unobserved heterogeneity is constant over time then panel data

[5] See Griliches (1992); Bloom, Schankerman, and Van Reenen (2005).

can help. The unobserved factor can be treated as a fixed effect and then the estimation can proceed with either dummy variables for each firm (that is, the within groups estimator) being included, or by differencing the data (for example, first differences). Another problem is endogeneity. The factor inputs (such as IT) are chosen by firms and are not, therefore, exogenous when included on the right-hand side of the production function. One solution to this is to find external instruments that affect the decision to invest in IT, but do not affect the productivity of the firm directly.[6]

The literature has not followed up this solution, however, and most studies ignore these issues and simply estimate a production function using ordinary least square (OLS) methods. However, some studies examine various approaches for dealing with these problems and a minority[7] actually compare the results derived from alternative advanced econometric techniques. Below three approaches are discussed: TFP-based, General Method of Moment (GMM), and Olley Pakes (OP).

III.A TFP-based approaches

A common approach in the ICT literature dealing with this issue is to consider a transformation that constructs a measured TFP growth term. For example, Brynjolfsson and Hitt (2003) estimate the following forms of equations

$$\Delta\tilde{a}=\beta_1\Delta c \qquad \text{(III.1)}$$

where the dependent variable is measured TFP (or 'four factor' TFP')

$$\Delta\tilde{a}=\Delta y-s_l\Delta l-s_k\Delta k-s_c\Delta c-s_m\Delta m \qquad \text{(III.2)}$$

[6] Such as changes in the tax price, see Bloom, Griffith, and Van Reenen for examples from R&D.

[7] Stiroh (2004); Bloom, Sadun, and Van Reenen (2005) and Hempell (2005).

If ICT earned 'normal returns' then the estimated coefficient in equation (III.1) would equal zero (β_I=0). Unfortunately, although this resolves the endogeneity problem for the non-ICT factor inputs by moving them from the right-hand side to the left-hand side of the equation, the endogeneity of ICT remains a problem. In fact, it is likely to be exacerbated as the construction of measured TFP involves the variable of interest on the right-hand side of the equation. Any measurement error in ICT will be transmitted into a biased coefficient on β_I[8].

An additional problem is that classical measurement errors in ICT will generate an attenuation bias towards zero for β_I. This is one reason for turning to longer differenced models, the approach adopted by Brynjolffson and Hitt (2003) (although they interpret their increasing coefficients as being due to unmeasured organizational capital rather than measurement error). In general, the attenuation bias should be less for longer differences than for shorter differences as the transitory shocks will be averaged out increasing the signal to noise ratio for the ICT measure (Griliches and Hausman 1986). Unfortunately, in econometrics as in life there is no free lunch. Although long-differencing the data reduces the random measurement error, endogeneity problems are exacerbated because the transformed error term now includes more time periods.

III.B General method of moment (GMM) approaches

For notational simplicity, re-consider the basic production function as

$$y_{it}=\theta x_{it}+u_{it} \qquad \text{(III.3)}$$

where θ is the parameter of interest on a single factor input, x. Assume that the error term, u_{it}, takes the form

$$u_{it}=\eta_i + \tau_t + \omega_{it}$$

[8] Although note that the bias will be towards zero and researchers in the micro literature generally find IT coefficients that are higher than we would expect.

$\omega_{it}=\rho\omega_{it-1}+ \upsilon_{it}$ (III.4)

τ_t represents macro-economic shocks captured by a series of time dummies, η_i is a correlated individual effect, and υ_{it} is a serially uncorrelated mean zero error term. The other element of the error term, ω_{it} is allowed to have an AR(1) component (with coefficient ρ), which could be the result of measurement error or slowly evolving technological change. Substituting (III.4) into (III.3) gives the dynamic equation:

$y_{it}=\pi_1 y_{it-1}+\pi_2 x_{it}+\pi_3 x_{it-1}+\eta^*_i+\tau^*_t+\upsilon_{it}$ (III.5)

The common factor restriction (COMFAC) is $\pi_1\pi_2 =-\pi_3$. Note that $\tau^*_t = \tau_t -\rho\ \tau_{t-1}$ and $\eta^*_i=(1-\rho)\eta_i$.

Blundell and Bond (2000) recommend a system GMM approach to estimate the production function and impose the COMFAC restrictions by minimum distance. If the inputs are allowed to be endogenous, then instrumental variables are required. . A common method is to take first differences of (III.5) to sweep out the fixed effects:

$\Delta y_{it}=\pi_1\Delta y_{it-1}+\pi_2\Delta x_{it}+\pi_3\Delta x_{it-1}+\Delta\tau^*_t+\Delta\upsilon_{it}$ (III.6)

Since υ_{it} is serially uncorrelated the moment condition:

$E(x_{it-2},\Delta\upsilon_{it})=0$ (III.7)

ensures that instruments dated t-2 and earlier[9] are valid and can be used to construct a GMM estimator for equation (3.6) in first differences (Arellano and Bond 1991). A problem with this estimator is that variables with a high degree of persistence over time (such as capital) will have very low correlations between their first difference (Δx_{it}) and the lagged levels being used an instrument (for example, x_{it-2}). This problem of weak

[9] Additional instruments dated *t-3, t-4*, etc. become available as the panel progresses through time.

instruments can lead to substantial bias in finite samples. Blundell and Bond (1998) point out that under a restriction on the initial conditions another set of moment conditions is available:[10]

$$E(\Delta x_{it-1}\,(\eta_i + v_{it}))=0 \qquad \text{(III.8)}$$

This implies that lags of first differences of the endogenous variables can be used to control for the levels in equation (III.5) directly. The econometric strategy is to combine the instruments implied by the moment conditions (III.7) and (III.8). Consistent estimates of the coefficients can be recovered and used to recover the underlying structural parameters.

III.C The Olley-Pakes method

Reconsider the basic production function[11] as:

$$y_{it}=\alpha_l l_{it}+\alpha_k k_{it}+\alpha_c c_{it}+\alpha_m m_{it}+\omega_{it}+\eta_{it} \qquad \text{(III.9)}$$

The efficiency term, ω_{it} is the unobserved productivity state that will be correlated with both output and the variable input decision, and η_{it} is an independent and identically distributed error term. Assume that both capital stocks are predetermined and current investment (which will react to productivity shocks) takes one period before it becomes productive, that is, $K_{it}=I^K_{it-1}+(1-\delta^K)K_{it-1}$ and $C_{it}=I^C_{it-1}+(1-\delta^c)C_{it-1}$..

It can be shown that under certain regulatory conditions the investment policy functions for ICT and non-ICT are monotonic in non-ICT capital, ICT capital, and the unobserved productivity state.

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[10] The conditions are that the initial change in productivity is uncorrelated with the fixed effect $E(\Delta y_{i2}\eta_i)=0$ and that initial changes in the endogenous variables are also uncorrelated with the fixed effect $E(\Delta x_{i2}\eta_i)=0$.

[11] For notational simplicity we abstract from plant age, but we implement this in the estimation routine along the same lines as Olley and Pakes (1996).

$i^K_{it}=i^K(k_{it},c_{it},\omega_{it})$ (III.10)

$i^C_{it}=i^C(k_{it},c_{it},\omega_{it})$ (III.11)

The investment policy rule, therefore, can be inverted to express ω_{it} as a function of investment and capital. Focusing on the non-IT investment policy function it can be inverted to obtain the proxy: $\omega^K(i^K_{it},k_{it},c_{it})$. The first stage of the OP algorithm uses this invertibility result to re-express the production function as:

$$y_{it}=\alpha_l l_{it}+\alpha_k k_{it}+\alpha_c c_{it}+\alpha_m m_{it}+\ \omega^K(i^K_{it},k_{it},c_{it})\ +\eta_{it}$$
$$=\alpha_l l_{it}+\alpha_m m_{it}+\ \varphi(i^K_{it},k_{it},c_{it})\ +\eta_{it} \quad \text{(III.12)}$$

where $\varphi(i^K_{it},k_{it},c_{it})=\varphi_t=\omega^K(i^K_{it},k_{it},c_{it})+\alpha_k k_{it}+\alpha_c c_{it}.$

This function can be approximated with a series estimator or non-parametric approximation and use this first stage results to get estimates of the coefficients on the variable inputs. The second stage of the OP algorithm is:

$$\dot{y}_{it}=y_{it}-\alpha_l l_{it}-\alpha_m m_{it}=\alpha_k k_{it}+\alpha_c c_{it}+\omega_{it}+\eta_{it} \quad \text{(III.13)}$$

Note that the expectation of productivity, conditional on the previous period's information set (denoted Ω_{t-1}) is:

$$\omega_{it}\mid_{\chi_{it}=1}=E[\omega_{it}\mid\omega_{it-1}\ ,\ \chi_{it}=1]+\xi_{it} \quad \text{(III.14)}$$

where $\chi_{it}=1$ indicates that the firm has chosen not to shut down (a selection stage over the decision to exit can be incorporated in a straightforward manner). This expression for productivity state is based on the assumption that unobserved productivity evolves as a first order Markov process. Again, this relationship can be approximated with a high order series approximation $g(\omega_{it-1})$. Substituting this in to the second stage, and making expectations conditional on the previous period's information set gives:

$$E(\dot{y}_{it}|\Omega_{t-1})=\alpha_k k_{it}+\alpha_c c_{it}+g[\varphi(i^K_{it-1},k_{it-1},c_{it-1})-\alpha_k k_{it}+\alpha_c c_{it}] \quad \text{(III.15)}$$

Since the estimates of the function φ_{it-1} have already been obtained, this amounts to estimating by Non-Linear Least Squares (NLLS).[12]

IV. Data issues: Measuring ICT

IV.A Ideal measures of capital in a production function context

The ideal measure capturing the economic contribution of capital inputs in a production theory context is the flow of capital services. Building this variable from raw data entails non-trivial assumptions regarding: the measurement of the investment flows in the different assets and the aggregation over vintages of a given type of asset.[13] Assuming for the moment that investments in the specific asset can be measured without error,[14] we investigate the latter point.

For the sake of simplicity, assume that one type of capital is used for production. Output will depend on the aggregation of the different vintages of investments made over the years, after allowing for the fact that the capacity of earlier investments decays

[12] Numerous extensions to the basic OP methodology have been suggested. First, we consider the additional selection correction originally suggested by the authors. Second, Levinsohn and Petrin (2003) suggest using intermediate inputs as an alternative proxy for the unobserved productivity term. This has attractions for plant level data where investment is zero in a non-trivial number of cases. Ackerberg, Caves, and Frazer (2005) and Bond and Soderbom (2005) emphasize the identification problems underlying the original OP set up, which implicitly requires variation in firm specific input prices. Bond and Soderbom argue for the GMM approach discussed in the previous sub-section, which is identified in the presence of differential adjustment costs.

[13] If one is willing to work with an aggregate measure of capital, extra care must be taken in aggregating the different asset types, but we will abstract from this issue in this context. For a detailed treatment of the issue see Oulton and Srinivasan (2003).

[14] The main issues involved in the measurement of IT flows with industry and firm level data are discussed in detail in the next paragraphs.

after installation. Defining the decay factor for an investment of s years old d_s, and I_{t-s} as the real gross investment of vintage s, the aggregate capital stock can be written as:

$$K_t = \sum_{s=0}^{n} (1 - d_s) I_{t-s} \qquad \text{(IV.1)}$$

If it is assumed that the rate of decay is constant over time (geometric rate of decay), then equation IV.1 takes the very simple form:

$$K_t = I_t + (1-d) K_{it-1} \qquad \text{(IV.2)}$$

In the case of geometric decay, the rate of decay is equal to the *depreciation rate* (δ) (Oulton and Srinivasan 2003). Depreciation measures the difference between the price of a new and a one-year old asset at time t. Defining the price of a specific asset of age j at time s as $p_{s,j}$, then the depreciation rate is:

$$\delta_t = \frac{(p_{t,j} - p_{t,j+1})}{p_{t,j}} \qquad \text{(IV.3)}$$

Assuming that the depreciation rate of the asset does not vary over time, the time subscript can be omitted. A concept related to depreciation rate is the capital gain/ loss (f) associated with the investment in the specific asset. The capital gain/loss is defined as the change in the price of a new asset between periods t-1 and t, that is:

$$f_{t,j} = (p_{t,j} - p_{t-1,j}) \qquad \text{(IV.4)}$$

Both depreciation and capital gain/loss affect the definition of the rental price $\rho_{t,j}$ for the capital services of a capital input of age j at time t. This is defined as:

$$\rho_{t,j} = r_t p_{t-1,j} + \delta p_{t,j} - f_{t,j} \qquad \text{(IV.5)}$$

where r_t is the actual nominal rate of return during period t. The rental price is what the company would pay if instead of buying the capital good, it rents it from another firm. A profit maximizing firm will hire the capital good up to the point when the rental price equals the marginal revenue of the product of the capital good. Under perfect competition, the rental price will be equal to the value of the marginal product of the asset. In this case, the asset is said to deliver normal returns. When the marginal product is higher than the rental price, then the asset is said to deliver excessive returns.[15]

Basic capital theory applies equally to both ICT and non-IT assets. As this brief description suggests, empirical implementation of the theory of capital measurement is far from simple. This seems to be particularly true for ICT assets, as they entail several problematic issues related to the measurement of investment flows, and of depreciation rates and price deflators. The next two sections explore how the research has dealt with these issues, focusing first on industry level data, and then looking at firm level studies.

IV.B Measurement of ICT capital at the industry level

This section describes the main sources and methodologies used to measure ICT assets in an industry level framework, with a specific focus on the methodologies developed within the main US statistical offices – the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS). The BEA and BLS are the major data sources for studies that apply industry data to examine the productivity impact of ICT in the US economy. Moreover, US methodologies represent the frontier for ICT capital measurement and have been widely applied in non-US contexts[16] to derive industry level measures of ICT capital.

[15] Rental prices are also very important in constructing Tornqvist aggregate service flows of assets of different types. Rental prices rather than asset prices are used as weights to account for differences in the rate of return to capital, the rate of economic depreciation, the rate of nominal appreciation of assets and their tax treatment.

[16] Oulton and Srinivasan (2003), O' Mahony and de Boer (2002), van Ark *et al.* (2002))

US data

Both the BEA and the BLS develop data on capital stocks, by asset and industry, applying the Perpetual Inventory Method (PIM) to real investment figures. The BEA publishes basic industry level data on ICT spending for the US economy.[17] These estimates are derived using a top down approach. First, gross investments in ICT for the total US economy are computed starting from micro data - produced monthly by the Census Bureau – on computer shipments. Exports, intermediate, households, and government purchases[18] are deducted from this total, and imports are added. Second, industry totals on overall investments are built from micro data on establishments from the Economic Census and the Annual Capital Expenditures Survey (ACES) (since 1992) or the Plant and Equipment Survey (before 1992). To obtain series of ICT (and non-IT investments) by industry, the industry and asset totals are combined and distributed across the different industries using an occupational-employment-by industry matrix developed by the BLS, as documented in Bond and Aylor (2000), (implicitly) assuming a labour-capital fixed coefficient technology. BEA publishes the estimated asset-by-industry flows of all assets in the Capital Flows Table (CFT) and the Fixed Reproducible Tangible Wealth Investment Matrix (FRTW).[19]

Measuring nominal ICT flows is the first of a series of adjustments needed to obtain proper ICT capital. A basic step is the creation of appropriate deflators - to convert nominal flows into real flows. This issue is of particular relevance for ICT assets, which have experienced dramatic price and quality changes over the years. The BEA and the BLS, in concert with academic and computer industry economists, have made significant improvements in developing quality-adjusted prices for computer

[17] In this framework IT is defined as the aggregation of the different IT investment series produced by the BEA, i.e. mainframe computers, personal computers (PCs), direct access storage devices, printers, terminals, tape drivers, storage devices.

[18] The BEA also makes adjustments to reflect trade costs and transportation margins (to convert into purchaser value).

[19] These two tables represent the main sources for the construction of the IT capital stocks used in Jorgenson and Stiroh (2000a, 2000b), Jorgenson, Ho, and Stiroh (1999), Stiroh (2002a, 2002b, 2004), Oliner and Sichel (2000), Bosworth and Triplett (2002), Basu *et al.* (2003), Nadiri and Mun (2002), Chun and Nadiri (2002), Berndt and Morrison (1995).

equipment.[20] Since the early 1990s, the deflators used by BEA for computers and peripheral equipment have been derived from the producer price index (PPI) and the import price index, quality adjusted by BLS using hedonic techniques (briefly described in Holdway 2001).[21]

Another component is the creation of appropriate depreciation schemes – to take account of the rate of decay of the different vintages of investments. BEA's depreciation schemes differ from those used by the BLS. Since 1997, the BEA has used age-price depreciation for its weights, the assumption being that the depreciation pattern of most assets declines geometrically over time.[22] In contrast, the BLS uses a hyperbolic age-efficiency function.[23]

European Data

European statistics offices' published industry data on ICT assets lag behind the US. They have produced various country specific industry level data sets on ICT investment flows.[24] The dataset developed by van Ark, Inklaar and McGuckin (2002) is an example of combining official statistics on ICT flows at industry level for EU economies with

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[20] The IT deflators are described in Grimm, Moulton, and Wasshausen (2002).

[21] The basic principle of the hedonic deflators is as follows. The estimated prices of specified characteristics (e.g. speed for PCs) are used to quality adjust the price of a newly introduced model so that it is consistent with the discontinued model. For software the deflators are derived from PPI's, a BEA cost index, and a BLS employment cost index (ECI) and are applied to three subcategories (pre-packaged, own account, and custom software). A detailed description of the methodologies can be found in Landefeld and Grimm (2000).

[22] This is fully described in Fraumeni (1997). Until the 1999 revision, the estimated depreciation rates for computers were cohort and asset specific, taken from studies by Oliner. With the 1999 revision of the National Income and Product Accounts (NIPA) a new depreciation rate was introduced for PCs only. The value is 0.3119, based on Lane (1999), assuming that the value of a PC declines to 10 per cent of its initial value after 5 years. As noted by Doms *et al.* (2004), this schedule incorporates the full loss in PC value as it ages, capturing both depreciation and revaluation. Starting from the 2003 revision of the NIPA - and based on new evidence in Doms *et al.* (2004), the depreciation rate for PCs has been changed to 0.34.

[23] Other differences between the BEA and the BLS estimates relate to the construction of the aggregate capital stock measures. The BLS uses the Jorgenson methodology to build a service measure of capital stocks (also defined as an estimation of 'productive capital stocks') instead of the BLS wealth measure (the methodology is summarized in http://www.bls.gov/web/mprcaptl.htm).

[24] Note for the UK O'Mahony and de Boer and the Bank of England dataset introduced in Oulton and Srinivasan (2003).

US methodologies (especially on depreciation patters and hedonic prices), to produce broadly comparable estimates of ICT stocks from the late 1970s to 2003.[25] In order to build series for real ICT investments, they applied country specific data deflators obtained through the price index harmonization method developed by Schreyer (2002), using US deflators adjusted for each country's general inflation. Once the flows are obtained, capital stocks are derived applying PIM to US depreciation rates taken from Jorgenson and Stiroh (2000).

Discussion

Despite the major effort made by US statistical offices in the context of ICT measurement, and especially the development of robust ICT deflators based on hedonic techniques, the construction of the asset-by-industry investment matrix from which capital stocks are derived seems to suffer from potentially problematic measurement issues[26] (Becker *et al.* 2005). Similarly, available European data rely on interpolation techniques, as, for most European countries, the investment series are available only for specific years.[27]

Crepon and Heckel (2002) give examples of some of the problems that can arise when using industry level estimates of ICT stocks developed in a national accounting framework. In their work, measures of ICT capital at the two-digit level are built using

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[25] In this context IT is defined very broadly as comprising the whole category of office and computer equipment - including peripherals such as printers, photocopiers, etc - radio, TV and communication equipment, and software.

[26] Since the information on occupational activities by industry is used to produce an asset by industry matrix, this embedded relationship between industry IT flows and employment may introduce dangerous spurious correlations. For example, this issue may put at risk studies that use the data to investigate correlations between capital mix and employment mix choices (Chennells and Van Reenen, 2002). Moreover, the specific occupational categories used to break down the IT flows by industry are not published. Bosworth and Triplett (2002) note that the latest year for which the BEA flow table was used to allocate IT capital by industry is 1992. Another problematic issue is the measurement of software investments especially custom-made software (Dedrick, Gurbaxani, Kraemer (2003).

[27] The country specific matrices of IT investments by industries are interpolated for intermediate years. For longer gaps in the data the Commodity Flow Method is employed. This supply side method first computes the total amount of ICT commodities available in a specific year by taking the value of total ICT production plus the net value ICT imports less ICT exports). Then the shares of investments across the different industries are allocated using as weights the shares of total investments over production minus exports plus imports computed from the input output tables

firm level data on ICT assets declared by firms in their tax returns. The industry data are built for an average of 300,000 firms per year over the period 1984-1998, and compared to the figures reported by Cette, Mairesse, and Kocoglu (2000) based on National Accounts. The share of ICT capital in value added, obtained through the aggregation of firm level data, is 1.7 per cent, while the share derived from National Account sources is 0.5 per cent. This stark difference may be due to the more detailed data entries obtained from micro sources, but also could be due to the different assumptions related to the PIM employed in the National Accounts' estimations.[28]

IV.C Measures of ICT capital at firm level

Using micro data rather than industry data allows the well-documented firm level heterogeneity in productivity and investment patterns to be taken into account, which is particularly relevant in the context of ICT assets. ICT frequently is found to have a differential impact on firm level productivity according to characteristics such as organizational structures and skills that are likely to differ even across firms within the same industry.

<u>Micro context, private surveys</u>

The first attempts to estimate the role of IT assets on firm level productivity data were made by Brynjolfsson and Hitt (1995, 2003). The data they used typically refer to volume measures of firms' hardware stocks on site, collected through telephone surveys organized and managed by private organizations such as the Computer Intelligence

[28] Interestingly, the higher shares reported by Crepon and Heckel does not seem to be related to selection issues.

Intercorp (CII). These volume measures are translated into value measures of hardware stocks using price and computing capacity information provided by CII.[29]

There are two advantages of such data. First, the detailed information collected (hardware stocks by type of equipment) provides a very precise snapshot of the type of IT stocks existing at a specific site, and does not require PIM. Secondly, as many of the firms in these surveys were sampled in different years, the data are suitable for longitudinal productivity analysis.

However, there are also some problematic aspects to their use. First, for the purposes of productivity analysis the IT data – collected at site level – needs to be matched with data from other financial information sources (such as Compustat for the US or Amadeus for several European countries), which refer to firms rather than sites within a firm. This implies that the IT data need to be adjusted by aggregation if multiple sites belonging to a single firm are sampled, or by applying weighting schemes to project the site level information to firm level. Secondly, as these type of IT surveys target very large firms (for the US the sample is Fortune 1000 firms), there might be a selection issue biasing the productivity results.

Micro context, census based data

In the last decade statistical offices have played a major role in collecting IT information at firm level. These data now represent a valid alternative to the micro level IT measures collected by private organizations, and are typically matched to other

[29] Several adjustments are made to apply the data in a production function framework. In Brynjolfsson, Bresnahan, and Hitt (2002) the nominal values are deflated using price information. Brynjolfsson, Bresnahan, and Hitt (2002) use prices developed by Robert Gordon (19.3% yearly changes). In Brynjolfsson and Hitt (2003) the data are transformed from wealth stocks (market value of the assets) into productive stock (the value of assets based on output capability) multiplying the wealth stocks by the annual aggregate ratio of the productive stock to the wealth stock of computer assets computed by the BLS (1,2). The CII data have been extensively used in other research on productivity. Some recent examples include Lehr and Lichtenberg (1999) - where CII data are combined with additional census based data on firm level IT investments - and Gilchrist, Gurbaxani, and Town (2001) – where CII data are used in the context of TFP growth regressions. More recently, Bloom, Draca, and Van Reenen (2005) used a similar type of data (detailed information on the volume of IT equipment existing in a specific site of a firm, collected via telephone survey) to analyse the impact of IT on productivity in the UK economy.

census based information on output and inputs, or to publicly available databases (such as Compustat), which contain firm level financial information.

In most cases, statistical offices collect information related to the *use* of IT equipment, rather than precise measures of IT expenditure or IT stocks. The surveys are at the employee level (that is, an employee of a specific firm is surveyed about his/her own particular use of IT), as in Greenan and Mairesse (1996),[30] or at firm level (that is a representative of the firm is asked about the number of employees using IT in general, about a specific type of IT equipment or procedure, such as broadband or e-commerce), as in Maliranta and Rouvinen (2004).[31] Using a similar approach, Atrostic and Nguyen (2005) for the US, and Atrostic *et al.* (2004) for Japan, employ firm level information on IT infrastructures (a dummy variable taking value one if the firm uses computer networks) to explore how firms use IT,[32] rather than how much they spend on it.

More recently, statistical offices have begun to collect micro level information on investment expenditures in IT. This type of information has the clear benefit of providing a direct measure of investment that can be quite easily used in a production function context. However, the IT investment data typically have been collected on a cross sectional basis, requiring the use of different approximations to recover measures

[30] Greenan and Mairesse (1996) use the questions on IT use by workers collected in the framework of the French survey TOTTO (Enquete sur les techniques et l'Organisation du Travail) to build firm level measures on computer use, which they match with the INSEE firm database. Clearly, the worker- level information requires specific assumptions regarding the degree of representativeness of the employees surveyed.

[31] Maliranta and Rouvinen (2004) use as IT measures the percentage of employees in Finnish firms using computers and/or LAN and Internet systems. These data are collected in the framework of Statistics Finland's Internet use and e-commerce in enterprises surveys. A similar measure is collected in the UK in the E-Commerce survey (Criscuolo and Waldron 2003).

[32] These studies combine basic information on the existence of computer networks within a firm with more detailed data on specific types of IT resources such as fully integrated ERP software.

of productive stocks of IT equipment for use in a production function context from flows.[33]

The existence of detailed information on IT flows over consecutive time periods allows researchers to build measures of IT stocks more closely following the procedure established in the PIM (see Bloom, Sadun, and Van Reenen 2005; Hempell 2005).[34] However, estimating capital stocks using PIM implies specific assumptions regarding the starting point of the PIM recursion.[35] This introduces a degree of measurement error in the estimates of stocks, especially when the time series is short. This problem is partially offset for IT assets, as they typically have a very high depreciation rate (≈30 per cent).

Discussion

Compared to IT data collected by private organizations, the census based data yield larger and more representative samples. Moreover, although the IT measures and the data collection criteria were generally determined independently by each country, recently there has been some multi-national collaboration (such as the OECD International Micro Data Initiative), which it is to be hoped will facilitate cross country

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[33] These data require very specific assumptions on the depreciation or the growth patterns of the capital stocks. If we assume full depreciation then the investment flows represent a valid proxy for capital stocks. This is the choice implicitly made by Doms *et al.* (2002) in a study focusing of the role of IT in US retail sector productivity, where the ratio of IT investments over total investments (drawn from the 1992 Asset and Expenditures Survey) is used to proxy for IT capital intensity for some 2000 retail firms. The same type of measure (IT investment share in total investments) is employed by Haltiwanger, Jarmin, and Schank (2003) in a comparison of IT effects in the US and Germany. Wilson (2004) uses a slightly more sophisticated framework to exploit the 1998 ACES on detailed firm level investments in IT (and in 54 other types of assets) in a production function context. He rewrites the PIM formula as: $K_{t-1}=(g_t+\delta)*I$, with $g_t=\Delta K_t/K_{t-1}$. He then assumes that in the steady state g should be approximately equal to zero, and states a direct proportionality between stocks and flows, running through the depreciation rate.

[34] Bloom *et al.* (2007) use four different surveys on micro level IT investments in the UK economy collected by the Office of National Statistics for the years 1995-2003. Hempell (2005) employs IT investment data from the Mannheim Innovation Panel in Services (MIP-S), collected by the ZEW on behalf of the German Federal Ministry of Education and Research since 1994.

[35] Bloom *et al.* (2007) build the initial conditions of the PIM assuming a direct proportionality between industry and firm level capital stocks. Defining the first time a firm appears in their sample as Y, they allocate the industry level capital stock to each firm according to investment weights, i.e. $K^j_{i,r}=(I^j_{i,r}/\check{I}^j_r)*\check{K}^j_r$ where $\check{K}^j_r$ and $\check{I}^j_r$ represent respectively total IT capital stock and investment for industry j in year r. For all periods following year r, they follow the standard PIM recursion.

comparisons of IT studies. The main issues in the use of these data are the scant availability of time series information (for both categorical variables and expenditure information) and the problems related to software measurement.

IV.D. Conclusions on data

Despite recent improvements, the gap between the theoretical conception of IT capital services and empirical measures of IT assets is still wide. This applies to industry level data where the estimation of the IT stocks may be undermined by problems related to the imprecise allocation of flows across different industries (US) and to the use of heavy interpolation techniques (Europe). The problem also applies to firm level data where information about investments is often not available, and if it is, it often covers a very short (or no) time series. In fact, many of the studies discussed below rely on even cruder indicator variables whose connection with the theory is likely to be even looser. Software continues to be a major problem as, below the macro level, it is rarely measured directly.

V. Econometric results for IT and productivity

In this section we review the main empirical finding related to the effects of ICT on productivity.

V.A Industry level

Early industry studies (for example, Berndt and Morrison 1995) found no significant relationship between IT and productivity. Industry level studies using more recent data, found significant returns to IT capital over the 1987-2000 period, based on a study of 58 industries (Stiroh 2004). Stiroh's study looked at IT capital as a whole, and at the individual sub-components (computers and telecom). Although Stiroh (2002a) found there was faster productivity growth in the IT intensive sectors post 1995, Stiroh (2004) found no evidence that the coefficients on IT capital rose in 1996-2000 (compared to

1987-1995). The absence of effects from earlier studies may be due less to the time period and more to the combination of noisier data and IT being a much smaller proportion of total capital.

However, when Stiroh (2004) looks at econometric estimators that attempt to control for fixed effects (for example, through differencing the data) and/or endogeneity (for example, through GMM) there are few significant results. This may be due to genuine misspecification and the absence of an IT effect or, more plausibly, because the industry data are too coarse for some of the more sophisticated econometric approaches. Most of the other studies in the industry level literature focus on TFP growth equations of the type discussed above in the TFP approaches section. Overall, the results mirror Stiroh's findings. The IT coefficients tend to be generally insignificant, unstable across time, and across countries (for example, Basu *et al.* 2003, Table 8). The TFP regressions have the problems of the aggregate industry data and the problems discussed in the section on TFP approaches, that IT is included on the left hand-side and the right hand-side of the estimating equations. Given concerns about aggregation and other biases attention has shifted to the more micro-level.

V.B Firm level

Most firm level studies do reveal a positive and significant association of IT with productivity. This is reassuring as many were undertaken in response to the Solow paradox, which suggested there was no productivity impact from IT. In most cases, the magnitude of the IT coefficients is larger than might be expected from the standard neoclassical assumptions underlying the growth accounting framework. A well-known example here is Brynjolfsson and Hitt (2003). The explanation that the high magnitudes are due to organizational capital gets some support from Bresnahan, Brynjolfsson, and Hitt (2002) who conducted a survey containing explicit questions on decentralization within firms. Black and Lynch (2001, 2004) and Caroli and Van Reenen (2001) do not find support for interactions between IT and organization, but they have less sophisticated measures of IT capital than Brynjolfsson and his colleagues. There is also a very wide range of estimates of the elasticity of output with respect to IT capital. The Stiroh (2004) meta-study is very useful for comparing the sub-set of studies considered here. He finds that the mean of the estimates across studies is about 0.05, which is well above the share of the IT stock in revenue as noted above. However, the estimates range from an upper end of over 25 per cent to minus 6 per cent. This wide variation is in part driven by methodological choice, but also is strongly suggestive of heterogeneity in the IT coefficient by country, industry, and type of firm. Finally, the evidence for spillovers is very weak. Most studies struggle to find convincing impacts from spillover effects. This suggests that the GPT effects stressed by the theorists may be somewhat exaggerated. While the spillover mechanism is pretty clear for innovation or R&D it is much less clear for ICT.[36]

VI. Conclusion

There has been significant progress made since the mid 1990s in the analysis of IT and productivity. The fall in the quality-adjusted price of computers has enabled researchers to build and analyse very large-scale databases that have revolutionized our understanding of the role of ICT and productivity. The proliferation of databases covering thousands of firms and decades of data has enabled significant intellectual advance. This chapter presents a very basic neoclassical framework (with a few extensions), which we think is helpful in considering the problem. There does seem to be some reasonable evidence of a strong firm level association between IT and firm performance (although causality has still to be convincingly demonstrated).

[36] Griliches' (1992) survey and some recent contributions (e.g., Bloom, Schankerman, and Van Reneen 2005) provide compelling evidence about the importance of spillovers from R&D.

Chapter II: ICT, Multinationals, and the US Productivity Miracle[1]

I. Introduction

IT seems to have played a crucial role for the reversal in the long-standing catch-up of Europe's productivity level with the United States. American labor productivity growth slowed after the early 1970s Oil Shocks but accelerated sharply after 1995. Although European productivity growth experienced the same slowdown, it has not enjoyed the same rebound (see Figure 1). Decompositions of US productivity growth show that the great majority of this growth occurred in those sectors that either intensively use or produce IT (information technologies)[2]. Closer analysis has shown that European countries had a similar productivity acceleration as the US in IT *producing* sectors (such as semiconductors and computers) but failed to achieve the spectacular levels of productivity growth in the sectors that *used* IT intensively (predominantly market

[1] This paper draws from joint work with Nick Bloom and John Van Reenen

[2] See, for example, Kevin Stiroh (2002). Dale Jorgenson (2001), Stephen Oliner and Daniel Sichel (2000). In the 2002-2004 period Oliner and Sichel (2005) find that US productivity growth remained strong, but there was a more widespread increase in productivity growth across sectors. See Robert J. Gordon (2004) for a general discussion.

service sectors, including retail, wholesale and financial services)[3]. Consistent with these trends, Figure 2 shows that IT intensity appears to be substantially higher in the US than Europe and this gap has widened over time. Given the common availability of IT throughout the world at broadly similar prices, it is a major puzzle why these IT related productivity effects have not been more widespread.

There are at least two broad classes of explanation[4] of this puzzle. First, there may be some "natural advantage" to being located in the US, enabling firms to make better use of the opportunity that comes from rapidly falling IT prices. These natural advantages could be tougher product market competition, lower regulation, better access to risk capital, more educated or younger workers, larger market size, greater geographical space, or a host of other factors. A second class of explanations stresses that it is not the US environment *per se* that matters but rather the way that US firms are organized or managed that enables better exploitation of IT.

These explanations are not mutually exclusive. In the final section of this chapter we present a model that has elements of both (i.e. organizational practices in US-based firms are affected by the US regulatory environment and some of these practices are transplanted overseas through foreign affiliates of American multinationals). Nevertheless, one straightforward way to test whether the "US firm organization" hypothesis has any validity is to *examine the IT performance of US owned organizations in a non-US environment.* If US multinationals at least partially export their business models outside the US – and a walk into McDonald's or Starbucks anywhere in Europe suggests that this is not an unreasonable assumption – then

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[3] Mary O'Mahony and Bart Van Ark (2003) decompose productivity growth for the same sectors in the US and Europe under common measurement assumptions. Compared to the 1990-1995 period, US productivity growth in sectors that intensively used IT accelerated by 3.5 percentage points between 1995 and 2001 (from 1.2% per annum to 4.7% per annum). In Europe, productivity growth in these sectors showed no acceleration (it was 2% per annum pre and post 1995). Productivity growth accelerated in the IT producing sectors by similar amounts in the US (1.9 points) and Europe (1.6 points). In the other sectors there was no acceleration in either the US or Europe.

[4] Another possibility is international differences in productivity measurement (Olivier Blanchard, 2004). This is possible, but the careful work of Mary O'Mahony and Bart Van Ark (2003) focusing on the same sectors in the US and EU, using common adjustments for hedonic prices, software capitalization and demand conditions, still find a difference.

analyzing the IT performance of US multinational establishments in Europe should be informative. Finding a systematically better use of IT by American firms outside the US suggests that we should take the US firm organization model seriously. Such a test could not be performed easily only with data on plants located in the US because any findings of higher efficiency of plants owned by US multinationals might arise because of the advantage of operating on the multinational's home turf ("home bias").

In this chapter, we examine the productivity of IT in a large panel of establishments located in the UK, examining the differences in IT-related productivity between establishments owned by US multinationals, establishments owned by non-US multinationals and domestic establishments. The UK is a useful testing ground for at least two reasons. First, it experiences extensive foreign ownership with frequent ownership change. Second, the UK Census Bureau has collected panel data on IT expenditure and productivity in both manufacturing and services since the mid-1990s. Therefore, we have arguably constructed the richest micro-dataset on IT and productivity in the world.

We report that the key fact in understanding productivity differences is the apparent ability of US multinationals to obtain higher productivity than non-US multinationals (and domestic UK establishments) *from their IT capital.* These findings are robust to a number of tests, including an examination of establishments before and after they are taken over by a US multinational versus a non-US multinational. Prior to takeover by a US firm the establishment's IT performance is no different from that of other plants that are taken over by non-US firms. After takeover, the American establishment's productivity of IT capital increases substantially (while the productivity of non-IT capital, labor, and materials does not).

Overall, these findings suggest that the higher productivity of IT in the US has something to do with specific characteristics of US establishments, which we define as their "internal organization" (we discuss other possible explanations as well). We also show that US firms are organized differently to non-US firms and that they can change their organizational structure more quickly. We suggest that the organizational inflexibility of European firms may be linked to different institutional characteristics such as, for example, the prevalence of restrictive labor market regulations.

This analysis is related to several other areas of the literature. First, there is a large literature on the impact of IT on productivity at the aggregate or industry-level.[5] Second, there is growing evidence that the returns to IT are linked to the internal organization of firms. On the econometric side, Tim Bresnahan, Erik Brynjolfsson and Lorin Hitt (2002) and Eve Caroli and John Van Reenen (2001) find that internal organization and other complementary factors, such as human capital, are important in generating significant returns to IT. On the case study side, there is a large range of evidence[6]. For example, Larry Hunter et al (2000) describe how IT radically changed the organization of US banks in the late 1980s. The introduction of ATMs substantially reduced the need for tellers. At the same time, PCs and credit-scoring software allowed staff to be located on the bank floor and to directly sell customers mortgages, loans and insurance, replacing bank managers as the primary sales channel for these products. Along with the IT enabled ability of regional managers to remotely monitor branches, this led to a huge reduction in branch-level management and much greater decentralized decision-making for the front-line staff. This re-organization of banks did not happen in much of Europe, however, until much later because of strong labor regulation and trade-union power. Third, in a reversal of the Solow Paradox, the firm-level productivity literature describes returns to IT that are *larger* than one would expect under the standard growth accounting assumptions. Erik Brynjolfsson and Lorin Hitt (2003) argue that this is due to complementary investments in "organizational capital" that are reflected in the coefficients on IT capital. Fourth, there is a literature on the superior establishment-level productivity of US multinationals versus non-US multinationals, both in the US (Mark Doms and Bradford Jensen, 1998) and in other countries, such as the UK (Chiara Criscuolo and Ralf Martin, 2005). We suggest that the main reason for

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[5] See, for example, Basu et al. (2003) or Stiroh (2004).

[6] Olivier Blanchard, Martin Bailey, Hans Gersbach, Monika Schnitzer and Jean Tirole (2002) discuss a large number of industry-specific examples.

this difference is the way in which US multinationals use new technologies more effectively than other multinationals[7]. Finally, the paper is linked to the literature on growth and regulation.[8] One of the unintended consequences of labor market regulation in the model is that it slows down the ability of firm's to re-organize. When faced by a radical technological shock (such as the big fall in IT prices), these adjustment costs can have serious consequences in terms of technological diffusion and productivity growth.

The structure of this chapter is as follows. Section I describes the empirical framework, Section II the data and Section III presents the main results. In Section IV we sketch a simple model that can account for the stylized facts we see in the data and Section V concludes.

II. Empirical Modelling Strategy

II.A. Basic Approach

We assume that the basic production function can be written as follows

$$q_{it} = a_{it} + \alpha_{it}^{M} m_{it} + \alpha_{it}^{L} l_{it} + \alpha_{it}^{K} k_{it} + \alpha_{it}^{C} c_{it} \qquad \text{(II.1)}$$

Q denotes gross output of establishment i in year t. A denotes (total factor) productivity, M denotes materials, L denotes labor, K denotes non-IT fixed capital and C denotes computer/IT capital. Lower case letters indicate that a variable is transformed into natural logarithms, so $q_{it} \equiv \ln Q_{it}$, etc.

We are particularly interested in the role of IT capital and whether the impact of computers on productivity is systematically higher for the establishments belonging to

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[7] In a similar vein, John Haltiwanger Ron Jarmin and Torsten Shank (2003) suggest that differences in the productivity distribution of Germany and American plants could be due to greater experimentation in the US.

[8] For example, Juan Botero, Simeon Djankov, Rafael Porta, Florencio Lopez-De-Silanes and Andrei Schleifer (2004).

US firms. With this in mind, consider parameterizing the output elasticities in equation (1) as:

$$\alpha_{it}^{J} = \alpha_{h}^{J,0} + \alpha_{h}^{J,USA} D_{it}^{USA} + \alpha_{h}^{J,MNE} D_{it}^{MNE} \qquad \text{(II.2)}$$

where D^{USA}_{it} denotes that the establishment is owned by a US firm in year *t* and D^{MNE}_{it} denotes that the establishment is owned by a non-US multinational enterprise (the base case is that the establishment belongs to a non-multinational domestic UK firm), the sub-script *h* denotes sector (e.g. industries that use IT intensively vs. all other sectors) and the super-script *J* indicates a particular factor of production (*M, L, K, C*). We further assume that establishment-specific efficiency can be parameterized as:

$$a_{it} = a_i + \delta_h^0 + \delta_h^{USA} D_{it}^{USA} + \delta_h^{MNE} D_{it}^{MNE} + \gamma_h' z_{it} + \xi_{kt} + u_{h,it} \qquad \text{(II.3)}$$

where *z* are other observable factors influencing productivity - establishment age, region and whether the establishment is part of a multi-plant group. The ξ_{kt} are industry-time specific shocks that we will control for with a full set of three-digit industry dummies[9] interacted with a full set of time dummies. So, (combining equations (II.1) through (II. 3)) the general form of the production function that we will estimate is:

$$q_{it} = \sum_{M,L,K,C\in J} \alpha_h^{J,0} x_{it}^J + \sum_{M,L,K,C\in J} \alpha_h^{J,USA} D_{it}^{USA} x_{it}^J + \sum_{M,L,K,C\in J} \alpha_h^{J,MNE} D_{it}^{MNE} x_{it}^J$$
$$+ a_i + \delta_h^{USA} D_{it}^{USA} + \delta_h^{MNE} D_{it}^{MNE} + \delta_h^0 D_{it}^0 + \gamma_h' z_{it} + \xi_{kt} + u_{h,it} \qquad \text{(II.4)}$$

where $x^M = m$, etc. Note that the industry*time interactions (ξ_{kt}) control for output prices, demand and any other correlated industry specific shock.

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[9] We also experimented with year-specific four digit dummies and explicit measures of output prices (up to the five-digit level) which generated very similar results to the baseline model with year-specific three-digit industry dummies.

Although we will estimate equation (II.4) in some specifications, most of the interactions between factor inputs and ownership status are not significantly different from zero. One interaction that does stand out is between the US ownership dummy and IT capital: the coefficient on computer capital is significantly higher for US establishments than for other multinationals and/or domestic establishments. Consequently, the preferred specifications are usually of the form:

$$q_{it} = \alpha_h^M m_{it} + \alpha_h^L l_{it} + \alpha_h^K k_{it} + \alpha_h^{C,0} c_{it} + \alpha_h^{C,USA} D_{it}^{USA} c_{it} + \alpha_h^{C,MNE} D_{it}^{MNE} c_{it}$$
$$+ a_i + \delta_h^{USA} D_{it}^{USA} + \delta_h^{MNE} D_{it}^{MNE} + \delta_h^0 D_{it}^0 + \gamma_h ' z_{it} + \xi_{kt} + u_{h,it} \qquad \text{(II.5)}$$

where the key hypotheses are whether

$\alpha_h^{C,USA} D_{it}^{USA} = 0$

and/or

$\alpha_h^{C,USA} D_{it}^{USA} = \alpha_h^{C,MNE} D_{it}^{MNE}$.

(i.e. whether the output elasticity of IT is significantly greater for US establishments).

II.B. Sub-sample of establishments who are taken over

One concern with the identification strategy is that US firms may "cherry pick" the best UK establishments. In other words, it is not US multinational's internal organization that helps improve the productivity of IT but rather the ability to recognize (and take over) UK establishments that are better at using IT capital. To tackle this issue, we focus on a sub-sample of UK establishments that have been taken over by another firm at some point in the sample period. We then estimate equation (5) before and after the takeover to investigate whether the IT coefficient changes if a US multinational versus a non-US multinational takes over a UK plant. We also investigate the dynamics of change: because organizational changes are costly, we should expect to see change taking place slowly over time (so we examine how the IT coefficients change one year after the takeover compared to two years later, and so on).

The identification assumption here is not that establishments that are taken over are the same as establishments that are not taken over. We condition on a sample of establishments who are all taken over at some point in the sample period. We are effectively making two assumptions here. First, we assume that US multinationals are not systematically taking over plants that are more (or less) productive in their use of IT than non-US multinationals. We can empirically test this assumption by examining the characteristics (such as the IT level, IT growth and IT productivity) of establishments who will be taken over by US multinationals in the pre-takeover period (relative to non-US multinationals). We will show that there is no evidence of such selection[10]. Second, we are assuming that US multinationals are not systematically better than non-US multinationals at predicting (pre-takeover) the higher future productivity of IT for statistically identical British establishments. Although we regard this assumption as plausible it is not directly testable. If US managers *did* possess such foresight (and we will show that it is only for post-takeover IT productivity that the US takeovers appear to be different than non-US multinational's takeover), we cannot identify this separately from the more general superiority of American firms' IT usage.

II.C. Unobserved Heterogeneity

In all specifications, we choose a general structure of the error term that allows for arbitrary heteroskedasticity and autocorrelation over time. But, there could still be establishment-specific unobserved heterogeneity. So, we also generally include a full set of establishment-level fixed effects (the "within-groups" estimator). The fixed-effects estimators are more rigorous, as there may be many unobservable omitted variables correlated with IT that generate an upwards bias for the coefficient on computer capital.

[10] If US multinationals have higher IT productivity why do we not observe some systematic selection of US firms taking over particular UK establishments? In the model we sketch in section IV, for example, US firms would want to take over firms who were organized in a similar fashion to themselves (as indicated by their prey's higher IT productivity). It is likely this incentive, however, is small compared to the many other causes of international merger and acquisition activity we observe in the data (which we confirm empirically in section III). Allowing for endogenous takeovers is an interesting area for future work. Identification of such a model of course requires some instrument which affects takeover probabilities without directly affecting productivity.

II.D. Endogeneity of the Factor Inputs

We also were concerned about the endogeneity of the factor inputs attributable to unobserved transitory shocks. We take several approaches to deal with this issue. We experiment with the "System GMM" estimator of Richard Blundell and Stephen Bond (1998) and with a version of the Steve Olley and Ariel Pakes (1996) estimator.

III. Data

The dataset is a panel of establishments covering almost all sectors of the UK private sector, called the Annual Business Inquiry (ABI). It is similar in structure and content to the US Longitudinal Research Database (LRD), which contains detailed information on revenues, investment, employment and material inputs. Unlike the US LRD though, the ABI can be matched to establishment-level IT expenditure data for several years and it also covers the non-manufacturing sector from the mid-1990s onwards. This is important, because the majority of the sectors that intensively use IT, such as retailing and wholesaling, are outside manufacturing. The dataset is unique in containing such a large sample of establishment-level longitudinal information on IT and productivity. A full description of the datasets appears in Appendix A.

We build IT capital stocks from IT expenditure flows using the perpetual inventory method and following Dale Jorgenson (2001), sticking to US assumptions about depreciation rates and hedonic prices. The dataset runs from 1995 through 2003, but there are many more observations in each year after 1999. After cleaning, we are left with 21,746 observations with positive values for all the factor inputs. There are many small and medium-sized establishments in the sample[11] - the median establishment employs 238 workers and the mean establishment employs 811. The sampling framework of the IT surveys means that the sample, on average, contains larger establishments than the UK economy as a whole. At rental prices, average IT capital is about 1% of gross output at the unweighted mean (1.5% if weighted by size) or 2.5% of

[11] Table A2 sets out the basic summary statistics of the sample.

value added. These estimates are similar to the UK economy-wide means in Susanto Basu et al (2003).

We also considered several experiments by changing the assumptions concerning the construction of the IT capital stock. First, because there is uncertainty over the exact depreciation rate for IT capital, we experimented with a number of alternative values. Second, we do not know the initial IT capital stock for ongoing establishments the first time they enter the sample. The baseline method is to impute the initial year's IT stock using as a weight the establishment's observed IT investment relative to the industry IT investment. An alternative is to assume that the plant's share of the industry IT stock is the same as its share of employment in the industry. Finally, we use an entirely different measure of IT use based on the number of workers in the establishment who use computers (taken from a different survey). Qualitatively similar results were obtained from all methods.

We have large numbers of multinational establishments in the sample. About 8% of the establishments are US owned, 31% are owned by non-US multinationals and 61% are purely domestic. Multinationals' share of employment is even higher and their share of output higher still. Table 1 presents some descriptive statistics for the different types of ownership, all relative to the three-digit industry average for a typical year (2001). Labor productivity, as measured by output per employee, is 24% higher for US multinational establishments and 15% higher for non-US multinational establishments. This suggests a nine percentage point productivity premium for US establishments as compared to other multinationals.[12] But US establishments also look systematically larger and more intensive in their non-labor input usage than other multinationals. US establishments have 14 percentage points more employees and use about 8 percentage points more materials/intermediate inputs per employee and 10 percentage points more non-IT capital per employee than other multinationals. Most interesting for the purposes of this study, though, the largest gap in factor intensity is for IT: US establishments are

[12] This is consistent with evidence that the plants of multinational US firms are more productive both on US soil (Mark Doms and Bradford Jensen, 1998) and on foreign soil (Chiara Criscuolo and Ralf Martin (2004)).

32 percentage points more IT intensive than other multinationals. Hence, establishments owned by US multinationals are notably more IT-intensive than other multinationals in the same industry; this alone could be the reason for their higher productivity in previous studies (as they have not been able to control for IT capital). In the econometric analysis, we will show that this is not the full story because for a given amount of IT capital US productivity appears to be higher.

IV. Results

IV.A. Main Results

One key result in the paper is that US establishments' IT use is associated with greater productivity than non-US establishments' IT use. Some indication of this can be seen in the raw data. In the first row of Table 2.2 we show that the mean value added per worker (normalized by the industry average) in establishments with high IT intensity (defined as above the sample median IT capital per worker) compared to those with lower IT intensity (below the sample median) is 34% higher among the US owned establishments. In the second row, we show that the equivalent "IT premium" is only 24% for establishments owned by non-US multinationals. The implied "difference in differences" effect is a significant US premium in IT productivity of 10%. There are a host of reasons why this comparison might be misleading, of course, but as we investigate them below it will become clear that the basic contrast in Table 2 turns out to be remarkably robust.

In Table 3 we examine the output elasticity of IT in the standard production function framework described in Section II. Column (1) estimates the basic production function, including dummy variables for whether or not the plant is owned by a US multinational ("USA") or a non-US multinational ("MNE") with domestic establishments being the omitted base. US establishments are 7.1% more productive than UK domestic establishments and non-US multinationals are 3.9% more productive. This 3.2% difference between the US and non-US multinationals coefficients is also significant at the 5% level (p-value =0.02) as shown at the base of the column. This implies that about two-thirds (6 percentage points of the 9 percentage point gap) of the labor productivity gap between US and other multinationals shown in Table 1 can be accounted for by the observables, such as greater non-IT factor intensity in the US establishments, but a significant gap remains.

The second column of Table 3 includes the IT capital measure. This enters positively and significantly and reduces the coefficients on the ownership dummies. US establishments are more IT intensive than other establishments; this explains some of the productivity gap. But it only accounts for about 0.2 percentage points of the initial 3.2% (= 0.0712 - 0.0392) productivity gap between US and non-US establishments. Column (3) includes two interaction terms: one between IT capital and the US multinational dummy and the other between IT capital and the non-US multinational dummy. These turn out to be very revealing. The interaction between the US dummy and IT capital is positive and significant at conventional levels. According to column (3) doubling the IT stock is associated with an increase in productivity of 5.35% (= 0.0449 + 0.0086) for a US multinational but only 4.5% (= 0.0449 + 0.0001) for a non-US multinational. Note that non-US multinationals are not significantly different from domestic UK establishments in this respect: we cannot reject the possibility that the coefficients on IT are equal for domestic UK establishments and non-US multinationals. It is the US establishments that are distinctly different. Furthermore, the linear US dummy is not significantly different from zero. Interpreted literally, this means that we can "account" for *all* of the US multinational advantage by their more effective use of IT. Hypothetically, US establishments with less than about £1,000 (about $2,000) of IT capital (i.e. ln(C) = 0) are no more productive than their UK counterparts (none of the US establishments in the sample have IT spending this low, of course).

To investigate the industries that appear to account for the majority of the productivity acceleration in the US we split the sample into "high IT using intensive sectors" in column (4) and "Other sectors" in column (5). Sectors that use IT intensively account for most of the US productivity growth between 1995 and 2003. These include retail, wholesale and printing/publishing[13]. The US interaction with IT capital is much stronger in the IT intensive sectors, in that it is not significantly different from zero in the other sectors (even though we have twice as many observations in those industries). The final three columns include a full set of establishment fixed effects. The earlier pattern of results is repeated with a higher value of the interaction than in the non-fixed effects results. In particular, column (7) demonstrates that US establishments appear to have significantly higher productivity of their IT capital stocks than domestic establishments or other multinationals. A doubling of the IT capital stock is associated with 1% higher productivity for a domestic establishment and 1.6% for a non-US multinational, but 3.9% higher productivity for an establishment owned by a US multinational[14].

The reported US*IT interaction tests for significant differences in the output-IT elasticity between US multinationals and UK domestic establishments. However, note that in the key specifications the IT coefficient for US multinationals is significantly different from the IT coefficient for other multinationals. The row at the bottom of Table 3 reports the p-value of tests on the equality between the US*IT and the MNE*IT coefficient (i.e. Ho:$\alpha_h^{C,USA} D_{it}^{USA} = \alpha_h^{C,MNE} D_{it}^{MNE}$).

IV.B. Robustness Tests

Table 4 presents a series of tests showing the robustness of the main results - we focus on the fixed effects specification, which is the most demanding, and on the IT intensive

[13] See Appendix Table A1 for a full list. We follow the same definitions of the sectors that intensively use IT as Kevin Stiroh (2002). We group the IT producing sectors (like semi-conductors) with the "Other Sectors" because we could not find significant differences in the IT coefficient between US and non-US firms. This is consistent with the aggregate evidence that the productivity acceleration in these sectors was similar in Europe and the US.

[14] The linear US dummy is negative and significant, implying that US multinationals with very low IT stocks are less productive than domestic establishments. However, using the estimates of column (4) only 2% of the employees of US multinationals are in these plants (5% using column (7)). Moreover, we show that when US firms take over an establishment's productivity can remain low for a year or two during the restructuring process, explaining the negative direct US dummy given the short time dimension of the sample.

sectors, which we have shown to be crucial in driving the result. The first column represents the baseline production function results from column (7) in Table 3. The results were similar if we use value-added-based specifications (see column (2)), so we stay with the more general specification using gross output as the dependent variable.

Transfer Pricing - Since we are using multinational data, could transfer pricing be a reason for the results we obtain? If US firms shifted more of their accounting profits to the UK than other multinationals this could cause us to over-estimate their productivity. But this would suggest that the factor coefficients on other inputs, particularly on materials, also would be systematically different for US establishments. To test this, column (3) estimates the production function with a full set of interactions between the US multinational dummy and *all* the factor inputs (and the non-US multinational dummy and all the factor inputs). None of the additional non-IT factor input interactions are individually significant, and the joint test at the bottom of the column of the additional interactions shows that they are jointly insignificant (for example, the joint test of the all the US interactions except the IT interaction has a p-value of 0.48). We cannot reject the specification of equation (5) in column (1) as a good representation of the data versus the more general interactive models of equation (4) in column (3).[15] This experiment also rejects the general idea that the productivity advantage of the US is attributable to differential mark-ups, because then we would expect to see significantly different coefficients on *all* the factor inputs, not just on the IT variable (Tor Klette and Zvi Griliches, 1996).

Another piece of evidence against the transfer pricing story is that the results are strongest in the IT-using sectors, which are mainly services, like retail. Manipulating the transfer prices of intermediate inputs is more difficult in services than manufacturing, as intermediate inputs generally are purchased from independent suppliers. If we estimate

[15] The p-value = 0.33 on this test. We also investigated whether the coefficients in the production function regressions differ by ownership type and sector (IT intensive or not). Running the six separate regressions (three ownership types by two sectors) we found the F-test rejected at the 1% level the pooling of the US multinationals with the other firms in the IT intensive sectors. In the non-IT intensive sectors, by contrast, the pooling restrictions were not rejected. Details from the authors on request.

the model solely for the retail sector, for example, the coefficient on the US*IT interaction is 0.0509 with a standard error of 0.0118 (the interaction of other multinationals with IT has a coefficient of -0.0142 with a standard error of 0.0096).

Systematic mismeasurement of American establishments' IT capital stock - One concern is that we may be underestimating the true IT stock of US multinationals in the initial year: this could generate a positive coefficient on the interaction term, because of greater measurement error of IT capital for the US establishments. This also could be due to transfer price concerns, causing the US firms to underestimate their IT expenditure for some reason.

To tackle this issue we turn to an alternative IT survey (the E-commerce Survey, described in the Appendix) that has data on the proportion of workers in the establishment who are using computers. This is a pure "stock" measure so it is unaffected by the initial conditions concern[16]. In Column (4) the IT capital stock measure is replaced with a measure of the number of workers using computers. Reassuringly, we still find a positive and significant coefficient on the US interaction with computer usage.

Functional Forms - We tried including a much broader set of interactions and higher order terms (a "translog" specification) but these were generally individually insignificant. Column (5) shows the results of including all the pair-wise interactions of materials, labor, IT capital, and non-IT capital and the square of each of these factors. The additional terms are jointly significant but the key US interaction with the IT term remains basically unchanged (it falls slightly from 0.0278 to 0.0268) and remains significant.

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[16] The IT capital stock measure is theoretically more appropriate as it is built analogously to the non-IT stock and is comparable to best practice existing work. The E-Commerce Survey is available for three years (2001 to 2003), but the vast majority of the sample is observed only for one period, so we do not control for fixed effects.

Selection of US establishments into sectors with high IT productivity - Another possible explanation for the apparently higher productivity of IT is that US multinationals may be disproportionately represented in specific industries in which the output elasticity of IT is particularly high. The interaction of IT capital with the US dummy then would capture omitted industry characteristics rather than a "true" effect linked to US ownership. To test for this potential bias, the regression includes as an additional control the percentage of US multinationals in the specific four-digit industry ("USA_IND")[17] and its interaction with IT. The interaction was positive but statistically insignificant (see column (6)), and the coefficient on the IT*US interaction remains significant and largely unchanged.

Skills - In column (7), we considered the role of skills. The main control for labor quality in Table 3 was the inclusion of establishment-specific fixed effects which, so long as labor quality does not change too much over time, should control for the omitted human capital variable. As an alternative, we assume that wages reflect marginal products of workers, so that conditioning on the average wage in the establishment is sufficient to control for human capital[18]. The average wage is highly significant and the interaction between the average wage and IT capital is positive and significant at the 10% level, consistent with technology-skill complementarity. The interaction between the US dummy and average wages in the establishment is insignificant (a coefficient of 0.0365 and a standard error of 0.0403)[19]. Nevertheless, even in the presence of these

[17] The variable is constructed as an average between 1995 and 2003 and is built using the whole ABI population.

[18] The problem is that wages may control for "too much", as some proportion of wages may be related to non-human capital variables. For example, in many bargaining models, firms with high productivity will reward even homogenous workers with higher wages (for example, see John Van Reenen, 1996, on sharing the quasi-rents from new technologies).

[19] As an alternative we matched in education information by aggregating up individual level survey (the Labor Force Survey) into industry by regional cells. In the specifications without fixed effects, there was some evidence for a positive and significant interaction between skills and IT consistent with complementarity between technology and human capital. The US*IT capital interaction remained significant. Including fixed effects, however, renders the skills variables and their interactions insignificant (even though US*IT interaction remains significant). Interactions between the US dummy and skills were insignificant in all specifications.

skills controls, the coefficient on the US ownership and IT interaction remains significantly positive.

Stronger selection effects for US multinationals because of greater distance from the UK - A further issue is that US firms may be more productive in the UK because the US is geographically further away than the average non-US multinational's home base (in the data most foreign multinationals are European if they are not American) and only the most productive firms are able to overcome the fixed costs of distance. To test this we divide the non-US multinational dummy into European versus non-European firms. Under the distance argument, the non-European firms would have to be more productive to be able to set up greenfield establishments in the UK. According to column (8) though, the European and non-European multinationals are statistically indistinguishable from each other; again, it is the US multinationals that appear to be different.

Unmeasured software inputs for US establishments - Could the US*IT interaction effect reflect greater unmeasured software inputs for US establishments? Although this is certainly possible when we compare US multinationals with domestic establishments it is less likely when we compare US multinationals with non-US multinationals because *a priori* there is no reason to believe that they have higher levels of software. It could, however, be a problem if US firms were globally larger than other multinationals (software has a large fixed cost component so will be cheaper per unit for larger firms than smaller firms). To address this issue, we included a measure of the "global size" of the multinational parent of the establishments. In the UK ABI data, US multinationals and non-US multinationals are similar in their median global employment size. As a more direct test, we introduce an explicit interaction term between the global size of the parent firm (defined as the log of the total number of worldwide employees) and IT capital in a specification identical to baseline specification in column (1) of Table 4. The interaction between global size and IT is insignificant and the US interaction with IT remained significant (at the 1% level) and significantly different from the non-US multinational interaction with IT at the 10% level[20].

We also used a measure of software capital constructed analogously to the main IT capital variable (see Appendix A). In the data, software expenditure includes a charge for software acquired from the multinational's parent. The IT capital interaction is robust to the inclusion of this measure of software capital (and its interaction with ownership status). For example, when we added software capital to a specification identical to column (1) of Table 4 the standard IT interaction with the US remained positive and significant[21].

So the evidence does not appear to support a large role for unmeasured software inputs driving the superior US productivity of IT. But even if this did play some role, it would still leave the puzzle of why US firms have so much higher software inputs than other multinationals. Commercial software is available globally and is costless to transport. One could argue that US firms have access to a better pool of computer programmers, for example from Silicon Valley, and these develop more advanced in-house software.[22] But even if this were true, market forces would rapidly provide this commercially if it had such a large positive effect on productivity. The model presented below in section IV offers one explanation of why the US may have "moved first" in organizational change based on lower labor market regulations: it is less clear why this should have been the case for software.

Controlling for endogenous inputs – We also estimated the production functions to control for the endogeneity of factor inputs using the GMM "System" estimator of

[20] The global size variable was only available for a sub-sample of 3,000 observations (from the baseline sample of 7,784). When we re-ran the baseline specification on this smaller sub-sample, the US interaction with IT was 0.032 (instead of 0.028 in the baseline) and significant at the 5% level. When we include the global size term the point estimate rose to 0.036 (the point estimate on the global size interaction was -0.0017). We are very grateful to Ralf Martin and Chiara Criscuolo for matching in the data.

[21] The IT hardware capital interaction had a coefficient of 0.0263 with a standard error of 0.0118.

[22] There is, of course, a highly successful European software industry, including firms like SAP that provides global enterprise application software.

Blundell and Bond (1998) and the Olley and Pakes (1996) estimator. The full results are shown in Appendix Table A3. In both cases the main finding - that the output-elasticity of IT for US multinationals is much larger than the output-elasticity of IT for non-US multinationals - is robust, even though the coefficients are estimated less precisely than under the baseline within-groups estimates.[23]

IV.C. US Multinational Takeovers of UK establishments

One possible explanation for the results is that US firms "cherry pick" the best UK establishments, that is, those that already have the highest productivity of IT. This would generate the positive interaction we find but it would be due entirely to selection on unobserved heterogeneity rather than to higher IT productivity caused by US ownership. To look at this issue, we examined the sub-sample of establishments that were, at some point in the sample period, taken over by another firm. We considered both US and non-US acquirers. Because of the high rate of merger and acquisition activity in the UK, this is a large sample (4,888 observations)[24].

In column (1) of Table 5, we start by estimating the standard production functions, for all establishments that are eventually taken over in their *pre-takeover* years (this is labelled "before takeover"). The coefficients on the observable factor inputs are very similar to those for the whole sample in column (2) of Table 3. Unlike the full sample, though, the US and non-US ownership dummies are insignificant, suggesting that the establishments taken over by multinationals are not *ex ante* more productive than those acquired by domestic UK firms.

[23] The coefficient on the US*IT interaction in the GMM system estimator is 0.118 with a standard error of 0.064 and this is significantly different from the non-US multinational interaction at the 10% level. The underlying theoretical model of Olley-Pakes does not allow us to simply include interactions, so we estimated the production function separately for the three ownership types (US multinationals, non-US multinationals and domestic UK establishments). The output-IT elasticity for US multinationals is twice as large as that of non-US multinationals.

[24] We have a larger number of observations "post-takeover" than "pre-takeover" as there was a takeover wave at the beginning of the sample in the late 1990s associated with the stock market bubble and high tech boom. For these establishments, we necessarily have a lot more post takeover information than pre-takeover information.

In column (2) of Table 5 we interact the IT capital stock with a US and a non-US multinational ownership dummy, again estimated on the *pre-takeover* data. We see that neither interaction is significant – that is *before* establishments are taken over by US firms they do not have unusually high IT coefficients. So, US firms also do not appear to be selecting establishments that already provide higher IT productivity. In columns (3) and (4) we estimate production function specifications identical to columns (1) and (2) but on the *post-takeover* sample. In column (3), the non-US and US multinational ownership coefficients are positive and significant. Thus, a transfer of ownership from domestic to multinational production is associated with an increase in productivity, particularly for a move to US ownership.

Column (4) is the key result for Table 5. It contains the estimates of a specification that allows the IT capital stock coefficient to vary by ownership status for the *post*-takeover sample. For the post-takeover period we indeed see that the interaction between IT and the US dummy is positive and significant at the 5% level but is insignificant for non-US multinationals. Hence, after a takeover by a US multinational, an establishment enjoys significantly higher IT-related productivity than a statistically similar establishment taken over by a non-US multinational. Note that the inclusion of the US interaction with IT also drives the coefficient on the linear US multinational term into insignificance, suggesting that the main reason for the improved performance of establishments after a US takeover is linked to the increased IT productivity (just as we saw in Table 3 for the whole sample). The fifth column of Table 5 breaks down the post takeover period into the first year after the takeover and the subsequent years (note that throughout the table we drop the takeover year itself as we cannot determine the exact timing within the year when the takeover occurred). The greater productivity of IT capital in establishments taken over by US multinationals is revealed only two and three years after takeover (this interaction is significant at the 5% level whereas the interaction in the first year is insignificant). This is consistent with the idea that US firms take some time to restructure before obtaining higher productivity gains from IT. Domestic and other multinationals again reveal no pattern, with all dummies and interactions remaining insignificant.[25]

The sample in Table 5 includes some firms that are taken over by domestic UK firms, so a stronger test is to drop these and consider only takeovers by multinational firms. In column (6) we replicate the specification of column (5) for this smaller sample and again find that establishments taken over by US multinationals have a significantly higher coefficient on IT capital after two or more years than non-multinational takeovers.

As another cut on the cherry-picking concept we ran linear probability models of US takeovers where the dependent variable was equal to one for establishments taken over by a US firm and otherwise zero. There is no evidence that US firms are more likely to take over establishments that are more IT intensive, or that establishments are increasing their IT intensity (see Appendix Table A4 for full results)[26].

V. Interpretation of the Results

We have established that foreign affiliates of US firms appear more productive than affiliates of other multinationals and that this productivity advantage appears to be linked strongly to their use of IT, suggesting an unobserved complementary input that is more abundant in US firms. The literature suggests that one candidate for this complementary input may be the internal organization of US firms.

In section V.A, we present some survey data to corroborate the idea that US firms have distinctive organizational features. We also suggest that a potential explanation for such differences can be found in specific policies - such as restrictive labour market regulations - which may inhibit organizational change. Some direct

[25] Taken literally, the negative coefficient on the US linear term in column (4) implies a negative US effect for firms with IT capital below approximatively £4,500 ($9,000). Only 0.1% of employment in US establishments is below this threshold.

[26] For example, the marginal effect of (lagged) IT capital in the US takeover equation was 0.0029 with a standard error of 0.0095 (we included controls for size, non-IT intensity, productivity, age and industry dummies – none of which were significant).

evidence on this hypothesis using explicit measures of labor market regulation are presented in sub-section IV.B.

V.A. The Organization of US firms

In this section we consider some supporting evidence on the different internal organization of US versus European firms. In Figure 3, panels 3a and 3b provide new evidence we collected on the internal organization of over 700 firms in the US and Europe. These show that, on average, firms operating in the US are significantly more decentralized than those operating in Europe.[27] This is also true when looking at US multinationals in Europe compared to non-US multinationals in Europe, with the US firms again being significantly more decentralized. In Panels 3c and 3d we use two other UK surveys, the Workplace Industrial Relations Survey and the Community Innovation Survey, to show that US multinationals also had a higher rate of change in organizational structure going back to the mid-1980s. So, in short, US firms are organized differently, both at home and abroad, and also change organizational structures more swiftly.

V.B. A little "direct evidence" on the model

In this sub-section we consider some more direct evidence that the different ability of European firms may be linked to institutions that generate organizational inflexibility, such as tight labor market regulations.

Christopher Gust and Jaime Marquez (2004) show that an employment protection index is negatively correlated with country-wide IT expenditure as a share of GDP for thirteen OECD countries. We suggests that these regulations may be partially "exported" to the multinational's establishments in the UK . To examine this idea we match in the World Bank's measure of the flexibility of labor regulation to the establishments in the dataset by country of ownership, which is shown in Figure 4. So, for example, the Germany data point plots the labor regulation index in Germany

[27] See Bloom and Van Reenen (2007) for details on the survey. Decentralization was measured in the same way as Timothy Bresnahan et al (2002) using questions related to task allocation and pace setting in order to indicate the degree of employee autonomy.

against the IT intensity for establishments owned by German multinationals. We find that the IT intensity of multinational affiliates is higher in the UK when labor market flexibility is greater in their home country (the correlation coefficient between IT intensity and labor market flexibility is 0.0579 and is significant at the 1% level)[28].

More ambitiously, Table 6 presents regressions based on the multinational-only sample where we include interactions with labor market regulation of the multinational's home country and the establishment's IT capital. The first column includes only the standard production function controls (i.e. it drops the ownership variables) and includes the index of the flexibility of labor regulation. The coefficient on the flexibility index is positive and significant suggesting higher TFP for multinationals whose home country has more flexible labor markets. The next column repeats the baseline specification of column (1) in Table 4 and shows that the standard results hold on this sample. In particular, the interaction between the US dummy and IT capital is significantly positive. In column (3) we include instead the interaction between labor regulation (in the multinational's home country) and IT. The coefficient on this interaction is also significantly positive: lighter regulations in the establishment's home country appear to be associated with greater productivity of IT in the UK. We repeat the specifications of columns (2) and (3) including fixed effects in columns (4) and (5) and show the robustness of the results. Ideally, we would like to show that the US interaction is driven to insignificance by on the interaction of IT with the labor regulation index. This is not the case; in column (6) when we include both interactions these are positive but individually insignificant[29].

VI. Conclusion

Using a large and original establishment level panel dataset we find robust evidence that IT has a positive and significant correlation with productivity even after controlling for

[28] When we drop all the observations from US multinationals the correlation coefficient is 0.0351 (significant at the 10% level).

[29] The interactions are jointly significant at the 10% level.

many factors, including establishment fixed effects. The most novel result, however, is that we can account for the US multinational advantage in productivity by the higher productivity of their IT capital. Furthermore, the stronger association of IT with productivity for US firms is confined to the same "IT using intensive" industries that largely accounted for the US "productivity miracle" since the mid 1990s. These results were robust to examining establishments that were taken over by other firms: US firms who took over establishments have significantly greater IT productivity relative to non-US multinationals who took over statistically similar establishments.

US firms appear to obtain significantly higher productivity from their IT capital than other multinational establishments (and domestic establishments), even in the context of a UK environment. This suggests that part of the IT-related productivity gains underlying the recent US "productivity miracle" may be related to US firm characteristics rather than simply the natural advantage (geographical, institutional or otherwise) of being located in the US environment.

There are many outstanding issues and research questions. First, according to the model the US is not always superior. Rather, it is the *flexibility* of the US economy in adapting to major changes (such as the IT revolution) that gives it a temporary productivity advantage. This model predicts that Europe will start to realize enhanced IT-enabled productivity growth over the next few years and resume the catching up process with the US that was observed until the mid 1990s. There may be some evidence of this occurring as Europe's productivity growth in 2006 picked up as America's slowed slightly[30]. Of course, if the world economy has moved into a stage of development where technology-related turbulence is inherently greater, then the more flexible US will retain an edge over Europe for the foreseeable future.

Second, it would be desirable to confront the model more directly with measures of organization and IT. This paper has looked at the consequences of organizational change on "standard" observables (although IT is also rarely observed at the micro level). A follow-up study to Nick Bloom and John Van Reenen (2006) has collected data

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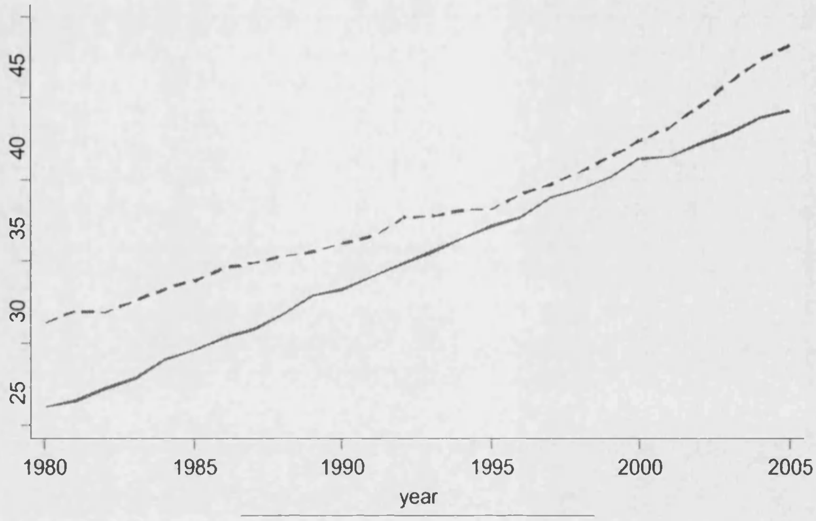
[30] *The Economist*, April 14th 2007, Economic Focus "Making Less With More"

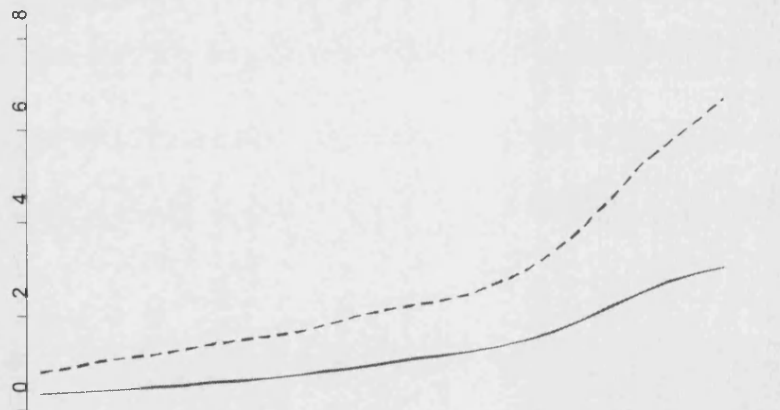
from several thousand firms on internal organizational structure, management and IT across eleven countries. We can use this data to directly examine some of the model's implications. Thirdly, we would like to understand the determinants of decentralization and other organizational design features of firms in much more detail.

Figure 1: Output per hour in Europe and the US, 1980-2005



Notes: The dotted line is the US, the continuous line is Europe. Productivity measured by GDP per hour in 2005 US $ PPPs. The countries included in the "EU 15" group are: Austria, Belgium, Denmark, Finland, France, Germany, UK, Greece, Italy, Ireland, Luxembourg, Portugal, Spain, Sweden, and Netherlands. Labor productivity per hour worked in 2005 US$. Source: The Conference Board and Groningen Growth and Development Centre, Total Economy Database.

Figure 2: IT capital per hour in Europe and the US, 1980-2005



Notes: The dotted line is the US, the continuous line is Europe. IT capital stock (in unit dollars) per hour worked. IT capital stock measured using perpetual inventory method and common assumptions on hedonics and depreciation. 2005 US $ PPPs. The countries included in the "EU 15" group are: Austria, Belgium, Denmark, Finland, France, Germany, UK, Greece, Italy, Ireland, Luxembourg, Portugal, Spain, Sweden and the Netherlands. Labour productivity per hour worked in 2005 US$ using PPPs. Source: Marcel P. Timmer, Gerard Ypma and Bart van Ark, "IT in the European Union: Driving Productivity Convergence?", Research Memorandum GD-67, Groningen Growth and Development Centre, October 2003, Appendix Tables, updated June 2005.

Figure 3a: Organizational devolvement, firms by country of location

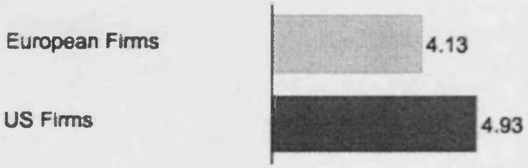


Figure 3c: Organizational change in the UK during 1981-1990

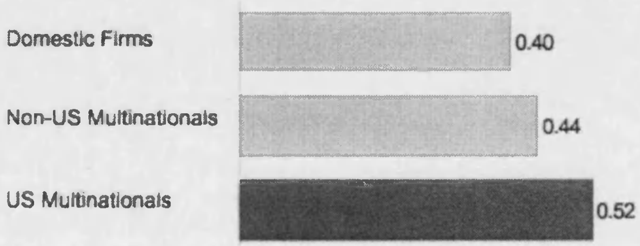


Figure 3b: Organizational devolvement, firms by country of ownership

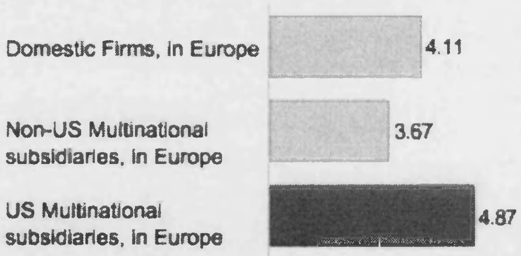
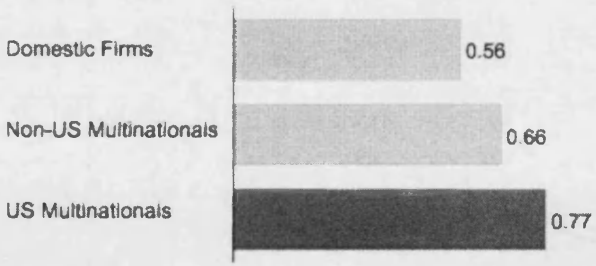
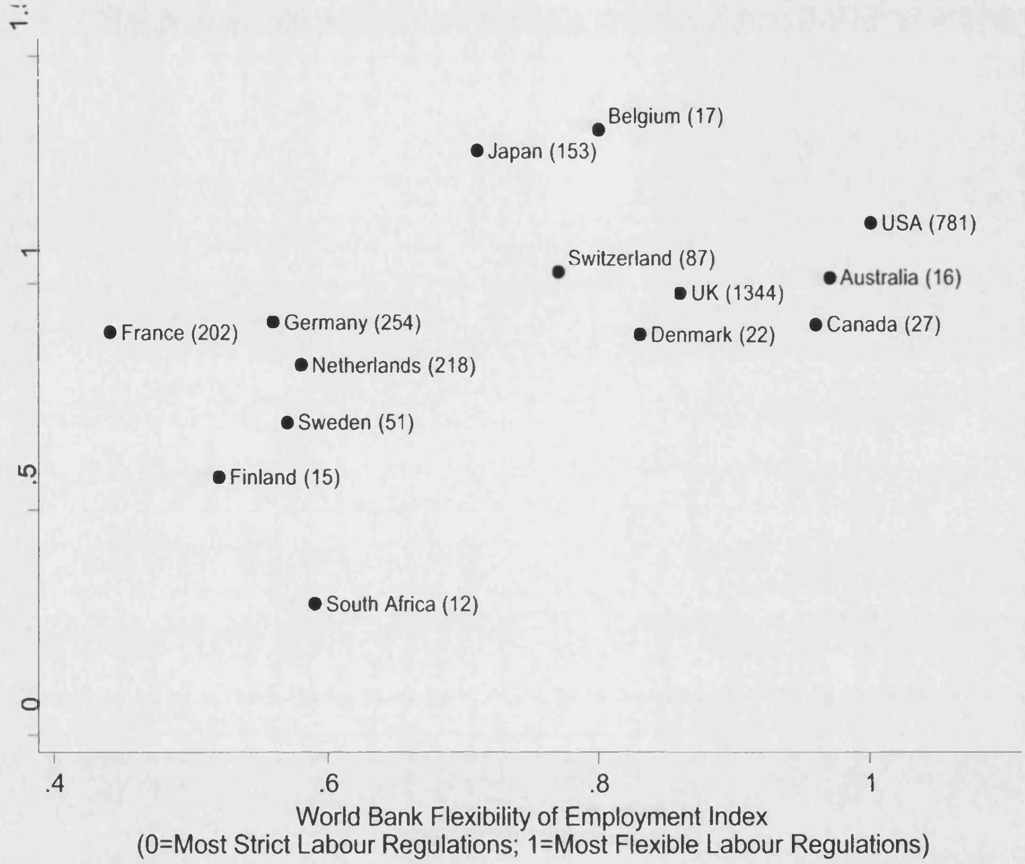


Figure 3d: Organizational change in the UK during 1998-2000



Notes: In Figures 3a and 3b the "Organizational devolvement" score is the average score for the 2 organizational questions for 548 firms in the US (219), UK (98) and France and Germany (231). The questions are taken exactly from Bresnahan et al. (2002) covering "Task allocation" and "Pace setting" where a higher scores indicate greater worker autonomy. Full survey details in Bloom and Van Reenen (2007). In Figure 3c the source is the WIRS data (1984 and 1990) which plots the proportion of establishments experiencing organizational change in previous 3 years (all establishments in the UK). US MNEs (N=190), Non-US MNEs (N=147), Domestic (N=2848). Senior manager is asked "whether there has been any change in work organization not involving new plant/equipment in the past three years". In Figure 3d the source is the CIS data: we plot the proportion of establishments experiencing organizational or managerial change in previous 3 years. The firm is asked "*Did your enterprise make major changes in the following areas of business structure and practices during the three year period 1998-2001?*" with answers to either "*Advanced Management techniques*" or "*Major changes in organizational structure*" recorded as an organizational change.

Figure 4: IT Intensity and the Flexibility of Labour Regulations



Notes: The sample includes only establishments of multinationals in IT using sectors. Each point represents average IT intensity (IT capital divided by employment normalized by the three digit industry average) by country. Each country average is based on at least ten observations and three digit industries with fewer than 10 observations are excluded. The labour regulation index is the "Rigidity of Employment" index, drawn from the World Bank "Doing Business" report.

Table 1 - Descriptive Statistics Broken Down by Multinational Status (Normalized to 100 for the three digit industry-year average)

		Employment	Value added per Employee	Gross output per Employee	Non IT Capital per Employee	Materials per Employee	IT Capital per Employee
US Multinationals							
	Mean	162.26	127.96	123.63	129.61	123.81	152.13
	St. Dev.	297.58	163.17	104.81	133.91	123.35	234.41
	Obs	569	569	569	569	569	569
Other Multinationals							
	Mean	148.58	113.71	115.22	120.65	116.02	119.58
	St. Dev.	246.35	107.87	86.50	126.83	107.63	180.34
	Obs	2119	2119	2119	2119	2119	2119
UK domestic							
	Mean	68.78	89.86	89.69	86.33	89.29	83.95
	St. Dev.	137.72	104.50	102.09	127.16	129.37	188.30
	Obs	4433	4433	4433	4433	4433	4433

Notes: These are 2001 values from the sample of 7,121 establishments.

Table 2 – Difference in Differences
Labor Productivity in establishments owned by US multinationals and by non-US multinationals

	High IT intensity Establishments	Low IT intensity Establishments	Diff
US Multinationals	3.893	3.557	**0.336*** **
	(0.742)	(0.698)	**(0.043)**
	1076	729	
Other Multinationals	3.711	3.473	**0.238*** **
	(0.756)	(0.664)	**(0.022)**
	4014	2827	
Diff	**0.182*** **	**0.084** **	
	(0.036)	**(0.037)**	
Diff in Diffs			**0.098** **
			(0.048)

Notes: Productivity is measured as ln(Value Added per Employee). "High IT intensity establishments" are observations where the ratio of IT capital to employment (demeaned by the three-digit industry and year average) is greater than the median. 8,646 Observations; only multinationals considered. Standard errors are clustered by establishment.

Table 3 – Production Function Allowing the I.T. Coefficient to Differ By Ownership Status

	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: ln(Output)	**ln(Q)**	**ln(Q)**	**ln(Q)**	**ln(Q)**	**ln(Q)**	**ln(Q)**	**ln(Q)**
Sectors	All Sectors	All Sectors	IT Using Intensive Sectors	Other Sectors	All Sectors	IT Using Intensive Sectors	Other Sectors
Fixed effects	**NO**	**NO**	**NO**	**NO**	**YES**	**YES**	**YES**
USA*ln(C)	-	0.0086*	0.0196**	0.0033	0.0049	0.0278***	-0.0085
USA ownership*IT capital		(0.0048)	(0.0078)	(0.0061)	(0.0064)	(0.0105)	(0.0071)
MNE*ln(C)	-	0.0001	-0.003	0.0037	0.0042	0.0055	0.0034
Non-US multinational *IT capital		(0.003)	(0.0041)	(0.0042)	(0.0034)	(0.0052)	(0.0044)
Ln(C)	0.0457***	0.0449***	0.0399***	0.0472***	0.0146***	0.0114**	0.0150***
IT capital	(0.0024)	(0.0026)	(0.0036)	(0.0035)	(0.0028)	(0.0047)	(0.0034)
Ln(M)	0.5474***	0.5475***	0.6212***	0.5065***	0.4032***	0.5020***	0.3605***
Materials	(0.0083)	(0.0083)	(0.0142)	(0.0104)	(0.0178)	(0.028)	(0.0209)
Ln(K)	0.1268***	0.1268***	0.1108***	0.1458***	0.0902***	0.1064***	0.0664***
Non-IT Capital	(0.0068)	(0.0068)	(0.0094)	(0.0092)	(0.0159)	(0.0229)	(0.0209)
Ln(L)	0.2690***	0.2688***	0.2179***	0.2869***	0.2917***	0.2475***	0.3108***
Labor	(0.0062)	(0.0062)	(0.0102)	(0.0076)	(0.0173)	(0.0326)	(0.0195)
USA	0.0642***	0.0151	-0.0824*	0.0641*	-0.011	-0.1355*	0.0472
USA Ownership	(0.0135)	(0.0277)	(0.0438)	(0.0354)	(0.0424)	(0.0768)	(0.0405)
MNE	0.0339***	0.0338**	0.0325	0.0194	-0.0162	-0.016	-0.0204
Non-US multinational	(0.0078)	(0.0161)	(0.0241)	(0.0214)	(0.0198)	(0.0327)	(0.0254)
Observations	21746	21746	7784	13962	21746	7784	13962
Test USA*ln(C)=MNE* ln(C), p-value	-	0.0944	0.0048	0.9614	0.9208	0.0403	0.134
Test USA=MNE, p-value	0.0203	0.5198	0.0108	0.2296	0.9072	0.1227	0.9665

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all columns is the log of gross output. The time period is 1995-2003. The estimation method in all columns is OLS. Columns (6) to (8) include establishment level fixed effects. Standard errors in brackets under coefficients in all columns are clustered by establishment (i.e. robust to heteroskedasticity and autocorrelation of unknown form). All columns include a full set of three digit industry dummies interacted with a full set of time dummies and as additional controls: dummies for establishment age (interacted with a manufacturing dummy), region, multi-establishment group (interacted with ownership type) and IT survey. See Appendix Table A1 for definition of IT using intensive sectors. "Test USA*ln(C)=MNE*ln(C)" is test of whether the coefficient on USA*ln(C) is significantly different from the coefficient on MNE*ln(C), etc.

Table 4 - Robustness Checks on the Production Function

Experiment	(1) Baseline Specification	(2) Value Added	(3) All Inputs Interacted with US and MNE	(4) Alternative IT measure	(5) Full "Translog" interactions	(6) % USA in 4 digit industry	(7) Wages as a proxy for skills	(8) EU and Non EU MNEs
Dependent var: ln(Output)	ln(Q)	ln(VA)	ln(Q)	ln(Q)	ln(Q)	ln(Q)	ln(Q)	ln(Q)
USA*ln(C) USA ownership*IT capital	0.0278*** (0.0105)	0.0604** (0.0245)	0.0328** (0.0141)	0.0711** (0.0294)	0.0268*** (0.0102)	0.0270** (0.0105)	0.0208** (0.0096)	0.0283*** (0.0105)
MNE*ln(C) Non-US multinational*IT capital	0.0055 (0.0052)	-0.0070 (0.0142)	0.0002 (0.0065)	0.0056 (0.0131)	0.0028 (0.0050)	0.0050 (0.0054)	0.0021 (0.0047)	-
Ln(C) IT capital	0.0114** (0.0047)	0.0263** (0.0106)	0.0126** (0.0050)	0.0285*** (0.0083)	0.0327 (0.0463)	0.0090* (0.0048)	-0.0227 (0.0163)	0.0114** (0.0047)
Ln(M) Materials	0.5020*** (0.0280)	-	0.4925*** (0.0312)	0.6390*** (0.0195)	0.2779 (0.2225)	0.5017*** (0.0279)	0.4455*** (0.0296)	0.5023*** (0.0278)
Ln(K) Non-IT Capital	0.1064*** (0.0229)	0.2157*** (0.0546)	0.1075*** (0.0228)	0.1390*** (0.0170)	0.2686** (0.1255)	0.1070*** (0.0230)	0.0767*** (0.0216)	0.1063*** (0.0229)
Ln(L) Labor	0.2475*** (0.0326)	0.4835*** (0.0571)	0.2530*** (0.0343)	0.2171*** (0.0140)	0.3002 (0.2095)	0.2472*** (0.0329)	0.3958*** (0.0361)	0.2472*** (0.0325)
USA USA Ownership	-0.1355* (0.0768)	-0.3552** (0.1492)	-0.2734 (0.2578)	-0.0125 (0.1113)	-0.1419** (0.0683)	-0.1323* (0.0763)	-0.0967 (0.0739)	-0.1374* (0.0769)
MNE Non-US multinational	-0.0160 (0.0327)	0.0733 (0.0855)	-0.0489 (0.1687)	-0.0087 (0.0758)	-0.0112 (0.0322)	-0.0148 (0.0334)	-0.0010 (0.0309)	-
USA*ln(M) USA ownership*materials	-	-	0.0335 (0.0376)	-	-	-	-	-
MNE*ln(M) Non-US multinational *materials	-	-	0.0080 (0.0235)	-	-	-	-	-
USA*ln(K) USA ownership*Non IT capital	-	-	0.0242 (0.0368)	-	-	-	-	-
MNE*ln(K) Non-US multinational *Non IT capital	-	-	-0.0142 (0.0134)	-	-	-	-	-
USA*ln(L) USA ownership*Employment	-	-	-0.0767 (0.0497)	-	-	-	-	-
MNE*ln(L) Non-US multinational *Employment	-	-	0.0193 (0.0239)	-	-	-	-	-
USA_IND [% of US Multinationals in industry]	-	-	-	-	-	0.9194 (2.3378)	-	-
USA_IND*ln(C) [% of US Multinationals in industry]*IT capital	-	-	-	-	-	0.3607 (0.4119)	-	-

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln(Wage) **Average wage**	-	-	-	-	-	-	0.2137*** (0.0407)	-
ln(Wage)*ln(C) **Average Wage*IT capital**	-	-	-	-	-	-	0.0109* (0.0056)	-
EU MNE **EU ownership**	-	-	-	-	-	-	-	-0.0328 (0.0354)
NON-EU MNE **Non EU-NON USA Ownership**	-	-	-	-	-	-	-	-0.0066 (0.0910)
EU MNE*ln(C) **EU ownership*IT Capital**	-	-	-	-	-	-	-	0.0065 (0.0051)
NON EU MNE*ln(C) **Non EU-NON USA Ownership*IT capital**	-	-	-	-	-	-	-	-0.0079 (0.0158)
Observations	7784	7784	7784	2196	7784	7784	7780	7784
Test USA*ln(C)=MNE*ln(C), p-value	0.0403	0.0122	0.0224	0.0122	0.0244	0.0288	0.0575	-
Test USA=MNE, p-value	0.1227	0.007	0.3618	0.007	0.0602	0.1288	0.1982	-
Test on joint significance of all the interaction terms, excluding IT interactions (p-value)	-	-	0.3288	-	-	-	-	-
Test on joint significance of all the US interaction terms, excluding IT (p-value}	-	-	0.4837	-	-	-	-	-
Test on all the other MNE's interaction terms, excluding IT (p-value)	-	-	0.3838	-	-	-	-	-
Test on additional "translog" terms, p-value	-	-	-	-	0.0000	-	-	-
Test USA=EU, p-value	-	-	-	-	-	-	-	0.2072
Test USA=NON EU, p-value	-	-	-	-	-	-	-	0.2500
Test USA*ln(C)=EU*ln(C), p-value	-	-	-	-	-	-	-	0.0457
Test USA*ln(C)=NON EU*ln(C), p-value	-	-	-	-	-	-	-	0.0511

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all columns is the log of gross output. All columns are for the sectors that use IT intensively only. The time period is 1995-2003. The estimation method in all columns is OLS. All columns except (4) include establishment level fixed effects. Standard errors in brackets under coefficients in all columns are clustered by establishment (i.e. robust to heteroskedasticity and autocorrelation of unknown form). All columns include a full set of three digit industry dummies interacted with a full set of time dummies and as additional controls: dummies for establishment age (interacted with a manufacturing dummy), region, multi-establishment group (interacted with ownership type) and IT survey (except column (4)). The IT measure in column (4) is the log(number of people using computers). We also include interactions of the US dummy (and the MNE dummy) with ln(labor) in this column. Column (5) includes all the pair-wise interactions of materials, labor, IT capital, and non-IT capital and the square of each of these factors. Column (6) includes the percentage of non-US multinationals in the establishment's four digit industry. "Test USA*ln(C)=MNE*ln(C)" is test of whether the coefficient on USA*ln(C) is significantly different from the coefficient on MNE*ln(C), etc.

Table 5 - Production Functions Before and After Takeovers

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	**Before takeover**	**Before takeover**	**After takeover**	**After takeover**	**After takeover**	**After takeover (drop UK domestic acquirers)**
Dependent Variable: ln(Output)	**ln(Q)**	**ln(Q)**	**ln(Q)**	**ln(Q)**	**ln(Q)**	**ln(Q)**
USA*ln(C) **USA Takeover*IT capital**	-	-0.0322 (0.0277)	-	0.0224** (0.0102)	-	-
MNE*ln(C) Non-US multinational Takeover*IT capital	-	-0.0159 (0.0118)	-	0.0031 (0.0079)	-	-
USA **USA Takeover**	-0.0031 (0.0335)	0.1634 (0.1357)	0.0827*** (0.0227)	-0.0345 (0.0550)	-	-
MNE **Non-US multinational Takeover**	-0.0221 (0.0226)	0.0572 (0.0598)	0.0539*** (0.0188)	0.0412 (0.0380)	-	-
USA*ln(C) one year after takeover	-	-	-	-	0.0095 (0.0149)	-0.0103 (0.0176)
USA*ln(C) two and three years after takeover	-	-	-	-	0.0274** (0.0115)	0.0315* (0.0170)
MNE*ln(C) one year After takeover	-	-	-	-	0.0003 (0.0109)	-
MNE*ln(C) two and three years after takeover	-	-	-	-	0.0041 (0.0085)	-
Ln(C) **IT capital**	0.0582*** (0.0092)	0.0593*** (0.0097)	0.0495*** (0.0061)	0.0460*** (0.0067)	0.0459*** (0.0067)	0.0806*** (0.0169)
Ln(M) **Materials**	0.4949*** (0.0308)	0.4950*** (0.0306)	0.5276*** (0.0212)	0.5286*** (0.0211)	0.5287*** (0.0210)	0.5913*** (0.0448)
Ln(K) **Non-IT Capital**	0.1592*** (0.0256)	0.1591*** (0.0254)	0.1145*** (0.0162)	0.1145*** (0.0162)	0.1142*** (0.0161)	0.0311 (0.0333)
Ln(L) **Labor**	0.2723*** (0.0184)	0.2727*** (0.0185)	0.2927*** (0.0146)	0.2918*** (0.0146)	0.2924*** (0.0145)	0.2480*** (0.0367)
USA one year after takeover	-	-	-	-	0.0591 (0.0720)	0.0466 (0.1007)
USA two and three years after takeover	-	-	-	-	-0.0713 (0.0641)	-0.1507 (0.0951)
MNE one year after takeover	-	-	-	-	0.0230 (0.0534)	-
MNE two and three Years after takeover	-	-	-	-	0.0489 (0.0418)	-
Observations	1422	1422	3466	3466	3466	692
Test USA*ln(C) = MNE*ln(C), p-value	-	0.5564	-	0.0880	-	-
Test USA = MNE, p-value	0.5900	0.4430	0.2216	0.2104	-	-
Test USA one year = MNE one year, p-value	-	-	-	-	0.6743	-
Test USA two plus years = MNE two plus years, p-value	-	-	-	-	0.0894	-
Test (USA one year)*ln(C) = (MNE one year)*ln(C), p-value	-	-	-	-	0.6044	-
Test (USA two plus years)*ln(C) = (MNE two plus years)*ln(C), p-value	-	-	-	-	0.0691	-

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The sample is of all establishments who were taken over at some point (the omitted base is “domestic takeovers” - UK firms taking over other UK firms). The dependent variable in all columns is the log of gross output. The time period is 1995-2003. The estimation method is OLS. Standard errors in brackets under coefficients are clustered by establishment. A takeover is defined as a change in the establishment foreign ownership marker or - for UK domestic establishment - as a change in the enterprise group marker. The "before" period is defined as the interval between one and three years before the takeover takes place. The "after" period is defined as the interval between one and three years after the takeover takes place. The year in which the takeover takes place is excluded from the sample. All columns include a full set of three digit industry dummies interacted with time trends and as additional controls: age, region dummies, a multi-establishment group dummy and an IT survey dummy. “Test USA*ln(C)=MNE*ln(C)” is test of whether the coefficient on USA*ln(C) is significantly different from the coefficient on MNE*ln(C) , etc.

Table 6 - IT and Labour Market Regulation

	(1)	(2)	(3)	(4)	(5)	(6)
Fixed Effects	NO	NO	NO	YES	YES	YES
Sample	All MNE's	All MNE's	All MNE's	All MNE's	All MNE's	All MNE's
Dependent Variable	ln(Q)	ln(Q)	ln(Q)	ln(Q)	ln(Q)	ln(Q)
USA*ln(C) USA ownership*IT capital	-	0.0230*** (0.0081)	-	0.0287* (0.0161)	-	0.0161 (0.0154)
USA USA Ownership		-0.1186*** (0.0453)	-	-0.1483 (0.0988)	-	-0.1600 (0.1058)
Labor Regulation*ln(C) World Bank Labor Regulation Index*IT capital	-	-	0.0439** (0.0193)	-	0.0702** (0.0358)	0.0295 (0.0332)
Labor Regulation World Bank Labor Regulation Index	0.0968** (0.0434)	-	-0.1410 (0.0998)	-	-0.3651 (0.2700)	-0.0666 (0.2451)
Ln(C) IT capital	0.0488*** (0.0056)	0.0439*** (0.0055)	0.0134 (0.0158)	0.0152** (0.0073)	-0.0339 (0.0270)	-0.0041 (0.0254)
Ln(M) Materials	0.6347*** (0.0147)	0.6354*** (0.0147)	0.6352*** (0.0147)	0.5353*** (0.0340)	0.5375*** (0.0351)	0.5063*** (0.0296)
Ln(K) Non-IT Capital	0.0995*** (0.0134)	0.0972*** (0.0134)	0.0987*** (0.0135)	0.0733* (0.0402)	0.0738* (0.0409)	0.0923** (0.0395)
Ln(L) Labor	0.2046*** (0.0140)	0.2062*** (0.0140)	0.2042*** (0.0140)	0.2529*** (0.0486)	0.2514*** (0.0485)	0.2457*** (0.0396)
Observations	3144	3144	3144	3144	3144	3144

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all columns is the log of gross output. The time period is 1995-2003. The estimation method in all columns is OLS. The sample includes only multinationals. Columns (4), (5) and (6) include establishment level fixed effects. The labor regulation index is based on the "Rigidity of Employment" index, drawn from the World Bank "Doing Business" report. The index is transformed so that higher values imply more flexible systems. The transformation applied is y = (1-x) (so 0=inflexible, 1=most flexible). All columns include a full set of three digit industry dummies interacted with a full set of time dummies and as additional controls: dummies for establishment age (interacted with a manufacturing dummy), region, multi-establishment group (interacted with ownership type) and IT survey. Standard errors in brackets under coefficients in all columns are clustered by establishment (i.e. robust to heteroskedasticity and autocorrelation of unknown form). The sample is IT using intensive sectors only. See Appendix A1 for definition of IT using intensive sectors.

Appendix: Data and Additional Results

A1 ESTABLISHMENT DATASET: THE ANNUAL BUSINESS INQUIRY

The Annual Business Inquiry (ABI) is the major source of establishment level data in the UK. It underlies the construction of aggregate output and investment in the national accounts and is conducted by the Office of National Statistics (ONS) the UK equivalent of the US Census Bureau. The ABI is similar in structure and content to the US Longitudinal Research Database except that it covers non-manufacturing as well as manufacturing. The recently constructed US Longitudinal Business Database covers non-manufacturing but it does not have output or investment – items that are necessary to estimate production functions.

The ABI is a stratified random sample: sampling probabilities are higher for large establishments (e.g. 100% for all establishments with more than 250 employees). Each establishment has a unique "reporting unit reference number" (RUREF) which does not change when an establishment is taken over by a new firm. Data on the production sector (including manufacturing) is in the ABI which has a long time series element (from 1980 and before in some cases). Data on the non-production sector (services) is available for a much shorter time period (from 1997 onwards). The sample is large: in 1998 there are 28,765 plants in the production sector alone.

The questionnaire sent out on the ABI is extensive and covers all the variables needed to estimate basic production functions. The response rates to the ABI are high because it is illegal not to return the forms to the Office of National Statistics. The ABI includes data on gross output, value added, employment, the wage bill, investment and "total materials" (this includes all intermediate inputs – energy, materials, etc.). Value added is constructed as the sum of turnover, variation of total stocks, work of capital nature by own staff, insurance claims received minus purchases. The construction of the IT and non-IT capital stocks are described in the next section. We condition on a sample that has positive values of all the factor inputs, so we drop establishments that have zero IT capital stocks.

A2 INFORMATION TECHNOLOGY DATASETS

Working closely with statisticians and data collectors at ONS we combined five major IT surveys and matched this into the ABI establishment data using the common establishment code (RUREF). The main IT surveys include the Business Survey into Capitalized Items (BSCI), the Quarterly Inquiry into Capital Expenditure (QICE) and the Fixed Asset Register (FAR). We used information on hardware from the BSCI, QICE and FAR in the main part of the paper, one survey of computer use by workers (the E-Commerce Survey) and one software survey (ABI supplement). Of these, only the software survey was designed to cover exactly the same establishments as contained in the ABI survey, but because there is over-sampling of the larger establishments in all surveys the overlap is substantial, especially for the larger establishments. These surveys are compiled at the reporting unit level, and contain information on the value (in thousands of pounds) of software and hardware acquisitions and disposals. Once the stocks are built within each different survey, we combine them across surveys and, for hardware and software separately, we build across-surveys stocks.[1] In the following paragraphs we first describe the different surveys; we then illustrate the details of the Perpetual Inventory Method used for the construction of the capital stocks and the procedure followed to build across-surveys variables.

<u>*A2.1 Data Sources*</u>

Business Survey into Capitalized Items (BSCI). The BSCI asks for detail of acquisitions and disposals of capital in more than 100 categories, including computer hardware and software. The survey is annual and runs between 1998 and 2003; we dropped the 1998 cross section due to concerns over reliability expressed by the data collectors. There is a 100% sampling frame for businesses with more than 750 employees and a stratified random sample of businesses with between 100 and 750 workers. The BSCI contributes about 1,500 to 2,000 observations for each year between 1999 and 2003. We use the SIC92 code 30020 defined as "Computers and other information processing equipment". Notes to this category

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[1] We are careful to check for differences in coefficients due to the IT measures coming from different surveys. We could not reject the assumption that there were no significant differences in the IT coefficients arising from the fact that the IT stocks were built from different surveys.

specify "Microcomputers, printers, terminals, optical and magnetic readers (including operating systems and software bundled with microcomputer purchase)."

Quarterly Inquiry into Capital Expenditure (QICE). The QICE provides information on hardware and software investments from 2000Q1 until 2003Q4. The inquiry selects 32,000 establishments each quarter. Of these 32,000 companies, all establishments with over 300 employees are selected each quarter. Businesses with fewer employees are selected for the inquiry randomly. Each quarter one fifth of the random sample is rotated out of the sample and a new fifth is rotated in. The quarterly data have been annualized in several alternative ways and we checked the robustness of the results across these methods. First, we extrapolated within year for establishments with missing quarters[2]. As a second alternative, we constructed an indicator that gives the number of non-missing values that exist for each year and establishment and included this as an additional control in the regressions. Third, we dropped observations constructed from less than four full quarters. The results were robust across all three methods and the tables report results based on the first method.

Fixed Asset Register (FAR). The FAR asks for the historic cost (gross book value) of the fixed assets held on the firms' asset register, broken down by the years of acquisition. The survey provides information on IT hardware assets only, and covers the years 1995 up to 2000. The survey provides information for about 1,000 hardware observations.

E-Commerce Survey. The E-Commerce Survey was conducted in 2001, 2002 and 2003 with around 2,500 establishments in each cross section. Unfortunately these were random cross-sections so the overlap between years is minimal (preventing us from performing serious panel data analysis). Plant managers were directly asked "What proportion of your employees uses a computer, workstation or terminal". To construct an estimate of the number of employees using IT we multiplied this proportion by the number of workers in the establishment. Although this is conceptually much cruder than the IT capital stock, it has the advantage that we do not have to rely so much on assumptions concerning the initial conditions. In Table 4 we discuss the results from this measure, showing very similar results to those obtained from using the IT capital measure.

Software questions in the Annual Business Inquiry (ABI). The ABI contains a question on software expenditures from 2000 onwards. There are approximately 20,000 non-zero returned values for software investments in each year. We had some concerns about the accuracy of the establishment reports of software expenditure[3] so we focus in the main part of the paper on the IT hardware stocks.

A2.2 Estimation of IT capital stocks

We build stocks of IT capital applying the Perpetual Inventory Method (PIM) to the IT investment data (and the non-IT investment data) described above. The basic PIM equation is $K_{it}=I^h_{it}+(1-d^h)K_{it-1}$, where I^h_{it} represents real investment of asset type h (e.g. computer hardware, I^c) and d is the asset specific depreciation rate. To construct real investment we deflate nominal investments using the economy-wide (asset specific) hedonic price indices for software and hardware provided by the National Institute of Economic and Social Research (which are based on Jorgenson's US price deflators). We rebased to the year 2000 for consistency with the other PPI deflators (see below).

Zeros

Both the BSCI and the QICE code missing values as zeros. While in the BSCI we are able to identify actual zero investments through a specific coding, for the QICE this is not possible. In the construction of the capital stocks we treated the zero investments observations as actual absence of IT investments. In the regressions we drop observations with zero IT capital stocks

Interpolations

In order to maximize the number of observations over which we could apply the PIM, we interpolated net investment observations for a single year of data if we observed investment the year before and the

[2] The extrapolation was done by simple averaging, but we also tried more sophisticated quarterly models taking into account the quarter surveyed. This made practically no difference.

[3] For example, many software values are imputed and the coding for the imputation does not make it clear how the imputation took place and for which establishments.

year afterwards. This affected only 2.8% of the observations in the regression sample and results are robust to dropping these observations.

Initial Conditions

In order to apply the PIM methodology, we need to approximate a starting value to start the recursion. We apply a similar methodology as the one devised by Martin (2005) to construct establishment level capital stocks in the ARD. For each firm, we first build two digit industry-specific IT Investment/ Capital ratios using the NISEC02 industry level data-set provided by the National Institute of Economic and Social Research, which contains separate time-series data on IT capital stocks and runs up to 2001 (these are based on the input-output tables starting in 1975). We then use the ratio of the establishment's IT investment flow to the industry investment flow to impute the IT capital stock (i.e. we are assuming that the establishment's share of the IT capital stock in the industry is equal to the establishment's share of IT investment in the industry in the initial year). More precisely, we assume that for $t = 0$ only the initial establishment level IT capital stock C_{io} is $C_{io}=(I_{it}/I_{jt})\ C_{jt}$ where j represents an industry so a j sub-script represents an industry total – i.e. I_{jt} is total industry IT investment and C_{jt} is the total IT capital stock in time t. We apply this approximation to determine our initial condition in the first year that the establishment appears in our sample. For greenfield sites this is not an issue as their capital stock is zero. After the first year, we simply apply the Perpetual Inventory Method.

Some of the establishments that we observe only for the first time may be investing systematically at a different rate from the industry average. To check whether our results were driven by the methodology used to build the initial conditions, we considered an alternative methodology based on employment weights to calculate the starting value, $C_{io}=(L_{it-1}/L_{jt-1})\ C_{jt-1}\ (1\text{-d})+\ I^{C}_{jt}$. So this is assuming that the establishment's share of the industry IT stock in the initial period is equal to the establishment's lagged share of employment.

Depreciation

For all IT capital we chose a depreciation rate of 36%. This choice is consistent with the analysis by methodology followed by the BEA which, in turn, derives from the study by Doms, Dunn, Oliner and Sichel (2004). In this study, the depreciation rate for PCs is estimated at approximately 50%, this value including both obsolescence and revaluation effects. Since – as the BEA - we use real IT investments we have to use a lower depreciation rate to avoid double counting of the revaluation effect, included in the price deflators. Basu et al (2003) argue that the true geometric rate of depreciation should be, in fact, approximately 30%. The significance and the magnitude of the coefficient obtained for IT capital is not affected by the exact choice of the alternative depreciation rate.

Across-Survey Stocks

Following the steps described above, we obtain hardware and software stocks within each different survey. We then matched our constructed IT dataset with the ABI sample. In order to simplify the empirical analysis, we combined all the information of the different the surveys constructing overall across-surveys IT stocks for both hardware and software. Our strategy is to use the BSCI measure as the most reliable observation (as recommended by the data collectors). We then build our synthetic measure using the QICE stocks if the BSCI observation is missing or equal to zero and the QICE is different from zero. We finally use the FAR if both QICE and BSCI are missing and/or equal to zero and the FAR is not.

In order to keep track of the possible measurement error introduced using this procedure, we introduce in all the IT regressions a dummy that identifies the provenience of the observation for both the hardware and the software stocks. These dummies and their interactions with the IT coefficients are not significantly different from zero. A small portion of the firms included in our dataset responded to more than one survey. We use some of this overlapping sample to get a better understanding of the measurement error in the data. By comparing the reports from the same establishments we calculate that there is much more measurement error for software than for hardware, which is one reason why we currently focus on hardware. We did not find any evidence that the measurement error for IT capital was different for US firms than other firms.

A3 DEFINITION OF I.T. INTENSIVE USING INDUSTRIES

We focus on "IT intensive" sectors that are defined to be those that use IT intensively and are not producers of information or communication technologies. The definitions of IT usage and IT producers are based on O'Mahony and Van Ark (2003) who base their definitions on Kevin Stiroh (2002). They use US data to calculate the capital service flows and define IT use intensity as the ratio of IT capital services to total capital services. IT intensive using sectors are those where (a) the industries has above median IT capital service flows to total capital service flows and (b) the industry is not an IT producing industry. All industries are based on ISIC Revision 3.

A4 CLEANING

We used standard procedures to clean the ABI and the IT data. First, we dropped all observations with negative value added and/or capital stock. Secondly we dropped the top and bottom percentile of the distribution of the growth of employment and gross value added. Thirdly, we dropped extreme values of total capital stock per employee and gross value added per employee. This step of the cleaning procedure was performed on the overall ABI sample. We applied a similar cleaning procedure also to our across surveys IT variables. We dropped the top and bottom percentiles of the ratio of the IT capital (and expenditure) relative to gross value added[4].

A5 DEFINITION OF FOREIGN OWNERSHIP AND UK MULTINATIONALS

The country of ownership of a foreign firm operating in the UK is provided in the ABI and is based on information from Dun and Bradstreet's Global "Who Owns Whom" database. Dun and Bradstreet define the nationality of an establishment by the country of residence of the global ultimate parent, i.e. the topmost company of a world-wide hierarchical relationship identified "bottom-to-top" using any company which owns more than 50% of the control (voting stock, ownership shares) of another business entity. UK Multinationals are identified via the matching of the ABI with the Annual Foreign Direct Investment (AFDI) register made by Criscuolo and Martin (2004). The AFDI identifies the population of UK firms which are engaging in or receiving foreign direct investment (FDI)[5]. Each establishment in the ABI that is owned by a firm which appears in the AFDI register can consequently be defined as a multinational. UK multinationals are thus UK-owned firms which appear in the AFDI.

A6 TAKEOVERS

The identification of takeovers consists of three basic steps. First, for all the available years (1980-2003 for manufacturing and 1997-2003 for services) we use all the raw ABI data (including "non-selected" establishments where we know employment but not output or capital). We thus create a register file that allows us to keep track of the whole history of each firm, and exploit the uniqueness of the reporting unit reference number (RUREF) to correct for obvious reporting problems (i.e. establishments that disappear in one year, and appear again after some time). Second, for each establishment we keep track of changes in the foreign ownership information and the enterprise group reference number (this is a collection of RUREFs owned by a single group) to identify foreign and domestic takeovers[6]. Third, to control for measurement error in the takeover identification, we drop from the sample some ambiguous establishment observations: (a) establishments that are subject to more than three takeovers during their history; (b) for the establishments with two or three takeovers, we dropped observations where a time period could be simultaneously as "pre" and "post" takeover. We use up to three years prior to the takeovers in the "pre-takeover" regressions and up to three years after the takeover in the "post takeover" regressions. The year when the takeover occurred is dropped because it is unclear when in the year the establishment switched.

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[4] The results of the regression are qualitatively similar if the IT data are cleaned using the ratio of investments per employee or stocks per employee.

[5] The working definition of Foreign Direct Investment for this purpose is that the investment must give the investing firm a significant amount of control over the recipient firm. The ONS considers this to be the case if the investment gives the investor a share of at least ten per cent of the recipient firm's capital.

[6] Foreign takeovers are observed if a firm experiences a change in the foreign ownership marker. Domestic takeovers are observed if a UK firm changes its enterprise reference number. See Griffith et al (2004) for more details on the methodology.

A7 DESCRIPTIVE STATISTICS

Panel A of Table A2 gives some descriptive statistics for our key variables. Note that median employment in the establishment is 238 which are larger than the ABI median because the IT surveys tend to focus on the larger establishments. Average IT stock is just over £1m ($2m) and value added per worker is just under £40,000 ($80,000). Labor accounts for 31% of revenues and materials 58% on average. IT capital is estimated at 1% of revenues (non-IT capital is 10%).

Panel B of Table A3 breaks down mean values of the IT capital - output ratio and ln(IT capital) by ownership type and whether or not the sector is IT intensive. Unsurprisingly, across all establishments the IT capital-output ratio is much higher in the IT intensive industries compared to other sectors (3% compared to 2%). More interestingly, US multinationals have a higher IT capital-output ratio than non-US multinationals only in the IT intensive sectors (4% compared to 3%). In the other sectors US and non-US multinationals have a similar IT-output ratio (3% in each). The levels of IT capital show much higher values for US establishments than non-US multinationals (especially in the IT intensive sectors).

A8 ADDITIONAL RESULTS

Table A3 contains alternative econometric estimates of the production function allowing for endogenous factor inputs. First, in column (1) we present results using the Blundell- Bond (1998) system GMM estimator. We have to restrict the sample to firms where we have at least four continuous years of information on all variables which, given our short time series and sampling frame, severely reduces the sample size (this is also the reason why we use all sectors, not just the IT intensive sectors). Even on this sub-sample we are still able to identify a significant interaction effect between IT capital and the US dummy variable. The coefficient on IT for US firms is significantly different from the IT coefficient on non-US firms at the 10% level. The structural model of firm behaviour underlying the Olley-Pakes (1996) approach is not consistent with simply including interactions, so instead we estimate the production function separately for the three ownership types separately: US multinationals in column (2), non-US multinationals in column (3) and UK domestic firms in column (4). The IT coefficient is twice as large for US multinationals as it is for non-US multinationals, which is consistent with our earlier findings. The standard errors are also large, however, due to the smaller sample size, so we are not able to reject the null that the coefficients are the same.

Table A4 estimates takeover regressions as a function of lagged covariates. The sample is of those establishments who were at some point taken over by another firm. In columns (1) and (2) the dependent variable is equal to one if the establishment was taken over by a US multinational and zero otherwise (i.e. if it was taken over by a non-US multi-national or a domestic UK firm). In columns (3) and (4) we drop the takeovers by UK domestic firms so that the dependent variable is equal to one if the establishment was taken over by a US multinational and zero otherwise (i.e. if it was taken over by a non-US multinational). Columns (1) and (3) examine whether more IT intensive establishments were more likely to be taken over by a US multinational. Columns (2) and (4) examine whether establishments which were growing more IT intensive were more likely to be taken over by a US multinational. There seems to be no significant correlation between lagged IT levels or growth and the probability of being taken over by a US firm.

Table A1 - Breakdown of the Industrial Sectors by IT Usage

IT Intensive Sectors

Manufacturing	*Services*
18 Wearing apparel, dressing and dying of fur	51 Wholesale trades
22 Printing and publishing	52 Retail trade
29 Machinery and equipment	71 Renting of machinery and equipment
31 Manufacture of Electrical Machinery and Apparatus n.e.c. excludes 313 (insulated wire)	73 Research and development
33 Precision and optical instruments, excluding 331 (scientific instruments)	
351 Building and repairing of ships and boats	
353 Aircraft and spacecraft	
352+359 Railroad equipment and transport equipment	
36-37 miscellaneous manufacturing and recycling	

Other Sectors

Manufacturing	*IT producing sector?*	*Services*	*IT producing sector?*
15-16 Food drink and tobacco	No	50 Sale, maintenance and repair of motor vehicles	No
17 Textiles	No	55 Hotels and catering	No
19 Leather and footwear	No	60 Inland transport	No
20 Wood	No	61 Water transport	No
21 Pulp and paper	No	62 Air transport	No
23 Mineral oil refining, coke and nuclear	No	63 Supporting transport services, travel agencies	No
24 Chemicals	No	64 Communications	Yes
25 Rubber and plastics	No	70 Real estate	No
26 Non-metallic mineral products	No	72 Computer services and related activity	Yes
27 Basic metals	No	741-743 Professional business services	No
28 Fabricated metal products	No	749 Other business activities n.e.c.	No
30 Office machinery	Yes		
313 Insulated wire	Yes	***Other sectors***	
321 Electronic valves and tubes	Yes	10-14 Mining and quarrying	No
322 Telecom equipment	Yes	50-41 Utilities	No
323 Radio and TV receivers	Yes	45 Construction	No
331 Scientific instruments	Yes		
34 Motor vehicles			

Notes: See text for definitions. IT intensive sectors are those that have above median IT capital flows as a proportion of total capital flows and are not IT producing sectors.

Table A2 - Descriptive Statistics

Panel A: All Establishments

Variable	Frequency	Mean	Median	Standard Deviation
Employment	7121	811.10	238.00	4052.77
Gross Output	7121	87966.38	20916.48	456896.10
Value Added	7121	29787.61	7052.00	167798.70
IT Capital	7121	1030.60	77.44	10820.69
ln(IT Capital)	7121	4.46	4.35	2.03
Value Added per worker	7121	40.43	29.53	55.19
Gross Output per worker	7121	124.74	86.03	136.55
Materials per worker	7121	82.38	47.23	103.52
Non-IT Capital per worker	7121	85.28	48.56	112.54
IT Capital per worker	7121	0.96	0.34	2.08
IT expenditure per worker	7121	0.41	0.14	0.89
Material costs as a share of revenues	7121	0.57	0.60	0.23
Employment costs as a share of revenues	7121	0.83	0.64	0.86
Non-IT Capital as a share of revenues	7121	0.30	0.26	0.20
IT Capital as a share of revenues	7121	0.010	0.004	0.018
Age	7121	8.38	5.00	6.74
Multigroup dummy (i.e. is establishment part of larger group?)	7121	0.53	1.00	0.50

Panel B: Breakdown by Ownership Status and Sector

		IT Capital over gross output (C/Q)			Ln(IT Capital)		
		All sectors	IT Using Intensive Sectors	Other Sectors	All sectors	IT Using Intensive Sectors	Other Sectors
All firms	Mean	0.03	0.03	0.02	4.46	4.78	4.27
	St. Deviation	0.04	0.04	0.04	2.03	2.06	1.99
	Observations	7121	2703	4418	7121	2703	4418
US Multinationals	Mean	0.04	0.04	0.03	5.57	5.69	5.46
	St. Deviation	0.05	0.05	0.04	2.00	1.94	2.05
	Observations	569	260	309	569	260	309
Other Multinationals	Mean	0.03	0.03	0.03	5.18	5.34	5.07
	St. Deviation	0.04	0.04	0.04	1.96	1.99	1.93
	Observations	2119	853	1266	2119	853	1266
UK domestic	Mean	0.02	0.03	0.02	3.98	4.33	3.79
	St. Deviation	0.04	0.04	0.03	1.91	1.99	1.83
	Observations	4433	1590	2843	4433	1590	2843

Notes: All monetary amounts are in sterling in year 2001 prices. Total stocks are constructed as described in the Appendix. All variables in units of 1,000s except ratios and employment.

Table A3 - Olley Pakes and GMM results

	(1)	(2)	(3)	(4)
Sample	All establishments	US multinationals	Other multinationals	Domestic UK establishments
Estimation Method	GMM	Olley Pakes	Olley Pakes	Olley Pakes
Sectors	All sectors	IT Using Intensive Sectors	IT Using Intensive Sectors	IT Using Intensive Sectors
Dependent Variable	Ln(Q)	ln(Q)	ln(Q)	ln(Q)
USA*ln(C) USA ownership*IT capital	0.1176* (0.0642)	-	-	-
MNE*ln(C) Non-US multinational *IT capital	0.0092 (0.0418)	-	-	-
Ln(C) IT capital	0.0793*** (0.0382)	0.0758** (0.0383)	0.0343** (0.0171)	0.0468*** (0.0116)
Ln(M) Materials	0.4641*** (0.0560)	0.5874*** (0.0312)	0.6514*** (0.0187)	0.6293*** (0.0267)
Ln(K) Non-IT Capital	0.2052*** (0.0532)	0.0713 (0.0674)	0.1017*** (0.0285)	0.1110*** (0.0270)
Ln(L) Labor	0.2264*** (0.0728)	0.1843*** (0.0337)	0.2046*** (0.0139)	0.2145*** (0.0173)
Observations	1074	615	2022	3692
First order serial correlation, p value	0.0100	-	-	-
Second order serial correlation, p value	0.3480			
Sargan-Hansen, p-value	0.4570	-	-	-

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all columns is the log of gross output. The time period is 1995-2003. All variables are expressed in deviations from the year-specific three digit industry mean. Column (1) is estimated using System-GMM (Blundell and Bond, 1998). One step GMM results reported. In column (1) instruments are all establishment level factor inputs lagged t-2 and before (when available) in the differenced equation (i.e. m_{t-2}, l_{t-2} ,k_{t-2},c_{t-2}, q_{t-2}, USA_{t-2}, MNE_{t-2}, $(USA*c)_{t-2}$, $(MNE*c)_{t-2}$,q_{t-2},) and lagged differences in the levels equation (Δm_{t-1}, Δl_{t-1} , Δk_{t-1}, Δc_{t-1}, ΔUSA_{t-1}, ΔMNE_{t-1}, $\Delta(USA*c)_{t-1}$, $\Delta(MNE*c)_{t-1}$,). Serial correlation tests are LM tests of the first differenced residuals (see Arellano and Bond, 1991). Sargan-Hansen Test of instrument validity is a test of the over-identification. "Test USA*ln(C)=MNE*ln(C)" is test of whether the coefficient on USA*ln(C) is significantly different from the coefficient on MNE*ln(C), etc. Columns (2)-(4) are estimated using Olley Pakes (1996). We use a fourth order series expansion to approximate the phi function. Standard errors in Olley-Pakes are bootstrapped (clustered at the establishment level) with 200 replications. All columns include age, region dummies and a dummy taking value one if the establishment belongs to a multi-firm enterprise group as additional controls.

Table A4 - Non Random Selection of UK Takeovers Compared to Other Takeovers?

	(1)	(2)	(3)	(4)
Dependent Variable = 1 if establishment taken over by US firm, = 0 for all other takeovers	**US Takeover=1**	**US Takeover=1**	**US Takeover=1**	**US Takeover=1**
Sample	**All takeovers**	**All takeovers**	**All except domestic takeovers**	**All except domestic takeovers**
$\ln(C/L)_{t-1}$	0.0029 (0.0095)	-	-0.0003 (0.0365)	-
$\Delta\ln(C)_{t-1}$	-	-0.0236 (0.0246)	-	-0.0876 (0.0714)
$\ln(L)_{t-1}$	0.0140 (0.0106)	0.0108 (0.0111)	-0.0183 (0.0377)	-0.0222 (0.0379)
$\ln(K/L)_{t-1}$	0.0108 (0.0209)	0.0109 (0.0204)	-0.0174 (0.0645)	-0.0346 (0.0650)
$\ln(Q/L)_{t-1}$	0.0236 (0.0269)	0.0270 (0.0263)	0.0333 (0.0860)	0.0580 (0.0843)
Age	-0.0014 (0.0038)	-0.0017 (0.0039)	-0.0003 (0.0085)	-0.0014 (0.0087)
Observations	563	563	190	190

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all columns is a dummy taking value 1 if the establishment is taken over by a US Multinational and zero otherwise. Takeovers by UK firms ("domestics") are excluded in columns (3)-(4). The time period is 1995-2003. All columns include two digit industry dummies, region and year dummies. The estimation method in all columns is by a linear probability model. Standard errors in brackets under coefficients are robust to heteroskedasticity.

Chapter III: The Effects of Big-Box Entry on Mom and Pop Stores

I. Introduction

"Big-boxes" - large stores located in the periphery of cities - are a major feature of the modern retail sector. They are associated with significant improvements in the efficiency of the retail industry[1], and have channelled the expansion of global retail chains such as Wal-Mart. However, their effect on local communities is controversial. While consumers may benefit from lower prices, greater convenience and product variety offered by big-boxes[2], "mom and pops" retailers – small stand-alone retail firms, typically located in central areas - are believed to suffer from their competition.

Since mom and pops stores are perceived to contribute to the vitality of town centres and to provide valuable local shopping facilities, several OECD countries have attempted to protect them introducing tight entry regulations against big-boxes[3]. These policies have recently been criticised for their possible implications on the productivity

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[1] The role of store size for the productivity of retail firms is analysed in Oi (1993), Basker et al (2007), Holmes (2002) and Ellickson (2007). Holmes (2006) discusses the complementary relationship between store size, Information Technologies (IT) and in-house distribution systems. Haskel and Sadun (2007) find a significant and positive association between store size and chain productivity using UK Census data.

[2] Ellickson (2007) describes the explosion in product variety associated with the emergence of large stores in the U.S., which grew from 14,145 in 1980 to 21,949 in 1994 to over 30,000 by 2004. Basker (2007) discusses the price effects generated by the entry of Wal-Mart stores across U.S. cities.

[3] See Pilat (1997) for a concise description of entry regulations across OECD countries.

and the competitiveness of the industry, since the retail activity is characterised by significant economies of scale[4].

Perhaps surprisingly, the literature has never analysed a more fundamental question i.e., whether restricting the entry of big-boxes does effectively shield mom and pop stores from the competition of retail chains. In this chapter, we argue that blocking the entry of big-boxes may paradoxically *harm* mom and pop stores. Key to the story is the fact that big-boxes are typically opened by large retail chains, which are able to choose between different store sizes and locations. Therefore, chains may react to the introduction of entry constraints on big-boxes changing the characteristics of their new stores, rather than by simply reducing their overall openings. In this setting, the counterfactual to big-box entry is not a market with no entrants, but with *different* entrants. In the specific case where chains decide to open small and central stores instead of big-boxes, entry regulations may increase the competitive pressures faced by mom and pop stores and accelerate their decline and exit.

These mechanisms are investigated in the framework of the UK retail sector, where in 1996, after the *laissez-faire* approach of the Thatcher era, a planning reform introduced new restrictions on the opening of stores above 2,500 square meters. The appearance of the new regulations reduced dramatically big-box entry. More interestingly, the reforms also induced a change in the size and location of stores opened by retail chains, which began to shift their activity towards smaller stores in central areas. Both phenomena are illustrated in Figure 1a (ODPM, 2004), which shows that after 1996 the number of out-of-town stores openings fell considerably, while the number of central and smaller food stores increased, after a period of relative stability in the early 1990s. The aggregate data also shows that the intensification of chain stores in central areas is associated with a decline of mom and pop stores. The employment growth of stand-alone retailers - i.e. retail firms consisting of a single

[4] Nicoletti and Scarpetta (2003) and Van Ark et al. (2002) discuss the negative effects of retail entry regulations across Europe and OECD countries. The implications of entry regulations for the UK retail sector are discussed in McKinsey (1998) and Blanchard (2003). Haskel et al (2007), use comparable Census data to analyse the structure of the retail industry across the UK, Japan and the US. They show that more regulated environments are associated with smaller retail outlets and lower productivity.

retail establishment - fell from an annual average of -1% between 1989 and 1996 to -3% between 1998 and 2004, after the new regulatory constraints were introduced (Figure 1b).

The planning reforms delegated to local government bodies (Local Authorities) the concession of planning grants, which were essential prerequisites for the construction of big-boxes. Local Authorities were encouraged to follow the general guidelines which constrained the entry of big-boxes, but could make their planning decisions in a regime of almost complete independence from the central government. Therefore, the restrictiveness of the new entry regulations effectively varied within and across Local Authorities. We exploit this setting to examine the effects of planning grants on independent retailers across and within Local Authorities.

The analysis is based on a novel dataset, which combines information on the population of retail stores with an exhaustive list of the planning decisions made by 302 English Local Authorities, observed between 1998 and 2004. We rely on an instrumental variable approach to isolate the variation in planning grants determined by entry regulation, from that determined by local demand conditions. The instruments exploit the fact that the concession of planning grants was effectively managed by locally elected politicians. Empirically, we use the political composition of the planning boards to predict the the restrictiveness of entry regulation at the local level. In particular, we document that planning grants decrease with increases in the share of Conservative councillors in the Local Authority, even controlling for the time varying socioeconomic characteristics of the electorate, and looking both across and within planning boards over time. This is consistent with the considerable political weight of middle-class homeowners and small retailers in the Conservative party.

In line with the aggregated stylized facts, we show that in Local Authorities where *more* big-boxes were allowed to enter, mom and pops stores experienced *higher* rates of employment growth. These results hold both with OLS and when using changes in local political composition as an instrument to deal with the endogeneity of big-box entry. We decompose the effects of planning grants across the different margins of adjustments (entry, exit and incumbents), and show that the reduction in the exit margin drives most of the positive grants' effect. According to the estimates, the sharp decline in big-box entry - which followed the 1996 reform - accounts for about 8% of the decline experienced by independent retailers between 1998 and 2004.

The strategy used to identify the causal effects of the planning grants follows Bertrand and Kramarz (2002), who studied the role of entry regulations in the French retail sector. The main difference with this paper and Bertrand and Kramarz is that, while they look at the implications of entry regulations for total retail employment, we focus on the relationship between the regulation of big-box entry and mom and pop stores. By doing this, we address explicitly the concerns over the effects of big-boxes on independent retailers, which is one of the key motivations behind the existence of the regulatory constraints. Moreover, by breaking down the regulatory impact along the different margins of adjustment, we characterise more precisely the mechanisms through which entry regulations have an effect of retail jobs.

The broad theme of the paper is related to the growing literature looking at the competitive effects of Wal-Mart and K-Mart stores on local competitors across U.S. counties, such as Basker (2002), Neumark et al. (2005) and Jia (2006)[5]. In the U.S., entry regulations are often advocated as a tool to protect traditional mom and pops retailers from the competitive effects of big-boxes[6]. In this paper we show that entry regulations may actually fail to safeguard the survival of small retailers, when retail chains can choose among alternative store investments.

The paper is also related to the growing literature on the investment decisions of large retail chains. Holmes (2006) looks at the location decision of Wal-Mart across

[5] Basker (2005) finds that Wal-Mart is associated with an overall positive effect on retail employment immediately after entry (+100 jobs), which is halved after five years, when some small and medium retail establishments close. However, using a different IV approach and Wal-Mart entry data, Neumark et al. (2005) find a negative effect (-2% to -4%) on total retail employment and on payrolls per worker (-3.5%). Jia (2006) looks at the effect of Wal-Mart and Kmart entry on small discount retailers using a fully structural approach. She finds that Wal-Mart expansion from the late 1980s to the late 1990s explains about fifty to seventy percent of the net negative change in the number of small discount retailers.

[6] http://walmartwatch.com/battlemart/go/cat/zoning_regulations

the US, and rationalizes the gradual diffusion from the Bentonville, Arkansas (the location of Wal-Mart's company headquarters) in light of significant economies of densities at the firm level. Beresteanu and Ellickson (2006), Aguirregabiria and Vicentini (2006) and Aguirregabiria, Mira and Roman (2007) provide formal treatments of the investment decisions of oligopolistic, multi-store retail firms. However, none of these papers model explicitly the within –chain choice between large and small retail outlets.

Finally, Smith (2006) combines a random households survey with a dataset of store characteristics to analyse the consequences of the regulations introduced in the UK retail sector on consumer and producer welfare. He concludes that the regulations of 1993 imposed suboptimal store characteristics on both consumers and firms, forcing them to focus on small instead of middle-sized stores. With respect to Smith, in this paper we add that the entry regulations were also responsible for the acceleration in the decline of small retailers.

The remainder of the paper is organized as follows. Section II describes the basic features of the English planning regime and the 1996 reform. Section III focuses on the econometric modelling. Section IV introduces the instrumentation strategy. Section V presents the results and Section VI concludes.

II. Entry Regulation in the UK

In the UK, new developments need to comply with environmental and urban design considerations, which are described in general planning guidelines. While the broad characteristics of the planning regime have remained fairly constant, the attitude *vis-à-vis* big-box stores significantly changed over time. Until the late 1980s, the liberalising (and, to some extent, centralising) efforts of Mrs Thatcher's government were characterised by a *laissez faire* approach towards large retail stores, which coincided with a strong wave of retail decentralisation, and a significant increase in big-box openings. Planning policies registered a drastic change from the early 1990's onwards[7], driven by the concern that big box were draining activities away from town centers. In order to "sustain and enhance the vitality and viability of town centers", new entry regulations were introduced in 1993 and, more significantly, in 1996.

The first important aspect of the reforms is that they introduced specific criteria of admissibility for retail developments over 2,500 square meters, especially if located outside town centers. These were the "sequential test" (1993), i.e. proof that the proposed out of town developments could not be created in alternative in-town or edge- of-town locations and the "test of need" (introduced in 1996 and reinforced in 1999), to prove that new retail developments are "needed" in the area.

The second, key innovation introduced by the reforms is that they considerably increased the discretionary power of Local Authorities[8] in the implementation of the planning guidelines. With the new planning regime, Local Authorities became directly responsible for the interpretation of the planning guidelines and, most importantly, for the selection of the large stores that could enter the area under their jurisdiction. This implied that number of applications granted by Local Authorities became a function of both local demand conditions, which generated the number of potential entrants in the market, *and* the activity of locally elected politicians[9], which determined the extent to which central entry regulations were binding in the Local Authority and, therefore, the selection of the actual entrants.

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[7] The UK Competition Commission (2000) notes that "the policy has significantly evolved from a position in which out-of-centre development was acceptable to one in which it should be seen as a last resort".

[8] Local Authorities represent the lowest level of local government in the UK. Their boundaries coincide with well-defined socio-geographic entities (a town, or a city and its surroundings), with the major exception of London, which is subdivided into 32 Boroughs. In some areas there is a county council responsible for some services within a county, with several district councils responsible for other services, including planning. The units analyzed in this paper are district councils. There is a total of 434 Local Authorities across the UK, of which 354 only in England.

[9] The Barker review (2006) reports that, on average, 96% of retail applications for stores above 1,000 square meters between 2005 and 2006 were decided by elected politicians.

Overall, the reforms introduced significant monetary and non-monetary costs in the application process[10]. Perhaps unsurprisingly, the new entry regulations reduced the number of big-box openings. This is illustrated in Figure 2a, where we plot the number of grants for large retail stores over time. We can see that planning grants - which we consider to be a consistent proxy of big-box entry - fall dramatically in the period 1996-2003, compared to the period 1993-1995.

However, the fall in big-boxes did not coincide with a reduction in the total number of new stores, but simply with a change in their size and location. In particular, the reform induced the major retail chains to move away from large retail outlets and to open small stores in central areas. Griffith and Harmgart (2005) show that, since the late 1990s, the top four UK retail chains substantially increased the number of small convenience stores opened in central locations relative to investments in large stores located in peripheral areas. Figure 2b (taken from Haskel and Sadun, 2007) plots the size distribution of stores belonging to national UK chains in the periods 1997/98 and 2002/2003 to study the store distribution of retail chains over time. The histograms show that, over the relatively short time period of four years, the median size of a store belonging to a large supermarket chain fell from 75 to 56 employees.

We look in closer detail at the evolution of planning grants using the applications database maintained by the Office of the Deputy Prime Minister (ODPM) - the institution in charge of overseeing planning matters in England, which keeps a record of all applications received and planning grants made by the English Local Authorities. We had access to the list of all retail applications processed between 1993

[10] The Barker review (2006) reports that applications for large retail stores cost an average of £70,000. In a recent inquiry conducted on the UK Grocery market, the Competition Commission (2000) reports an average cost of £50,000. The CC also reports that application delays for the major supermarkets could vary from a minimum of 4 months to a maximum of 24 months.

and 2003, classified by type of development (major of minor applications), relevant Local Authority, and year[11].

The focus is on grants for stores above 1,000 square meters – major application in the planning jargon – a category which includes big-boxes[12]. Overall, planning grants for big-boxes are a fairly rare phenomenon. On average, a Local Authority approves only 2.5 large stores openings per year (or 0.022 applications per '000 people) and 22% of the sample is represented by Local Authorities that have granted zero applications in a given year. These figures, however, hide a lot of heterogeneity across Local Authorities. This is apparent from Figure 3, where we map all English Local Authorities according to the average number of major planning applications they granted between 1993 and 2003. Grants also vary within Local Authorities over time, and Local Authority fixed effects and time dummies explain only 48% of grants' variance.

We refer to Section IV for a closer analysis of the role of elected politicians in the planning process, while we explore the correlation between planning grants and basic demand variables in Table 1. Grants for big-boxes are more likely where the fraction or urban areas is higher, and in densely populated Local Authorities. Grants are also more likely in areas with a younger population, and with lower average incomes and a lower percentage of college graduates. This reflects the fact that large stores – which focus their activity on the convenience of their offer – tend to target

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[11] The ODPM data does not provide the exact location of the development within a Local Authority, or the brand name of the applicant. This lack of information constraints the empirical analysis to Local Authority aggregates, and requires the assumption that Local Authorities behave as fairly independent markets. Therefore, we exclude from the analysis Local Authorities for which the independence assumption is obviously inappropriate – such as the 32 small Local Authorities (Boroughs) representing London. Moreover, we exclude from the sample Local Authorities with a population of more than 400,000 people, whose complexity is not likely to be captured by the aggregated data. This corresponds to the exclusion of all Local Authorities in the 99[th] percentile of the distribution of population across Local Authorities. The Local Authorities of Birmingham, Bradford, Leeds, Liverpool, Manchester and Sheffield are dropped from the sample as a consequence of the selection.

[12] Tesco – the leading supermarket chain in the UK – classifies large and medium stores as follows: Hypermarkets, 64,000 (5946 square meters); Superstores, 31,000 square feet (2880 square meters); Metro, 11,800 square feet (1096 square meters). Small convenience stores (Express) are on average 2,100 square feet (195 square meters). www.tescocorporate.com/images/Tesco%20PLC%2030-mar-05.pdf.

price sensitive consumers. The correlation with local demand conditions suggests that simple OLS regression may provide a biased estimate of the effect of planning grants on independent retailers, and therefore the need to find a suitable identification strategy.

III. Econometric Modeling

The specification starts from a primitive model, where the employment of independent retailers is a function on the number of big-boxes active in the same Local Authority:

$$emp_{jt}=\theta\, bb_{jt}+\gamma X_{jt}+\beta_t+\varepsilon_{jt} \qquad \text{(III.1)}$$

where emp_{jt} is the natural logarithm of independent stores' employment in Local Authority j at time t; bb_{jt} is the number of big-boxes working in Local Authority j at time t; β_t are year fixed effects; X_{jt} is a vector of time-varying Local Authority characteristics; and ε_{jt} is an error term. We assume that ε_{jt} can be decomposed in a constant and a time-varying component, such that $\varepsilon_{jt}=\alpha_j+\mu_{jt}$. To control for the α_j - fixed factors that might affect the level of the retail employment aggregates in the Local Authorities - we estimate equation (III.1) using a first difference transformation., i.e.:

$$\Delta emp_{jt}=\theta\, \Delta bb_{jt}+\gamma \Delta X_{jt}+\Delta\beta_t+\Delta\varepsilon_{jt} \qquad \text{(III.2)}$$

Note that that, in each period, the change in the number of big-boxes working in a Local Authority can be expressed in net entry terms, i.e. $\Delta bb_{jt}=bb\_entry_{jt}-bb\_exit_{jt}$.. Under the reasonable assumption that big-boxes have negligible exit (i.e. $bb\_exit_{jt-1}\approx 0$), we can express the growth of independents' employment as a function of the number of big-boxes entering the Local Authority:

$$\Delta emp_{jt}=\theta\, bb\_entry_{jt}+\gamma \Delta X_{jt}+\Delta\beta_t+\Delta\mu_{jt} \qquad \text{(III.3)}$$

The opening of a big-box requires a planning grant (Section II). Moreover, since the planning process entails non-trivial (monetary and non-monetary) costs, planning grants are almost inevitably transformed into actual stores. Therefore, the number of big-boxes entering a Local Authority at time t will be closely related to the number of planning applications for large stores granted by the Local Planning Authority, some time before the actual construction and opening of the store. In other words, defining as s the amount of time that is needed to create a big-box from the moment the planning application has been granted, $bb\_entry_{jt}=grants_{jt-s}$. This leads to equation (III. 4), which represents the benchmark specification of this paper:

$$\Delta emp_{jt}=\theta\ grants_{jt-s}+\gamma\Delta X_{jt}+\Delta\beta_t+\Delta\mu_{jt} \qquad \text{(III.4)}$$

Since no further licenses are needed once the planning application is obtained, s essentially corresponds to a construction lag[13]. Although the precise delay will vary from case to case, official government reports and the assumptions made by retail developers suggest an average construction delay between one and two years[14].

Data on retail employment by store type and location is drawn from previously untapped data files of the UK Census (Interdepartmental Business Register, IDBR)[15]. This source provides information on the exact location and employment of the population of retail stores active in the UK, for each year between 1998 and 2004. We focus on stores classified under the industry code "Non-specialized retail" (SIC 521), a

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[13] Betrand and Kramarz (2002), using a similar methodology for the French retail sector, allow for a four year period lag between a granted application and an actual entry of a store. In their case the longer lag is justified by the need to obtain a licence to run the store after the planning application has been granted. We include robustness checks to verify the sensitivity of this timing assumption.

[14] ODPM (2004) and DTI (2004). Similar construction lags have been estimated by the specialist magazine "The Builder", which reports in a cost model date April 1993 and average construction lag of 40 weeks. http://www.building.co.uk/story.asp?sectioncode=113&storycode=1025793.

[15] This is a major difference with respect to Bertrand and Kramarz (2002), where retail region-time specific employment aggregates were drawn from the French Labour Force Survey. Using store level data is clearly needed in this context, since the focus is on specific type of retailers rather than broad employment aggregates.

sector which best describes the activity of big-boxes[16] and represents 60% of total retail employment in the UK.

In all regressions, we include year dummies to capture aggregate economic shocks that might affect independents' employment. Local Authorities have very little discretion in setting their own policy, with the notable exception of planning matters. For this reason, the year dummies should control for most of the other policy changes that might have occurred over the period under study such as, for example, minimum wage policies[17]. We also include regressors to control for demand differences across Local Authorities, such as their degree of urbanization, age and income profile. We test the robustness of the main results with respect to the inclusion of additional controls for time-varying socioeconomic characteristics of the Local Authorities (such as the industry composition, average skills and population growth).

Finally, all regressions are weighted by the share of English population in the Local Authority to ensure representativeness. Standard errors are clustered at the Local Authority level to control for heteroskedasticity autocorrelation patterns of unknown form (Bertrand et al, 2004). Table A.1 in the Appendix provides the basic summary statistics for the variables included in the sample.

IV. Using Local Political Power for Identification

A major problem in the estimation of equation (III.4) relates to the endogeneity of big-box entry. As discussed in Basker (2005) and Jia (2006), the very same unobserved time-varying factors that influence the growth of independent stores, are likely to play a significant role in determining the number of big-boxes opening in a market, and therefore the number of planning applications submitted to the relevant Local Authority.

[17] The minimum wage was introduced on a national basis in the UK in 1999. For more details see Draca, Machin and Van Reenen (2006).

As discussed in Section II, UK planning reforms delegated to locally elected councilors the implementation of the entry regulations. This generates a link between political power in the Local Authority and planning grants, which we exploit for the identification of the effects of planning grants. In doing this, we follow a methodology similar to Bertrand and Kramarz (2002). In the baseline IV regression, we use the shares of the political parties elected in the Local Authority to instrument for big-box entry. This is a valid IV strategy under the assumptions that a) the planning behavior of local politicians can be described by their party affiliation, and b) the changes in the political composition of the Local Authorities are exogenous to the $\Delta\mu_{jt}$ shocks affecting independents. We discuss the plausibility of these assumptions below.

IV.A. Right Wing Parties and Big-Box Entry

More than any other party in the UK, Conservatives have traditionally been associated with a strong opposition towards new retail developments, also defined as *Nimby*-ism (Not in My Backyard).[18] This opposition has been justified with concerns on the potential environmental impact of big-boxes[19]. However, this also clearly reflected the political weight of middle-class homeowners and small retailers in the Conservative party, which feared the competition of big-boxes, or their effect on the value of their properties [20].

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[18]This view is broadly confirmed by the results of a recent survey commissioned by the Saint Consulting (a private group focusing on planning issues). The survey shows that the majority of people opposing new developments in their local areas voted Conservative. Moreover, Conservative others tended to oppose convenience food stores and supermarkets more than any other party. http://www.saintconsulting.ca/

[19] Greed (2000) reports that the Nimby-istic attitude of Conservative politicians in the early 1990s reflected the need to capture the Green vote, since at the time 15% of voters were voting Green and this was seen as a serious threat to retaining a Conservative majority.

[20] For example, according to the British Election Study, in the 2001 general election small business owners (including retailers) were three times more likely to vote Conservative than any of the two other major party. Small business owners accounted for 5.85% of all Conservative votes, against the 1.84% of Labour and 1.91% of Liberal Democrat votes. The British Election Study follows the "Goldthorpe-Heath" classification, which provides a total of eleven different socio-economic cells. The cell "Small proprietors, with Employment" is the one including independent retailers and where the difference between the Conservatives and the other parties is starkest.

We analyse the relevance of the Conservative party for planning grants combining the ODPM applications database with the British Local Election Database[21] (BLED), which provides information at the candidate level on all local elections that have taken place in the UK between the late 19th century and 2003. For the purposes of this paper, the data has been aggregated at the Local Authority level, and the sample constrained to the period 1993-2003 and to the 302 English Local Authorities that are at the base of the results presented in the econometric section.

We look at the relationship between Conservative and retail planning grants in Table 2. In column 1 we show the correlation between number of retail applications granted by the Local Authority and a dummy for Conservatives absolute majorities in the council, controlling for year dummies. The correlation is indeed very strong, with a coefficient of 0.70, significant at the 1% level. Further analysis shows that even the *relative* majority dummy and the *share* of Conservative seats are associated with more restrictive planning outcomes (columns 2 and 3).[22]

A possible worry is that the negative correlation between grants and Conservatives could be driven by the unobserved demand characteristics of the Conservative electorate. Therefore, in column 4 we repeat the estimation including some basic demand variables that were found to be significantly associated with retail grants in Table 1[23]. Including these extra controls lowers the point estimate of the Conservative share to 1.55 (standard error 0.42), but does not reduce its significance level, which remains at the 1%. A further concern is that the correlation between planning outcomes and Conservatives could be driven by unobserved trends at the Local Authority level. Columns 5 and 6 repeat the estimation including, respectively, regional fixed effects interacted with a year trends, and Local Authority fixed effects[24].

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[21] The election data are presented in the Appendix.

[22] The omitted category in column 3 is the share of seats going to all other parties.

[23] Conservative majorities are more likely in areas with higher median hourly wages and college graduates, while they are less likely in areas with higher manufacturing and mining employment shares.

[24] We can use Local Authorities fixed effects since elections are rather frequent. In about half of the sample, a third of the council is elected every year. In the other Local Authorities elections take place every four years.

In both cases the point estimate is lower in absolute value (coefficient -1.10, standard error 0.53), but still significant at the 5% level. Finally, in column 7 we repeat the estimation controlling for the other political parties[25]. The coefficient on the Conservative share actually rises, and remains significant at the 5% level (coefficient -1.51, standard error 0.72).

IV.B. Exogeneity of political outcomes

A crucial issue for the validity of the IV approach is whether we can consider the changes in the political composition of the Local Authorities to be exogenous to the unobserved $\Delta\mu_{jt}$'s driving employment growth of independent retailers[26].

The first concern is that changes in the political composition of the local council could be directly determined by the employment growth of mom and pop stores at the time of big-box entry. Note, however, that the instrumentation strategy exploits changes in the political composition *at the time the grant was given,* which is typically some time before the actual entry of the store (in most specifications we assume a 2 year delay). Therefore, for a bias to exist we would need the voters to base their political preferences on the basis of mom and pops' employment growth at least two years *after* the elections. We believe that this possibility is unlikely.

The second concern is that the political outcomes and the drivers of retail employment – and in particular that of independent retailers - could be driven by a common unobserved factor. For example, changes in the socio-economic characteristics of the electorate could result in variations both in political outcomes and shopping preferences. To address this concern we will show robustness checks where we control for the time varying socioeconomic characteristics of the Local Authorities (including income, industry composition and average educational qualifications attained by the local population).

[25] The omitted category is the share of seats going to the Labour party.

[26] We focus on the changes in the political composition, as the levels are controlled for by the first difference transformation.

Finally, a bias would arise in the IV estimates if the councillors could affect the retail sector via alternative channels. In fact, Local Authorities could set and collect a local property tax on non-residential property (known as the UK business rate) only until 1990. The Central government decided to take this tax setting power away from Local Authorities as it was acknowledged this was taxation without representation. Planning was the only area of responsibility of Local Authorities that could affect businesses directly during the sample (Duranton et al, 2006).

V. Big-Box Entry and Mom and Pop Stores

V.A. Main results

In Table 3 we examine the effects of planning grants on retail employment. Before focusing on mom and pop stores, we start by looking at the relationship between grants and the employment growth of *all* stores classified in "Non Specialised retail". We start with the estimation of equation III.4 by OLS, regressing *total* employment growth on lagged planning grants, including as additional controls only a set of year dummies. Column 1 shows that grants are strongly associated with positive *total* employment growth, with a coefficient of 0.0019 (standard error of 0.0005). This result is in line with previous studies, which have documented - using different techniques and samples – the positive employment effects from more lenient regulatory approaches in the retail sector across French (Bertrand and Kramarz, 2002) and Italian regions (Viviano, 2006).

The key innovation of this paper, however, is to analyse whether the effects of entry regulations are heterogeneous across different types of retail firms. We look at this issue in columns 2 and 3, where we analyse the employment growth of stores belonging to retail chains separately from independent retailers. Column 2 shows a very strong and positive association between planning grants and chains' employment growth (coefficient 0.0019, standard error 0.0006). This finding is consistent with the idea that grants proxy for big-boxes, which are mostly opened by retail chains. The interesting fact to notice, however, is that grants have a *positive and significant* association with the employment growth of independent retailers. The coefficient on lagged planning grants is 0.0012, significant at the 5% level (standard error 0.0006).

In this simple specification, a possible worry is that the positive coefficient on planning grants may reflect spurious demand effects. However, in column 4 we see that the positive effect of big-boxes is virtually unchanged (coefficient 0.0015, standard error 0.0006). once we include as additional regressor the employment growth of chain stores, which proxies for the generalized growth of retail employment[27], and controls for income (as proxied by the log median hourly wage), demographic (percentage of people below 15 years) and urban (% of urban and village areas) characteristics[28]. Finally, the OLS coefficient is robust to the introduction of regional-specific trends in the employment growth of independent retailers, which could potentially be correlated with big-box entry. In fact, the coefficient of big box in column 5, where we include a full set on local authority fixed effects and their respective interaction interacted with a time trend, is still significant and of similar magnitude (0.0072, standard error 0.0021).

So far, we have described the OLS results as mere associations, since they may potentially suffer of the simultaneity biases described in section IV. In order to infer something on the causality of the relationship between planning grants and independents, we turn to the IV estimates. In particular, we exploit the variation in the composition of the Local Authorities – which are in charge of making planning decisions – to predict planning grants for a large retail store. Column 6 presents the estimates of the first stage, where we regress the number of planning grants given at time t-2 on the share of Conservative seats in the Local Authority at time t-2, together with rest of regressors included in the specification of column 5. In line with the

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[27] The employment growth of chain stores appears with a negative (albeit insignificant) coefficient (-0.0200, standard error 0.0196).

[28] Income and urban characteristics are positively but not significantly correlated with independents' growth, in line with the idea that these stores thrive in densely populated areas. The percentage of young people is negatively and significantly correlated with independents' growth, possibly reflecting (including a more detailed description of the age profiles did not substantially change this result).

results of Table 2 – which referred to the whole planning sample, spanning from 1993 to 2003 – a higher share of Conservative seats in the Local Authority is negatively and significantly correlated with fewer planning grants, and therefore with lower big-box entry.

The power of the political instrument is confirmed by the Kleibergen-Paap statistic (the equivalent to the Cragg Donald test with non i.i.d errors), which is well beyond the threshold suggested by Stock and Yogo (2002) to identify weak instruments problems. More importantly, the 2SLS estimates of the coefficient on big-box entry shown in column 7 are positive, significant at the 5% level (coefficient 0.0079, standard error 0.0040). Although the IV estimates are substantially higher than the OLS results, the Hausman test shows that the differences between the OLS and the IV estimates of column 5 are not statistically significant.

V.B Robustness checks on IV estimates

We now turn to Table 4 to assess the stability of the IV results to a series of different robustness checks. Before discussing the additional results, in the first column of Table 4 we report the baseline specification, which corresponds to the one reported in Table 3, column 5.

The first check relates to the concern that the (lagged) political instruments could be correlated with the same unobserved shocks driving the employment growth of independent stores. In particular, the existence of unobserved factors, positively correlated with independents' growth, and negatively correlated with the share of Conservatives, would be enough to generate a positive bias in the IV estimates. To address this concern, column 2 reports the result of a regression where we include as additional controls variables proxying for the socio-economic characteristics of the Local Authority (these include population growth, proportion of skilled people, proportion of people employed in retail, manufacturing and mining). None of the extra controls are significant in the second stage, and the coefficient on large stores remains significant at the 10% level (coefficient 0.0072, standard error 0.0037).

Another critique regards the timing assumption adopted to translate planning grants into proxies for big-box entry. To test the sensitivity of the results with respect to the assumption that only the grants accepted in t-2 enter at time t, in column 3 we look at the relationship between independents' growth and the number of planning grants conceded between t-2 and t-4 . The coefficient on this new entry measure remains positive and significant, and of similar magnitude with respect to the baseline estimates (coefficient 0.0022, standard error 0.0013). As a further check on the timing assumption, in column 4 we look at the relationship between the level of independents' employment, and the stock of retail major applications granted between 1993 (the first year of the planning data sample) and t-2, including in the regression a full set of Local Authorities dummies. The coefficient on planning grants remains positive and significant at the 10% level (coefficient 0.0040, standard error 0.0024). This is the case even when we estimate the regression using two years averages to reduce the possible impact of measurement error in both the entry and the employment variables (coefficient 0.0082, standard error 0.0040).

In column 6, we re-estimate the baseline specification of column 1 using a different instrument set, which includes not only the share of Conservative seats, but also the shares of all the other parties' seats. Including all the other parties does not contribute much to the first stage, and the Kleibergen-Paap statistics on weak instruments drops below the critical value for a 20% maximal bias in the size of the IV estimates. However, the coefficient on large stores remains positive and significant, despite a slight drop with respect to column 1 (coefficient 0.0056 standard error 0.0032).

Finally, in column 7 we run a placebo regression to check that the planning variables are not proxying for other economic shocks affecting the Local Authorities. In particular, we look at the IV estimate of the grants' effect on the growth of manufacturing employment. This exercise shows that the effect of planning grants on the growth of manufacturing employment is insignificant (coefficient -0.004, standard error 0.006). This finding mitigates the concern that planning grants might capture something beyond the entry of a large retail store.

V.C. Margins of adjustment

Although the effects of planning grants are consistently positive between chains and independents, they may nonetheless be heterogeneous *within* independents. For example, since very small corner stores are typically chosen for "top-up" shopping, they might be less vulnerable to big boxes' competition compared to large stand-alone supermarkets. Moreover, the effects of big box may vary across entering, exiting and incumbent stores. We explore these hypotheses looking at the effect of planning grants independents of different sizes, and across different margins of adjustment. In particular, we use the employment growth decomposition of Davis and Haltiwanger (1992) to analyze individually the growth contributions of entrants, exitors and (expanding or contracting) incumbents.

The Davis and Haltiwanger (1992) method calculates the employment growth rate of independent stores within each Local Authority j at time t as a weighted average of all the *k* individual stores' growth, i.e.:

$$g_{jt} = \sum_k \frac{e_{jtk}}{E_{jt}} g_{jtk} \qquad \text{(V.1)}$$

where e_{jtk} is the size of store k at time t in Local Authority j, i.e. the simple average of the store employment at time t and t-1; E_{jt} represents the aggregate employment of all independent stores in the Local Authority at time t; g_{jtk} is the time t growth rate of store s in Local Authority j, i.e. the change in establishment employment from t-1 to t, divided by e_{jtk}. This growth rate is symmetric about zero, and it lies in the closed interval [-2,2], with deaths (births) taking value of -2 (2). By construction, total employment growth rate is the sum of the contributions to employment growth from entrants, exitors and incumbents, i.e. g_{jt}, = *Entry - Exit + Incumbents Expansion - Incumbent Contraction*. Furthermore, in order to study the heterogeneity hypothesis across different size classes, independent stores are classified according to their employment with respect to the employment median of independent stores (two employees).

This generates a total of fifteen different growth rates - five components (total growth, entry, exit, incumbents' expansion and contraction) for three different samples (all stores, stores with less than two people and stores with more than two people). We regress each growth component for each sub-sample against the planning grants variable, using the same baseline IV specification on column 5, Table 3. The results of this exercise are reported in Table 5, where the regressions are divided between all independents (panel A), independents below two employees (panel B) and independents above two employees (panel C). Overall, the positive effect of planning grants is mostly accounted for by a reduction of the exit component of independents'. In particular, the coefficient on the exit regression accounts for more than a 100% of the overall positive coefficient of large stores entry (coefficient -0.0158, standard error 0.0077). Independent stores with more than two employees account for most of the aggregate independents dynamics. Panel C shows that the effect of planning grants on the overall growth of independent stores with more than two employees is about twice the size of the one for smaller independents, i.e. the coefficient (standard error) are 0.0142 (0.0091) vs. 0.0017 (0.0032). An additional grant is associated with a 1.6% reduction in the exit component for larger independent stores (Panel C, column 3), compared to the 0.18% reduction estimated for small independent stores.

V.D. Magnitudes

Overall, the IV estimates confirm the result found with the simple OLS, i.e. big-box entry is associated with a positive effect on independents' growth. In order to evaluate the magnitude of the estimates, we look at the employment growth of independent retailers between 1998 and 2004, and see how much of it can be accounted for by the change in the number of planning grants between 1996 and 2002, to take into account the 2 year delay between obtaining the planning grant and starting the retail activity assumed in the baseline regressions. Between 1998 and 2004, the employment of independent retailers declined at an average yearly rate of 3% per annum, while on average 0.44 fewer planning applications were granted every year. According to the IV coefficient in Table 3, column 8, the estimated impact of the decline in planning grants is a yearly decline of 0.34% (0.44*0.0079*100) in independent stores' employment. Therefore, the decline in big-boxes accounts for roughly 8% of the actual decline in the employment of independent stores between 1998 and 2004, which is non negligible.

VI. Conclusions

This paper investigates the effects of entry regulations against big-boxes on mom and pop stores. The results show that regulating the entry of big-boxes may actually *harm* employment of mom and pop stores. Key to the story is the ability of retail chains – which are the main drivers behind the diffusion of big-boxes – to substitute between stores of different types. This implies that the net effect of entry regulations depends on the competitive pressures arising from the stores opened by retail chains instead of big-boxes.

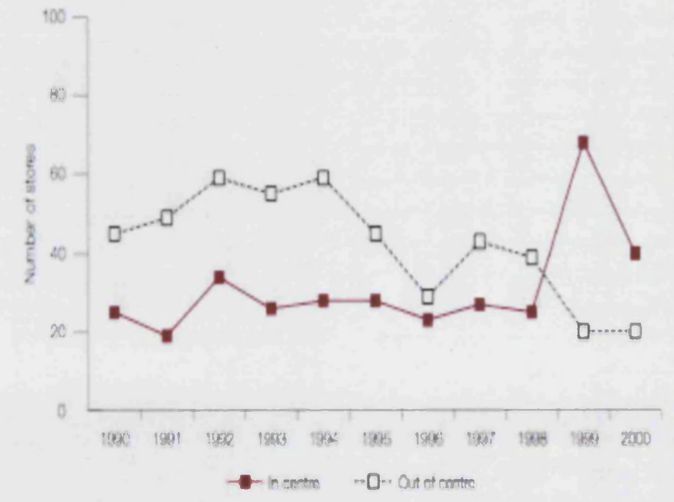
We investigate these mechanisms in the UK retail sector, where the constraints imposed on big-boxes show an exceptional degree of variation. We show that the introduction of entry regulations significantly reduced the number of big-box openings in the UK. However, this did not coincide with a reduction in the total number of new stores, but simply with a change in their size and location. In particular, the reform induced the major retail chains to move away from large retail outlets and to open small stores in central areas. The evolution of independents' employment in the post reform period suggests that, paradoxically, the increase in the competitive pressures generated by the smaller chain stores have been so strong for independents, to offset the possible benefits arising from the reduction in big-box entry.

Exploiting the differential restrictiveness of the planning reforms within the UK, we look at the effects of entry regulations at the Local Authority level. More specifically, we study the relationship between the employment of independent stores and the number of big-boxes obtaining a planning grant. The analysis is based on a unique dataset, which combines information on the population of retail stores with an exhaustive list of the planning decisions made by 302 English Local Authorities, observed between 1998 and 2004. We rely on an instrumental variable approach to isolate the variation in planning grants determined by entry regulation from that arising from local demand conditions. In particular, we exploit the fact that locally elected politicians managed the majority of retail grants for big-boxes. This introduced a link between the political composition of the Local Authorities and planning grants

In line with the aggregated stylized facts, we show that big-box entry - as proxied by planning grants - coincided with a *higher* employment growth of independent retailers. The positive effect of planning grants is found with both simple OLS estimates and IV regressions, where the grants are instrumented by the political composition of the local boards. According to the estimates, the sharp decline in big-box entry - which followed the 1996 reform -accounts for about 8% of the decline experienced by independent retailers between 1998 and 2004.

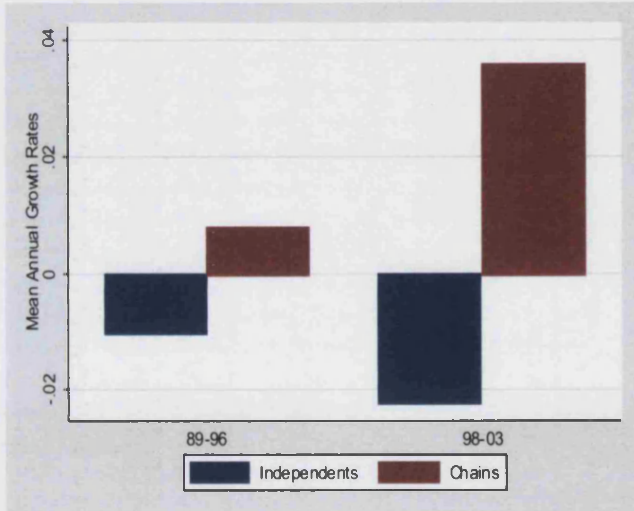
This paper argues that entry regulations against big-boxes may paradoxically harm on mom and pop stores. Due to data limitations, the estimates presented in this paper do not distinguish between the short and long run effects of entry regulations, nor do they look at the impact of the planning grants for central versus peripheral independents. These are clearly important issues to address, as they help qualifying the mechanisms generating the regulatory effects. Furthermore, although the discussion has mainly been focused on independent retailers, the IV strategy presented in the paper can be effectively employed to study the causal impact of big-boxes on equally interesting outcomes, such as wages, traffic and pollution. We leave these topics for future research.

Figure 1.a The location of new food stores after the 1996 English planning reform



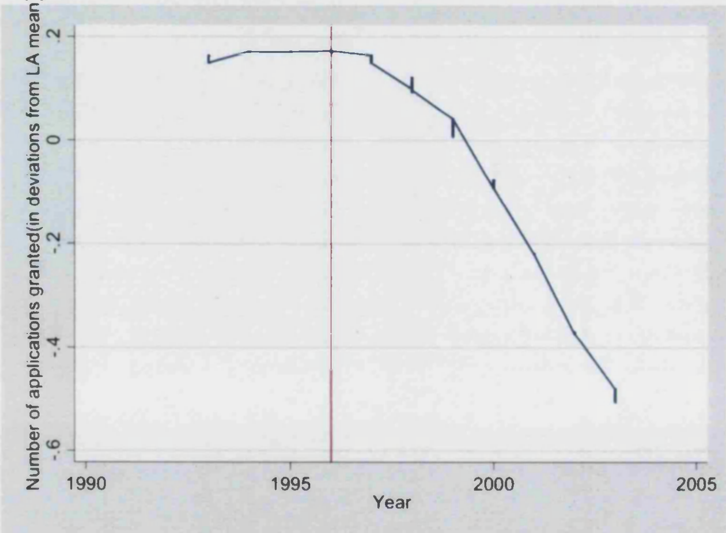
Notes: The graph plots from the number of openings of in and out-of-centre foodstores as recorded by the Institute for Grocery Retailing. Source: ODPM, 2004

Figure 1.b The employment growth rate of independent retailers after the 1996 English planning reform



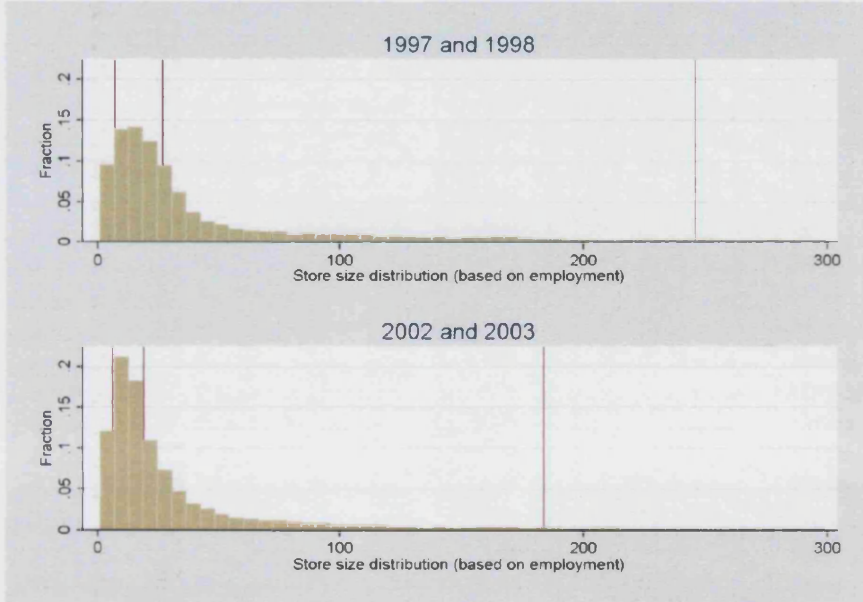
Notes: the bars represent the average employment growth of stand alone retail establishments in England between 1989 and 1996 and 1996 and 2003. Sources: Business Monitor (1976-1996), ABI (1998-2003)

Figure 2.a Grants for Large Retail Stores over time



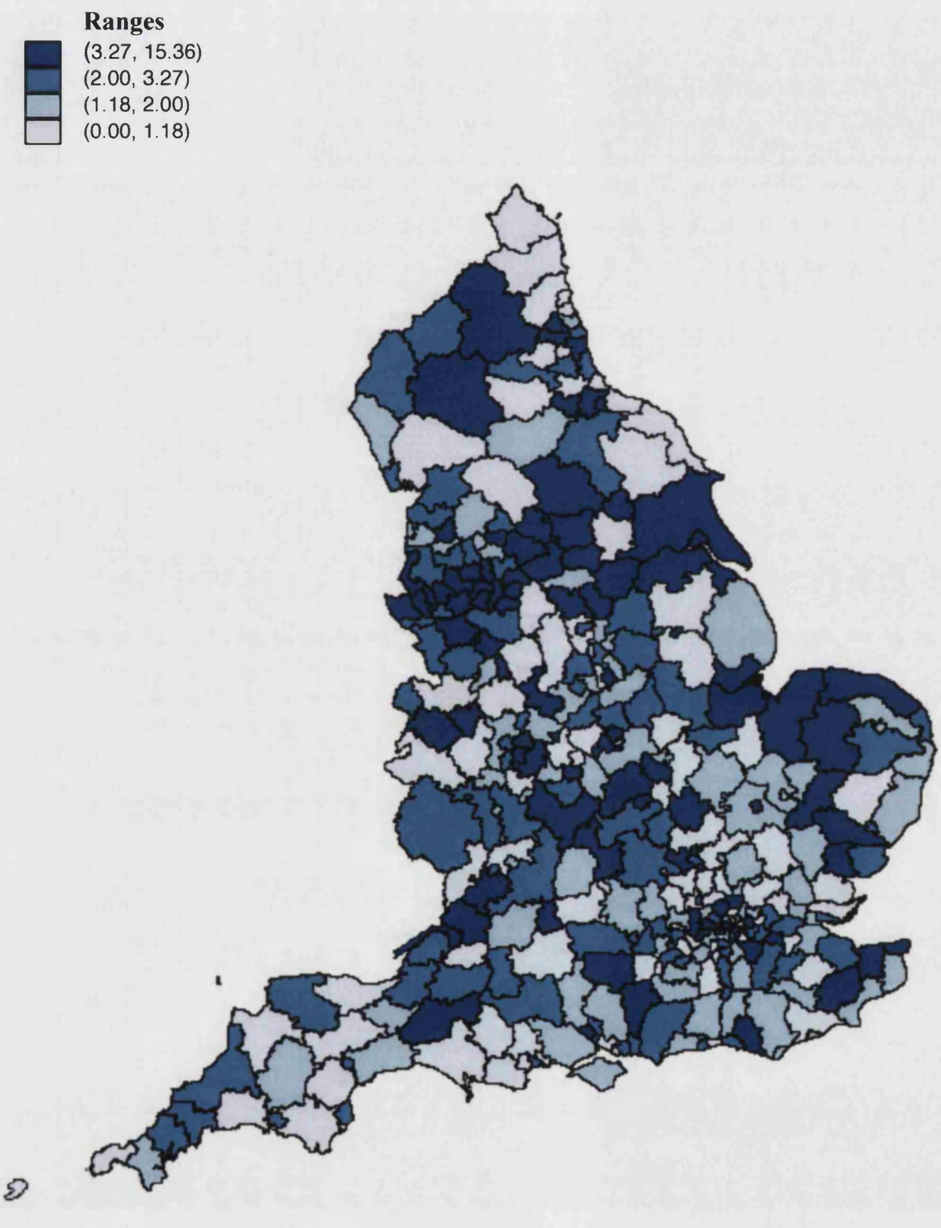
Notes: The graph reports the lowess estimate (bandwidth 0.8) of the number of major retail applications granted across 305 English Local Authorities, observed between 1993 and 2003. The graph plots deviations from Local Authority means

Figure 2.b Average store size of UK retail firms over time



Note: Figures are histograms of shop employment for each shop within a national supermarket chain in 1997/8 (top panel) and 2002/3 (bottom panel). Vertical lines mark the 10th, 50th and 90th percentiles of the distribution. A national chain operates 10 + UK regions. SIC521 is "non-specialised stores", mostly supermarkets. Source: Haskel and Sadun (2007).

Figure 3: Average Number of Planning Grants Across English Local Authorities (1993-2003)



Notes: The map shows the average yearly number of planning grants given by 354 different English Local Authorities between 1993 and 2004. Source: ODPM.

Table 1 - Planning Grants - Basic Correlations

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**
ln(Pop) Log population	2.3836*** (0.3121)	-	-	-	-	-
%Urban Percentage urban areas	-	2.1425*** (0.3779)	-	-	-	-
%Young Percentage people below 15 years	-	-	40.3867*** (9.1412)	-	-	-
Ln(W) Log median hourly wages	-	-	-	-0.2321 (0.7065)	-	-
%College Percentage people with a college degree	-	-	-	-	-12.010*** (3.3061)	-
%Retail Percentage employed in retail	-	-	-	-	-	29.9469*** (6.3283)
%Manuf Percentage employed in manufacturing	-	-	-	-	-	3.8144 (2.4484)
%Mining Percentage employed in mining	-	-	-	-	-	-38.2354* (21.1807)
Observations	3318	3318	3318	3318	3318	3318

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all columns is the number of major retail applications (above 1,000 square meters) granted by Local Authorities. The time period is 1993-2003. All estimates are based on 302 English Local Authorities. Errors are clustered at the Local Authority Level to control for heteroskedasticity and autocorrelation of unknown form in the residuals. Sources: ODPM, Census 2001, LFS, ASHE

Table 2 - Political Power and Planning Grants

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**	**$Grants_t$**
Abs Maj Con Dummy Conservative Absolute Majority	-0.7200*** (0.1854)						
Rel Maj Con Dummy Conservative Relative Majority	-	-0.7875*** (0.1924)	-	-	-	-	-
Sha_CON Share of seats won by Conservative Party	-	-	-2.0683*** (0.5225)	-1.5528*** (0.4201)	-1.1353*** (0.4165)	-1.1010** (0.5321)	-1.5184** (0.7244)
Sha_LD Share of seats won by Liberal Democrats	-	-	-	-	-	-	-0.6717 (0.6920)
Sha_Other Share of seats won by Other Parties	-	-	-	-	-	-	-0.6495 (0.4315)
Observations	3318	3318	3318	3318	3318	3318	3318
Controls		-	-	a	a	a	a
Region F.E.*year	no	no	no	no	yes	yes	yes
Local Authority F.E.	no	no	no	no	no	yes	yes
Omitted group	Other absolute majorities and no absolute majorities	Other parties' relative majorities	All other parties' shares	All other parties' shares	All other parties' shares	All other parties' shares	Labour party's share

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all columns is the number of major retail applications (above 1,000 square meters) granted by Local Authorities. The time period is 1993-2003. All estimates are based on 302 English Local Authorities. Errors are clustered at the Local Authority Level to control for heteroskedasticity and autocorrelation of unknown form in the residuals. All columns control for year dummies. Control "a" includes the log of population, the percentage of urban areas, log median hourly wage, percentage of people below 15 years, percentage of people with a college degree (NSV 3 or 4), percentage of people employed in retail, manufacturing and mining industries. Columns (4) and (5) include regional fixed effects interacted with a year trend, column (6) includes Local Authority fixed effects. Sources: ODPM, BLED, Census 2001, LFS, ASHE.

Table 3 - Employment Effects of Big-Boxes- Main results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	**Δln(emp$_t$)**	**Δln(emp$_t$)**	**Δln(emp$_t$)**	**Δln(emp$_t$)**	**Δln(emp$_t$)**	**Grants$_{t-2}$**	**Δln(emp$_t$)**
Type of Stores	**All**	**Chains**	**Indep.**	**Indep.**	**Indep.**	**-**	**Indep.**
Estimation Method	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**IV First Stage**	**IV Second Stage**
Grants$_{t-2}$ Big-box grants in t-2	0.0019*** (0.0005)	0.0019*** (0.0006)	0.0012** (0.0006)	0.0015** (0.0006)	0.0037* (0.0021)	-	0.0079** (0.0040)
Share Conservative Party$_{t-2}$ Share of Conservative seats in t-2	-	-	-	-	-	-2.7088*** (0.6181)	-
Observations	1815	1815	1815	1815	1815	1815	1815
Additional Controls	no	no	no	a	a	a	a
Local Authority F.E.*year	no	no	no	no	yes	no	no
Hausman test (Ho: IV=OLS col 5), pvalue	-	-	-	-	-	-	0.996
Kleibergen-Paap rk Wald F statistic (10% Maximal Size Critical Value=16.38)	-	-	-	-	-	-	19.205

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 1998-2004. All estimates are based on 302 Local Authorities. The dependent variable in column (1) is the employment growth of all stores classified in "Non specialized retail". The dependent variable in column (2) is the employment growth of chain stores classified in "Non specialized retail" . The dependent variable in columns (3) to (6) and (8) is the the employment growth of independent (i.e. stand alone) stores classified in "Non specialized retail". The dependent variable in column (7) is the number of planning grants for major retail applications at time t-2. Columns (1) to (6) are estimated by OLS. Column (7) represents the first stage regression of the 2SLS estimates shown in column (8). All columns include year dummies. Control "a" includes the employment growth rate of retail chains, the percentage of urban and village areas, the percentage of people below 15 years and the log of the median hourly wages in the Local Authority. Column (6) includes a full set of Local Authorities dummies, interacted with a time trend. All regressions are weighted by the share of population in the Local Authority. Errors are clustered at the Local Authority Level to control for heteroskedasticity and autocorrelation of unknown form in the residuals. The Kleiberg-Paap statistics is used instead of the Cragg Donald weak instrument test when errors are non i.i.d. Data sources: IDBR, ODPM, BLED, Census 2001, ASHE.

Table 4 - Robustness Checks on IV Estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	$\Delta ln(emp_t)$	$\Delta ln(emp_t)$	$\Delta ln(emp_t)$	$\Delta ln(emp_t)$	$\Delta ln(emp_t)$	$\Delta ln(emp_t)$	$\Delta ln(emp_t)$
Type of stores	**Indep.**	**Indep.**	**Indep.**	**Indep.**	**Indep.**	**Indep.**	**All**
Industry	**521**	**521**	**521**	**521**	**521**	**521**	**Manuf**
$Grants_{t-2}$	0.0079**	0.0072*	-	-	-	0.0056*	-0.0040
Major retail grants in t-2	(0.0040)	(0.0037)				(0.0032)	(0.0060)
Cumulative $Grants_{t-2}$	-	-	0.0040*	-	-	-	-
Sum of major retail grants, between 1993 and t-2			(0.0024)				
Sum $Grants_{t-2}$	-	-	-	0.0022*	-	-	-
Sum of major retail grants between t-4 and t-2				(0.0013)			
Average $Grants_{t-2}$	-	-	-	-	0.0082**	-	-
Major retail grants in t-2, 2 years average					(0.0040)		
Observations	1815	1815	2105	1808	909	1815	1815
Additional Controls	a	b	a	a	a	a	a
Parties included as instruments							
	Cons.	Cons.	Cons.	Cons.	Cons.	All	Cons.
Hausman test (Ho: IV=OLS), p-value							
	0.996	0.984	-	0.983	-	0.999	-
Kleibergen-Paap rk Wald F statistic (10% Maximal Size Critical Value=16.38)							
	19.205	21.149	23.932	19.783	18.967	6.579	19.205

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 1998-2004. All estimates are based on 302 Local Authorities. The dependent variable in column (1) is the employment growth of all stores classified in "Non specialized retail". The dependent variable in columns (1), (2) and (3)-(7) is employment growth of independent (i.e. stand alone) stores classified in "Non specialized retail". The dependent variable in column (3) is the log of independents' employment. In column (5) all variables are transformed in 2 year averages. All columns are estimated by 2SLS. The instrument in all columns except (6) is the share of Conservative seats in the Local Authority. Column (6) includes as additional instruments the share of Labour, Liberal Democrats and Independents seats. All columns include year dummies. Control "a" includes the employment growth rate of retail chains, percentage of urban and village areas, the percentage of people below 15 years and the log of median hourly wages in the Local Authority. Control "b" includes the variables listed in "a", in addition to the share of employment in retail, manufacturing and real estate industries, the percentage of people with a college degree or above (NSV 3 and above) and population growth. Column (3) includes a full set of Local Authorities dummies. All regressions are weighted by the share of population in the Local Authority. Errors are clustered at the Local Authority Level to control for heteroskedasticity and autocorrelation of unknown form in the residuals. The Kleiberg-Paap statistics is used instead of the Cragg Donald weak instrument test when errors are non i.i.d. Data sources: IDBR, ODPM, BLED, Census 2001, ASHE, LFS.

Table 5 - Margins of Adjustment

A. All Independent Stores					
	(1)	(2)	(3)	(4)	(5)
Dependent Variable	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**
Growth Components	**All**	**Entry**	**Exit**	**Expanding Incumbents**	**Contracting Incumbents**
Grants$_{t-2}$	0.0079**	-0.0045	-0.0158**	0.0020	-0.0002
Major retail grants in t-2	(0.0040)	(0.0055)	(0.0077)	(0.0017)	(0.0014)

B. Independents with less than or two employees					
	(1)	(2)	(3)	(4)	(5)
Dependent Variable	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**
Growth Components	**All**	**Entry**	**Exit**	**Expanding Incumbents**	**Contracting Incumbents**
Grants$_{t-2}$	0.0017	-0.0006	-0.0018	0.0006	0.0004
Major retail grants in t-2	(0.0032)	(0.0035)	(0.0034)	(0.0007)	(0.0006)

C. Independents with more than two employees					
	(1)	(2)	(3)	(4)	(5)
Dependent Variable	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**	**DH growth$_t$**
Growth Components	**All**	**Entry**	**Exit**	**Expanding Incumbents**	**Contracting Incumbents**
Grants$_{t-2}$	0.0142	-0.0054	-0.0160**	-0.0003	-0.0008
Major retail grants in t-2	(0.0091)	(0.0046)	(0.0067)	(0.0009)	(0.0007)

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 1998-2004. All estimates are based on 302 English Local Authorities and 1815 observations. The dependent variables are the different components of employment growth, computed using the Davis and Haltiwanger (1992) formula. Each cell reports the result a different regression of each growth component on the variable Grants(t-2). All coefficients are estimated by 2SLS, using as instrument for Grants(t-2) the share of Conservative seats in t-2. All regressions include as additional controls year dummies, the employment growth rate of retail chains, the percentage of urban and village areas, the percentage of people below 15 years and the log of median hourly wages in the Local Authority. All regressions are weighted by the share of population in the Local Authority. Errors are clustered at the Local Authority Level to control for heteroskedasticity and autocorrelation of unknown form in the residuals. The Kleiberg-Paap statistics is used instead of the Cragg Donald weak instrument test when errors are non i.i.d. Data sources: IDBR, ODPM, BLED, Census 2001, ASHE, LFS.

Appendix: Data and Additional Results

1.A UK Census Data

The data on independent retailers is drawn from the Inter Departmental Business Register (IDBR), which is at the base of most surveys run by the UK Census. The business register is compiled using a combination of tax records on VAT and PAYE, including information lodged at Companies House and Dun and Bradstreet. The IDBR captures two broad measures. First, it measures the structure of ownership of businesses using three aggregation categories: Local Units, Enterprises and Enterprise Groups. A Local Unit is a single mailing address, so this is best thought of a store. An Enterprise is a chain of local units/shops under common ownership. An Enterprise Group is a group of enterprises under common ownership. Second, the IDBR holds turnover and employment data for both stores and firms. This is based mostly on tax data (plus old records from previous inquiries) – although generally the turnover data is deemed to be imprecise The Annual Register Inquiry (ARI) is designed to maintain the business structure information on the IDBR. It began operation in July 1999 and is sent to large enterprises (over 100 employees) every year, to enterprises with 20-99 employees every four years and to smaller enterprises on an ad hoc basis. The ARI currently covers around 68,000 enterprises, consisting of about 400,000 local units. It asks each enterprise for employment, industry activity and the structure of the enterprise, including having to report employment of its local units. The first available year for the retail sample is 1997. However, this data is deemed to be imprecise and is therefore the analysis starts in 1998. The geographical location of the stores is obtained matching a five digit postcode with a dataset of geographical coordinates. I exclude from the sample stores that become part of retail chain at some point of their life. This is done to minimize measurement error in the independent store tag.

1.B ODPM Applications Database

The data on major planning applications and grants were obtained from the Office of the Deputy Prime Minister (ODPM) – recently relabelled as the department for "Communities and Local Government". The ODPM is the main institution in charge of overseeing planning issues in England. For this purpose, the department keeps detailed records of all the planning activity taking place across the country. The data used in this analysis was obtained upon a simple telephonic request. It includes all major (above 1000sqm) and minor applications submitted and approved across all English Local Authorities between 1993 and 2003, classified under the category "Retail, distribution and servicing". The data is anonymized and available only at the Local Authority–year level.

1.C British Local Elections Database

The British Local Elections Database (BLED) is a unique source of information of local election results in Great Britain. It contains more than 150,000 individual election results since the 1973 wholesale local reorganization. The results are provided at the candidate level, and can be aggregated at the ward and at the Local Authority level via geographical identifiers[29].

The aggregation is simplified by the fact that there is no element of proportional representation, i.e. the candidates to receive the most votes in the elections win. The term of a councillor is usually four years. Councils may be elected wholly, every four years, or 'by thirds', where a third of the councillors get elected each year, with one year with no elections.

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[29] Councils are divided into electoral divisions - known in district councils as 'wards', and in county councils as 'electoral divisions'. Each ward can return one or more members - multi-member wards are quite common. There is no requirement for the size of wards to be the same within a district, so one ward can return one member and another ward can return two. Metropolitan borough wards must return a multiple of three councillors, whilst until the Local Government Act 2003 multiple-member county electoral divisions were forbidden.

The variable used in the baseline regressions is the share of seats won by each party in the elections. In councils where the election takes place every four years, this variable coincides with the overall share of seats controlled in the council. In councils that elect a third of their councillors every year, this variable will only be proportional to the total share of seats in the council. The results are virtually identical using an estimate of the council composition. The only difference is that the sample is smaller, since for some Local Authorities – which have experienced discrete jumps in the number of councillors - the estimate is particularly noisy.

1.D Additional Data

The core retail data is complemented by additional sources (Census 1991 and 2001, Annual Survey of Hours and Earnings), which provide basic information on socio-economic characteristics - such as population, income and retail land prices - proxying for demand characteristics. As discussed in section III, time unvarying characteristics are primarily controlled for by Local Authority fixed effects or by first differenced transformations.

2. The British Local Government

The structure of local governments in England has experienced several changes over time. In 1974, a two-tier administrative structure of (shire) counties and non-metropolitan districts was set up across the whole of England and Wales, except for the Isles of Scilly, Greater London and the six metropolitan counties. Council functions were divided according to the level at which they could be practised most efficiently. In consequence, counties took on functions including education, transport, strategic planning, fire services, consumer protection, refuse disposal, smallholdings, social services and libraries, whereas the districts had responsibility for local planning, housing, local highways, building, environmental health, refuse collection and cemeteries. Responsibility for recreation and cultural matters was divided between the two tiers.

Following the Local Government Reorganisation in the 1990s major changes were implemented, such as the introduction of Unitary Authorities, single-tier administrations with responsibility for all areas of local government. Between 1995 and 1998 these were established in a number of areas across the country, especially in medium-sized urban areas, whilst other areas retained a two-tier structure. There are currently 46 unitary authorities in England, and 34 shire counties split into 239 (non-metropolitan) districts. London and the metropolitan counties retained their own structure.

3. Summary Statistics

Table A.1 shows the basic summary statistics for the sample of 305 English Local Authorities that are used in the econometric analysis. The average population of a Local Authority is about 130,000 people, or 10 people per hectare. Total average employment (i.e. independents and chains) in "Non-specialized retail" (SIC 521) is 2,742 people, divided between 123 stores or 100 retail firms. On average the sector has positive employment growth (3% per annum). The overall picture hides significant heterogeneity between independent retailers and chains. Independent retailers account for about 62% of all the stores, but only 10% of employment. Independents are characterized by much smaller stores (3 vs. 56 employees per store for chains). Table A.2 provides some information on employment dynamics for both independents and chains, using the employment growth rate developed by Davis and Haltiwanger (1992) defined in Section II.A. There are significant differences in employment growth rates, with independents shrinking at an annual rate of -3% and retail chains expanding at an annual rate of +4%. The table also shows that entry and exit play a crucial role for the dynamics of both independents and chains. Averaging between independents and chains, about 76% of job creation is accounted by births and 80% of job destruction in accounted by deaths[30].

[30] This picture is consistent with the dynamics of the US retail sector reported by Foster, Haltiwanger and Krizan (2006).

Table A.1 - Summary Statistics

		Mean	Median	Sd
Local Authority Characteristics	Population	129993	107450	93805
	Population Density (person per ht)	9.5	4.5	10.8
	Total Employment	2742	2276	2101
	Number of retail stores (SIC 521 only)	123	97	97
	Number of retail firms (SIC 521 only)	100	79	75
Independent Stores (SIC 521 only)	Total Independent Employment in LA	274	217	215
	Number of stores in LA	77	58	67
Chains (SIC 521 only)	Total Chain Employment in LA	2452	2023	1923
	Number of stores in LA	44	37	32
Entry of Large Stores	Average yearly grants for large stores	2.6	2	3.2

Notes: The table reports averages taken on a sample of 305 English Local Authorities, observed between 1998 and 2004. The data refers to the population of retail stores classified under the SIC code 521 (Non Specialized retail". Independent stores are firms with a single retail outlet. Chains are firms with multiple outlets. Sources: IDBR, Census 2001, ODPM.

Chapter IV: The Effects of Entry Regulations on Retail Productivity[1]

I. Introduction

In Chapter III we showed that a series of planning reforms introduced in the UK economy over the 1990s had a major effect on the investment decisions of large retail chains, inducing a substitution between "big-box" stores with smaller chain outlets located in central areas.

A crucial question is whether the regulatory-induced shift towards a smaller scale of retail activity had a significant impact on the productivity of the UK retail sector. Several authors emphasise the importance of scale economies for the activity of retail firms. Oi (1998), for example, discusses the role of fixed inputs such as parking and advertisement as sources of economies of scale at the store level. Others, like Holmes (2002) and Basker et al (2007) discuss the complementarity between store size with investments in bar codes and integrated distribution networks and, more generally, with the ability of retail chains to coordinate the activity of multiple stores.

In order to evaluate the productivity impact of the planning reforms, we use several micro data sets drawn from the UK Census, which provide detailed firm and store level information for a large sample of chains active in the UK, observed between

[1] This chapter draws on joint work with Jonathan Haskel.

1997 and 2003. We use this detailed information to analyse the relationship between the Total Factor Productivity (TFP) of retail chains and the typology of stores they own - as summarized by the median and the variance of their stores' distribution.

The analysis shows a consistent and statistically significant association between chain TFP and median store size, even once we control for a full set of firm level fixed effects. Interestingly, the relation is particularly strong in the Non-Specialised retail (SIC 521, supermarkets), the industry which accounts for most of the movement towards small stores in the aftermath of the reform.

The coefficients suggest that the fall in within-chain shop sizes lowered annual TFP growth in retailing by 0.4%. This is, about 40% of the post-1995 slowdown in UK retail TFP growth of about 1% (as documented by Basu et al, 2003). This finding suggests that the introduction of tight planning regulations had a significant impact on the productivity of the UK retail sector, constraining the entry of high TFP outlets.

The paper proceeds as follows. In Section II we document the data sources and some basic characteristics of the retail industry. In Section III we present the econometric modelling to study the role of store size of chains' TFP. Section IV shows the econometric results regarding the relationship between firm size and productivity. Section V concludes.

II. Data

II.A Data Sources

Our empirical analysis is based on micro data on retail firms and stores drawn from the official UK Office of National Statistics business surveys. These are the micro data underlying the UK National Accounts.

We use productivity data at the firm level drawn from the Annual Business Inquiry (ABI). The ABI is the main survey used in the UK to generate input and output measures for the national accounts. The ABI covers production, construction and some service sectors, but not public services, defence and agriculture. Firms are required to provide details on turnover (total and broken down in retail and non-retail components, and by commodity sold), expenditures (employment costs, total materials and taxes), work in progress, and capital expenditures (separately for acquisitions and disposals). Retailing firms, in particular, answer sections related to import or export of services and on the use of E-Commerce and employment, with further data on part-timers.[2] Since the ABI is covered by the Statistics of Trade Act, 1947, firms are obliged by law to provide data if they get a form. To reduce compliance costs however, only firms above a certain employment threshold (currently 250[3]) are all sent an ABI form every year. Smaller reporting units are sampled by size-region-industry bands.[4]

For each chain in our sample, we combine the productivity data at the firm level with a variable which summarises the size characteristics of the stores they own to examine how the TFP implications of different stores' distributions. For this purpose, we draw information on the population of retail stores active in the UK from the Interdepartmental Business Register (the IDBR). This business register is compiled using a combination of tax records on VAT and PAYE, information lodged at Companies House, Dun and Bradstreet data and data from other surveys. The IDBR provides information on the location and employment of each retail store existing in the UK. Each store comes with a numeric identifier which can be found also in the ABI data. This allows us to determine whether the store is part of a retail chain and, if so, to identify the chain it belongs to.

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[2] The total number of questions that is asked vary between long and short format survey forms, with the long format being sent only to firms above a certain employment level. The main difference between the two types of formats is that in long format firms are required to provide a finer detail of the broad sections defined above. For instance, in the long format firms break down their disposals and acquisitions information about 20 different items, whereas in the short format they only report the aggregate values. Also, in the long format, firms answer on questions such as the total number of sites and the amount of squared metres they consist of.

[3] The threshold was lower in the past. See Criscuolo, Haskel and Martin (2002) for more details.

[4] The employment size bands are 1-9, 10-19, 20-49, 50-99, 100-249, the regions are England and Wales combined, Scotland and Northern Ireland. Within England and Wales industries are stratified at 4 digit level, NI is at two digit level and Scotland is at a hybrid 2/3/4 digit level (oversampling in Scotland and NI is by arrangement with local executives). See Partington (2001).

II.B The Shift towards Small Stores in the Data

In Chapter III we illustrated the details of a series of planning reforms introduced by the UK Government over the 90s to slow down the diffusion of large and peripheral large stores. We argued that the planning reform induced retail chains to substitute large and peripheral stores (big-boxes) with smaller store formats. In this section, we use the detailed level of disaggregation provided by the Census data to analyse the changes in stores' distribution in the immediate aftermath of the planning reforms (1997-2003).

We consider seven sub-industries within the retail sector (from 521, "Non Specialised retail", to 527, "Repair Stores"). Table 1 shows the average sub-industry employment for 1997/8 and 2002/3. Table 1 also reveals the importance of the industry 521 "Non Specialized retail", where supermarkets are usually classified. "Non specialized retail" is also the most concentrated sub-industry, with a 15 firm concentration ratio of about 40%.

In Table 2 we look at firm heterogeneity, by dividing the sample of stores according to the type of retail firm that owns them. For this purpose, we define three types of retail firms: "stand-alone" stores, which are single owned shops, "small chains", which are chains of stores operating in at most nine out of the eleven UK regions and "large chains", operating in at least ten UK regions.

Looking at "Non Specialized Retail" first, the top row shows the share of employment has fallen fractionally in stand-alone stores, fallen more in small chains and risen in large chains. The same is true in terms of shops, with a particularly sharp fall in the share of stand-alone shops. The general pattern is repeated in all sectors, with the exception of Food and Pharmaceutical, where the employment share of stand alone shops has fallen only fractionally and the share of large chains has remained substantially flat (in Food).

In Table 3 we explore in more detail within-firm store distributions to analyse the importance of small stores across the different industries, by looking at the fraction of shops below the median size of the chain in the base period (the average size between

1997 and 1998)[5]. We restrict our analysis to stores belonging to chains (i.e. multi stores firms), and we distinguish once more between small and large chains. Moreover, in order to focus on the main retail sub-industries, we look separately at "Non Specialised Retail", "Food" and "Other Specialized Retail", while we group the rest of the industries together. This analysis shows that the increase of small stores is most pronounced in "Non Specialised Retail", as it is apparent from the fall of store size at the 25th, 50th and 75th percentiles of the store distribution[6]. Median store size has fallen from employing 72 persons to 57, whilst the size at the 75th percentile has fallen from 141 persons to 117 persons. For other industries there is much less change. Median sizes have hardly changed at all, although there has been a slight decline in the 75th percentile for large chains.[7]

III. Empirical Model

In order to test the role of store size for the productivity of retail chains we use a simple Cobb-Douglas production function[8] of the following form, for retail chain *i*:

(III.1) $$\ln Q_{it} = \ln A_{it} + \sum_{Z=K,N,M} \gamma^{Z} \ln Z_{it}$$

[6] We can calculate two versions of this statistic. We can simply take all S stores, regardless of firm, and compute the median or other size, giving one measure for all stores. Or, we can take all stores, allocate them to their firm, and calculate a particular percentile, say the median for each of the F firms, and finally take the average of this figure, say the median, over the F firms. This second method is used in the Tables and corresponds to the regression where we need a median per firm. The first method is used to construct the first figure.

[7] As a matter of information, our regression sample is not quite this picture, since with fixed effects we use firms who are present in at least two periods. But the changes are similar, namely a fall in shop sizes for supermarkets and little change elsewhere).

[8] Notice that the total number of stores is included in the capital stock K. Moreover, the specification abstract from possible complementarities between the share of large stores and other inputs.

where Q is gross output, Z are the standard inputs of production (capital, labour and material) and A is TFP at the firm level. We express firm level TFP as a weighted average of large and small stores efficiency, where the weights are represented by the share of large store production over total chain output. Formally:

(III.2) $$\ln A_{it} = \gamma^S \varphi(S_{it}) + \gamma^X X_{it} + u_{it}$$

where $\varphi(S_{it})$ is a function that measures the share of large stores in the total production of the retail chain i at time t. The X's are other observable factors influencing productivity such as the geographical extension of the chain (regional or national), the ownership status of the chain (domestic or multinational), firm age, region etc. We estimate (III.1) using firm level panel data by OLS, and OLS with fixed effects[9]. The estimation of equation (III.1) presents some conceptual issues[10]. We address these questions below.

III.A Measuring Retailing Output and the Relation between Output and Inputs

The literature argues that the right output concept when considering productivity of a retailer is not the goods it sells, but the bundle of retailing services it offers, which surround the sales of the goods[11]. Betancourt (2004, p.19ff) defines these services as ambience, product assortment, accessibility of location, assurance of delivery, and information[12]. In an ideal setting, we would need the prices and quantities of these

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[9] The econometric issues involved are discussed in, for example, Griliches and Mairesse (1986).

[10] This question is discussed in, for example, Betancourt (2002), Oi (1981) and Triplett and Bosworth (2003).

[11] This follows from the generic argument that retailers offer fundamentally intermediation activities in the same way that a business who transports shoes from A to B does not produce the shoes, but the bundle of transport services surrounding the shoes.

[12] Consider the example of a shoe seller, where the measured output is sales of shoes. A partial list of the inputs might be the following. First, the bought-in shoes themselves and second the shop (assuming it has a location). Third, the factors enabling a transaction to be made (staff to open the shop and take the money, cash tills, heating and lighting etc.) and fourth the bundle of distribution services surrounding the sale of shoes in the shop; the location of the shop, the ambience in the shop (e.g. the lighting, design, quality of the staff), the reputation of the shop for e.g. accepting returned goods etc.

attributes to measure retail output. However, since services are typically not priced directly, the main challenge is to recover their value from observable data, which is typically on overall revenues and various input expenditures.

In order to do this, we need a theory of how the various inputs and outputs in retailing are related. Let us denote this real bundle of services under the vector D. Define PQ as sales of goods at retail price P, P_WQ_W as the value of goods purchased for resale at the wholesale price P_W, other intermediate inputs used in retailing (lighting, electricity etc.) as P_MM and primary factors labour and capital as P_XX. Our data are typically values of sales, PQ, and values of expenditures on measured inputs, P_WQ_W , P_MM and P_XX. We define three output measures: sales=PQ, gross margins $P_{GM}Q_{GM}$ =PQ-P_WQ_W and value added P_VQ_V =PQ-P_WQ_W -P_MM.
The most general form of a production function describing Q would be

(III.3) $$Q=AF(D,Q_W,M,X)$$

where A is the TFP parameter. An important question is what are the properties of $P_{GM}Q_{GM}$ =PQ-P_WQ_W, or more accurately, what are the marginal product properties of (III.3) observable from $P_{GM}Q_{GM}$? This question parallels the question in the production function literature on gross output versus value added, where it is shown that the extent to which the properties of the gross output production function are recoverable from the value added production function if either a) Q takes a special functional form so that the ratio of Q_W to Q is fixed (either technologically, or that relative factor prices do not change) or b) that Q_W is separable from the other inputs so that (III.3) can be written as:

(III.4) $$Q=F(A(D,M,X)Q_W)$$

As Triplett and Bosworth (2004) point out, separability means that the elasticity of substitution between D, M or X and Q_W is zero, or that retailers choose Q_W and then choose to allocate M and X independently of the choice of Q_W. As Oi (2000) and

Triplett and Bosworth (2004) point out, the separability assumption is increasingly unlikely in retailing[13], and TFP growth calculated from (III.3) will not give the same information as (III.4). Therefore, we base our production function estimates on gross output and not margins.

III.B Measuring Inputs

To obtain a measure of the share of large stores we have to take a number of steps. Since our main dataset does not contain information on the square footage of retail stores, we use employment at the store level to approximate for the average size of a store. We proxy for the share of large stores belonging to retail chain i using moments drawn from its stores' distribution. For example, everything else equal, the size distribution of the j stores belonging to the chain that opens a new large store will shift to the right. The main measures that we use are median store employment and – symmetrically - the fraction of stores that are below the median observed at the beginning at the sample.

We specify the Z variables in (III.1), as the usual production function arguments of capital, employment and material use (our dependent variable will be gross output). The measure of capital here is build up via the perpetual inventory method using data on investment in plant, buildings and machinery. This does not by any means measure capital in the firm since much of the effective retailing capital stock is due to factors like, for example, floor area. In addition, the investment data is at the firm level and not the shop level so that the acquisition of pre-existing shops (takeovers) will not show up as investment. Thus, our shop size variables may be picking up aspects of the mis-measured capital stock.

Betancourt (2004) argues that sales of a retail store are affected by distribution services such as ambience, product assortment, accessibility of location, assurance of delivery and information. Like other studies, we do not have detailed measures of these

[13] For example, bikes used to be sold fully assembled, whereas now they are sold flat packed giving customers the choice to assemble the bikes themselves or have the shop do it.

factors. We include industry dummies to control for any common regional and industry level of distribution services. Thus, for example, we do not compare food retailers with second-hand car dealers but compare within 4-digit industries. Moreover, we enter a dummy for whether the shop is part of a national chain or not, which should additionally control for ambience-type effects. Finally, we also enter fixed firm effects so that we are comparing changes in sales, controlling for other things, rather than levels: to the extent that factors such as ambience and location convenience remain fixed, this should be controlled for.

III.C Identification

Our primary objective is to estimate the coefficient on φ, the variable summarizing the typical size of the stores belonging to the chain. In doing this, our identification assumption is the share of small stores is primarily determined by the regulatory shock, to which firms react with different speed of adjustment.

If this condition holds, i.e. the factors driving of φ are orthogonal to firm characteristics, then the estimated coefficients are unbiased. If, however, this orthogonality condition fails, our OLS estimates will be biased. Consider the case where better managers both raise productivity and employment, a partial explanation as to why large firms are more productive. This would tend to make OLS estimates of productivity and store size overstated[14]. To control for this type of biases we use fixed effects, thus the impact of φ will be biased only if *changes* in unobserved managerial skill cause both *changes* in φ and *changes* in TFP.

A second problem arises from the fact that we do not have firm-specific output or input prices, rather four-digit industry prices. The consequences of this for production function estimation are explored in e.g. Klette and Griliches who point out that omission

[14] There is likely measurement error in the reporting of store employment as well. If it is classical then that would potentially bias the effect toward zero. Whether it is classical is not clear however, since we might assume that measurement error is greater the more stores that a firm has and the more new stores a firm opens (since to some extent the ONS checking procedures and forms are based on previously recorded store numbers).

of firm-specific output prices, under the assumption that demand is Dixit-Stiglitz introduces a term in (p_i-p_I) in the error term, so that cross-sectional comparisons of TFP reflect both differences in technology but also prices deviations. Similarly, if there input prices are firm-specific then the error term also contains a term in $-\gamma^Z(p_i^Z-p_I^Z)$ for the Z'th input and cross-sectional comparisons of TFP reflect also the ability of firms to source inputs cheaper than others (such firms will have higher measured TFP). With fixed effects, we induce a bias to the extent that deviations in within firm scale measures from the mean are correlated with deviations of output prices net of input-elasticity weighted deviations of input prices. The direction or magnitude of this bias is not clear. In the levels, it seems reasonable to assume that larger firms can source cheaper inputs, giving them higher measured TFP. Since this level effect is controlled for, bias would occur to the extent that changes in φ are correlated with changes in $-\gamma^Z(p_i^Z-p_I^Z)$, i.e. any effect of median size (as an example of an φ measure) on measured TFP would be biased upwards if firms with rising median sizes were achieving higher input price gaps. We might imagine that more monopolistic firms would be able to achieve higher input price gaps, and that this might be more likely in large firms. However, in the data we see that large retail firms have registered, in fact, *falls* in median store size, which would induce a negative correlation between median size and price gaps. This, in turn, would imply that we underestimate the coefficient on median store size.

An additional problem is that large stores are likely to differ in terms of product mix. For example, smaller stores in large chains often carry high value product mixes, and that they do not feature special offers in the way that large stores do. In order to work out the possible bias for our estimates, we suppose that a) small stores only sell high value goods and b) large stores offer high and low price baskets of goods, c) large stores can sell high value goods only at a discounted price. The basket offered by large stores is then: $B_L=P_H(1-s)Q_H+P_LQ_L$ whereas the basket offered by small stores is $B_S= P_HQ_H$. Denote the number of stores in a chain as N, with δ the fraction of small stores, in which case the firm level basket, which is what we measure, $B_F=N((1-\delta)B_L+\delta B_S)$.

Under this scenario, in the cross-section there will be a correlation between the fraction of small stores and the revenues from full price high-margin goods. If these revenues are higher[15] then this would likely raise overall revenues, at the margin. This works in the opposite direction to what we have found.

Finally, possible biases in the OLS estimates may arise since our productivity data is at the chain – and not at the store - level. We postulate a log-linear relation between firm-level outputs and inputs, and within-firm measures of input distributions. However, the log of firm-level output or input is different from the sum of the logs of outputs or inputs. Therefore, we have to be careful that the within-firm measures do not appear just due to aggregation. To examine this issue, we consider a simple case where each shop *j* within a firm has a Cobb-Douglas relation of the form $Q_j = N_j^{\alpha} K_j^{\beta}$. We only observe $Q_i = \Sigma_j Q_j$, $K_i = \Sigma_j K_j$, $N_i = \Sigma_j N_j$ but for each chain *i* we do observe the N_js $\forall j \in i$. Let us start by assuming that Q, Y and N are log- normally distributed within the firm. Making use of the relation that for a log-normally distributed variable $\log(\Sigma_j X_j) = \Sigma_j (\log X_j) + \sigma^2_{\log X}/2$, where $\sigma^2_{\log X}$ is the standard deviation of logX, we can write the firm-level (which is what we observe) relation between inputs and outputs as $\ln Q_i = \gamma^N \ln(N_i) + \gamma^K \ln(K_i) + \frac{1}{2}\left(\sigma^2_{\log Q_j} - \gamma^N \sigma^2_{\log N_j} - \gamma^K \sigma^2_{\log K_j}\right)$.

Following these steps, equation (III.1) becomes:

$$\ln Q_{it} = \gamma^S \varphi(S_{it}) + \sum_{Z=K,N,M} \gamma^Z \ln Z_{it} + \frac{1}{2}\left(\sigma^2_{\log Q_i} - \sum_{Z=K,N,M} \gamma^Z \sigma^2_{\log Z_i}\right) + \gamma^X X_{it} + u_{it} \quad \text{(III.5)}$$

This shows that the relation between observed log firm output and observed log firm inputs in (III.1) has an extra term in it, namely the within-firm variance of log output *net* of the sum of the output elasticity weighted within-firm variances of log inputs. Eq. III.5

[15] It would seem reasonable that they are higher i.e. the demand at these stores is sufficiently inelastic so revenue is large even with the lack of sale prices, since this would cover higher land rents at such stores who are e.g. in centres of town, or in stations and airports where presumably space is priced at a premium.

shows that the use of logs does indeed induce a relation between log output and within firm input distributions. It is important to note however, that the induced term is not, even in this simple case, a simple dispersion measure of one of the inputs, such as the median or standard deviation, but is rather the *gap* between the dispersion of output and the (weighted) sum of dispersion of inputs. The bias to φ depends upon the correlation between this and the gap term (with fixed effects, strictly between changes in φ and changes in the gap). Working out the sign of this correlation is not simple. Observed heterogeneity in φ, for example, might generate positive or negative gap, depending on its relative effect on output, compared to that on the other inputs[16]

III.C Additional Controls

In all regressions, we clustered standard errors at the chain level to control correlations of unknown form in the residuals. We also include a set of time and regional dummies, plus controls for the multinational status of the firm, the nationality of its major shareholder, its age, and the region of location of the central headquarters. Since larger chains also tend to have larger store sizes, we also include a dummy for whether the firm is a national chain or not (the omitted category is a regional chain).

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[16] As a matter of data, we only have within-firm data on N and so can only investigate the correlation between log median shop size for each firm and σ^2_{logN} (the variance of shop sizes within firms). This is 0.20, significant at the 1% level. Finally, note this equation above is derived when the inputs are log linear and the output elasticities in the store-level production function do not vary across stores in a chain. In the more general case, one still obtains a relation being the gap between the dispersion of output and the output-elasticity weighted dispersion of inputs. In the constant output elasticity case with just one input X Albuquerque (2003) shows the equivalent of the last term on the right-hand side of (9) to be $\acute{L}(Y)-\gamma\,\acute{L}(X)$ where $\acute{L}(Y)=\ln(\acute{Y}/\bar{Y})$, $\acute{Y}$ and $\bar{Y}$ equal the arithmetic mean and geometric mean of Y_i across the stores within the chain *j* (similarly for X), and γ is the output elasticity of X. In the case of the log-normal distribution the relation between the arithmetic and geometric mean implies the expression becomes that in (9). See Alburquerque (2003, expression (4)) for a generalisation of this: with more factors the term involves additional output-elasticity weighted terms, and with varying γs across stores within a chain, additional terms in the covariance of the log level of inputs (relative to the chain average) and the store-specific γ (relative to the chain average). These aggregation results are also consistent with Lewbel (1992) results on scale-invariance.

IV. Store Size and Chain Productivity

IV.A Main Results

Table 4 sets out our key result, which is the positive and significant relationship between the average size of chains' stores and their TFP. The underlying data in Table 4 comprises only retail chains, i.e. multi store firms, for a total of 7,469 observations between 1997 and 2003.

Column 1 sets out the estimation of the production function outlined in equation (5). The coefficient on employment, capital and materials are all statistically significant and of expected magnitude. The results also show a (statistically insignificant) positive TFP advantage to being a national chain (the omitted category being regional chains). Column 2 repeats the regression of column 1, including a full set of firm level fixed effects, primarily to control for the unobserved characteristics of retail chains, including services and distribution infrastructures. In the fixed effects specification, the coefficients on the inputs are lower, in line with the well-known exacerbation of measurement error with fixed effects. The national chain dummy indicates a (statistically significant) positive TFP advantage, relative to regional chains, of about 7%.

Column 3 reports the main regression of the paper, where we add to the standard inputs of production the log of the median size of stores belonging to the chains. The variable median store size is positive and significant, suggesting that a 1% increase in median store size is associated with 0.02% increase in firm level TFP. In order to check the robustness of this finding to the use of alternative measures of store size, in columns 4 and 5 we use the share of stores with employment below the (firm specific) median store size at the beginning of the sample period as a proxy for the presence of large stores within the chain. We express this variable both in frequency and employment terms in columns 4 and 5, respectively. Both variables are significantly negative (respectively -0.069 and -0.0641). This suggests that an increase in the number of stores below the beginning of period median is associated with lower overall firm productivity.

Overall, our results suggest that, controlling for overall firm size, fixed effects and other inputs, within-firm store sizes have a statistically significant association with firm productivity. Firms with smaller within-firm store sizes (measured either as median size or fraction of small firms) are associated with lower productivity.

To explore the role of industry heterogeneity, we run separate regressions for each three-digit SIC industries. This enables us to decompose better the effects on productivity, given that the shift towards small stores appears to be heterogeneous across sectors. We consider sectors 521, 522 and 524 – which are the largest industries in terms of employment – individually, and we amalgamate the remaining sectors together due to small sample problems. The top row of Table 5 reports the coefficient on log median store size for each 3-digit sector[17]. The second and third rows of Table 5 report the coefficients estimated on the variable "fraction of small shops" using, respectively, the shares measured in employment and frequency terms. The table suggests that the results shown in Table 4 are mainly driven by "Non specialised retail" (SIC521) and "Other specialised retail" (SIC524), which together represent 86% of total retail employment and 92% of total retail value added. For supermarkets (SIC521), there is a strong positive effect from median size, with no significant effect from the fraction of small shops. For "Specialised Retail" (SIC524), there is also a strong positive effect from median size, and a negative effect from the fraction of small shops. The other sectors have no particularly statistically significant effect.

IV.B Robustness Checks

In Table 6 we set out some robustness checks on the sample of Table 3. Column 1 and 2 of Table 6 show the benchmark specification for, respectively, median store employment and percentages of small stores. To explore whether the correlation between TFP and median store size captures some unobserved effects due to the distribution network of retail chains, in columns 3 and 4 we run the baseline regression

[17] In these regressions we include all the other controls reported in Table 4.

controlling for vertical integration. For this purpose, we use a dummy which takes value 1 if some of the establishments belonging to the firm are classified in Wholesale (SIC 51), or if the firm belongs to a larger enterprise group which owns other firms whose main SIC code is Wholesale[18]. The coefficient on the vertical integration variable is positive and significant. However, this does not compromise the significance of the coefficients on the size variables, which remain virtually unchanged.

We also explored whether the median store size effect is just a reflection of the notion that serving more small stores involves more transport and, to the extent that there might be congestion involved, lower productivity. The result of this exercise is shown in column 5, where we entered transport costs (ln_T) separately to input costs. In the data, the fraction of transport costs are positively correlated with the fraction of small stores, but the regression table shows that the coefficient on small stores is hardly altered[19].

In a final check, we tried an IV type approach to the baseline specification of Table 4, column 3. Our strategy consists in using initial (i.e. the median store size in the first year the firm is observed) median size as an instrument for subsequent median size[20]. The rationale behind the instrument is that the response to the exogenous change in planning regulation (which raised the cost of opening larger shops) might have differed according to the stores distribution that firms had in the pre-regulatory environment. For example, firms with initially larger stores might have faced higher adjustment costs in changing stores' distribution (i.e. opening smaller stores) in subsequent periods. This is consistent with the evidence that "big-box" retailers such as ASDA/Wal-Mart had significant problems in adjusting their store strategies to the new

[18] The results are robust if we use only the first part of the definition, i.e. a firm is vertically integrated if its main SIC code is Retail (SIC 52) but some of its establishments are classified in Wholesale (SIC 51).

[19] We did not find any evidence of complementarity between store size and transport costs either.

[20] Since we control for fixed effects, this effectively uses initial median size as an instrument for subsequent changes in median size, where initial median size is measured as the median size of the shops within the chain in the first period the chain is observed and the sample is all observations excluding the first period the chain is observed.

planning regime after the 1996 reform (Competition Commission, 2000, Griffith and Harmgart, 2005).

The sample used in this exercise is of 2,353 observations. In the first stage the coefficient on initial median store size is -0.0006 (significant at the 1% level), suggesting that, indeed, firms with larger stores in the initial period experienced smaller changes in stores size. The F test prescribed by Stock and Staiger (1998) in the first stage regression is 36, which is well beyond the Stock and Yogo threshold of 16. The IV coefficient of log median size is 0.144 (se=0.06), both larger than the OLS with fixed effects (coefficient=0.013, se=0.014) and more precisely estimated.

Discounting the bias from weak instruments, the IV results may be upward biased due to a correlation between the instrument and unobservable variables. A second possibility is that IV is unbiased, but OLS/LSDV is downward biased, due to the negative correlation between omitted factors causing chain productivity and median store size. Third, OLS/LSDV might be downward biased due to measurement error in the changes in median store size, which is corrected when in the IV regressions. Finally, it is possible that there are heterogeneous coefficients and that IV has identified the local marginal effect arising from initially big firms, for whom there might have been a very severe penalty to becoming small.

IV.C Economic Significance of the Results

Our results show a statistically significant association between chain productivity and variables measuring the relevance of large shops for retail chains. To judge the economic significance of these findings, we proceed in Table 7 to consider the effect of changes in median employment for the overall productivity of the retail sector.

First, we measure average TFP growth using the retail data in our sample. Table 7 shows the results for the four industries and for the total sectors, where the total sector results are the employment-weighted numbers using the employment weights in row 2. Row 3 shows TFP growth for each firm, using the change in log output less the cost-share weighted change in log input,[21] weighted by the fraction of employment in the firm in the relevant SIC for each year. The figures in row 3 are the sums of this for each SIC and the total column the weighted sum (of each number in row 3, weighted by the industry employment shares in row 2).[22] Row 3 shows annual TFP growth rates of -0.28% in supermarkets, 0.10% in food, 0.56% in pharmaceutical and 0.84% in the rest. The overall productivity growth rate for retailing is, on our sample, 0.07%[23]. Interestingly, the sector with the greatest fall in the median store size has had the lowest TFP growth.

Row 4 of Table 7 shows the coefficient on log median employment size from the earlier regression. Rows 5 and 6 show the median employment in each industry for our sample in 1997/8 and 2002/3. As we saw in Table 3, in the regression sample median employment has fallen in "Supermarkets" and risen slightly elsewhere. The seventh row shows the predicted effect from the actual change times the coefficient. In supermarkets, the predicted effect is to lower annual $\Delta \ln TFP$ by 0.64% per year. In SIC524 and "Rest (524)" the effect is to raise it by 0.55% per year and the effect is small and negative in SIC522 (due to the negative coefficient in Table 5).

The final two rows of Table 7 set out two counterfactuals. Row 8 imagines there was no reduction in median store size in supermarkets (but other sectors were unaffected). Given the supermarkets are so much larger than other industries, this seems to be the counter-factual of immediate interest, since it is likely that only for

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[21] The factor cost shares were for employment the share of gross output accounted for by labour costs, for materials the share accounted for by purchases of materials and for capital the remaining share. An alternative is to use the implied output elasticities from the regressions instead of the factor cost shares. In the light of the possible biases to the elasticities we used the actual factor cost shares,which also eases comparison with aggregate figures.

[22] Strictly speaking the TFP growth rates should be Domar weighted but we ignore this here: there are few sales by each retailer to the other and employment is somewhat better measured than output.

[23] Basu et al (2003) report UK gross output industry level TFP growth rates, 1995-2000 for retail trade, of -0.58%. Timmer and Inklaar (2005) report, for the period 1995-2002, a TFP growth of +0.24%. Our TFP estimates might different from Basu et al and Timmer et al for a number of reasins. First, our TFP growth rates are calculated for the sample of chains included in the regressions, and thus omit small shops (as we show below however, chains account for 96% of value added in retailing). Moreover, the chains in the sample had to survive at least two periods to be included in the sample. Thus it misses, to some extent, the industry productivity gains from entry and exit of new firms.

supermarkets would store size regulation be binding. However, for completeness, row 9 shows no change in any median store size in all industries.

Comparing rows 8 and 9 with the actual case in row 2, in row 8, TFP growth is raised in supermarkets (by the amount shown in row 7) and unaffected elsewhere. In row 9, it is raised in supermarkets, but slightly lowered elsewhere. This exercise suggests that, in the absence of changes in store sizes in supermarkets, productivity growth would have been 0.44% per annum rather than the actual 0.07% per annum (see the total columns in row 3 and row 9)[24]. Thus, we estimate an implied slowdown in TFP growth due to changes in store sizes of (0.27-0.07)=0.37 per annum. This number corresponds to about 39% (0.37/0.96) of the slowdown in TFP growth documented by Basu et al (2003) for the whole retail industry.[25] Since UK retailing by itself accounts for 1/3rd of the UK (private sector) economy-wide TFP deceleration, our estimates imply that regulation in retailing accounts for 13% (1/3rd of 39%) of the UK economy-wide TFP deceleration between 1995 and 2003.

V. Conclusion

In the mid-1990s, the UK government introduced a series of planning regulations, which constrained the entry of large retail stores. Retail chains reacted to the new policies substituting large stores with small and central retail outlets. We argue that the shift towards small retail formats induced by the regulations had a strong, negative effect on the productivity of retail chains.

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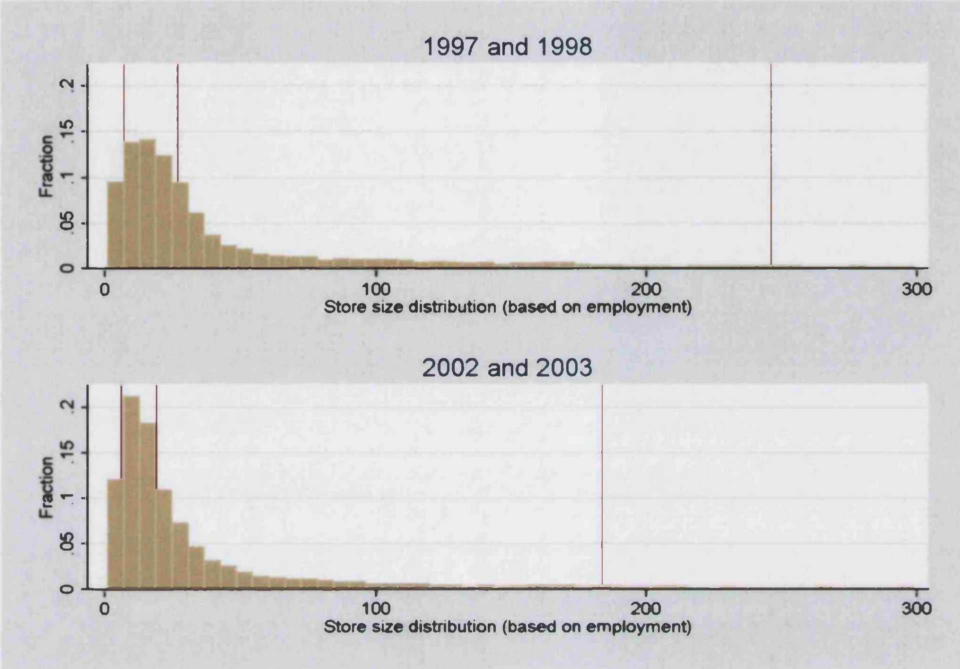
[24] In the scenario where median store size of frozen at the beginning of the period values in all sectors, even though productivity growth falls for the non-supermarket sectors, supermarkets are large enough that overall productivity growth still rises. Note however, that since median store sizes rose in "Pharmaceuticals" and "Rest", keeping median store sizes at their initial level lowers TFP growth

[25] The 0.96 figure corresponds to the movement form 0.38% per annum between 1990 and 1995, to -0.58% per annum between 1995 and 2000. Another way to think of our data is relative to the US, although the counter-factual is not as clear without knowing what happened in the US to store sizes for large chains in supermarkets. Timmer and Inklaar suggest that US retail TFP growth is about 7 times and 2 times respectively that in the UK. Our data here suggests that with change in median shop sizes, UK TFP growth would have been about 3 times greater. Therefore, our results over-explain the Timmer/ Inklaar figures.

Consistently with this hypothesis, we provide evidence of a positive and significant relationship between chain TFP and variables measuring the size of chains' stores. Our results suggest the fall in shop sizes lowered TFP growth by about 0.4% per annum, about 40% of the post-1995 slowdown in UK retail TFP growth. Given that the slowdown in retailing alone accounts for about 1/3rd of the entire slowdown registered by the UK market sector TFP growth between 1995 and 2003, we argue that entry regulations accounted for about 13% of the UK economy wide TFP slowdown.

In Chapter V we analyse the role of store size on chains' TFP in the US and Japan, finding comparable results. A simple explanation of the store size effect might be that the correlation is generated by pure economies of scale at the store level. A more complex channel involves complementarities between store size, shared information across stores and other inputs, such as, for example, IT investments. We plan to study these transmission channels in future work.

Figure 1. Changes in the store Distribution of National Supermarket Chains



Notes: Figures are histograms of shop employment for each shop within a national supermarket chain in 1997/8 (top panel) and 2002/3 (bottom panel). Vertical lines mark the 10th, 50th and 90th percentiles of the distribution. A national chain operates in at least 10 of the 11 UK regions. SIC521 is "non-specialised stores", mostly supermarkets. Source: ARD data at ONS.

Retail Sectors

SIC	Industry	Notes
521	**Retail sales in non-specialised stores covering e.g. food, beverages or tobacco**	Includes supermarkets and department stores
522	**Food, beverages, tobacco in specialised stores**	
523	**Pharm and medical goods, cosmetic and toilet articles**	Includes chemists
524	**Other retail sales of new goods in specialised stores**	Includes sales of textiles, clothing, shoes, furniture, elect appliances, hardware, books, newspapers and stationary, cameras, office supplies, computers. Clothing is biggest area
525	**Second-hand**	Mostly second-hand books, second-hand goods and antiques
526	**Not in stores**	Mostly mail order and stalls and markets
527	**Repair**	Repair of personal goods, boots and shoes, watches and clocks

Table 1. Summary Statistics by Three Digit Industries

		Total employment		**Stores**		**Cr 15**	
sic3		**1998-1999**	**2002-2003**	**1998-1999**	**2002-2003**	**1998-1999**	**2002-2003**
521	**Supermarkets**	876905	1100000	14853	18552	43.2%	45.0%
522	**Food, Bev, Tob**	94692	78763	13266	10957	2.9%	2.0%
523	**Pharmaceutical**	70483	65324	6975	7031	3.2%	2.4%
524	**Other**	521455	705689	48455	53369	10.5%	13.2%
525	**Second-hand**	2917	3878	819	1469	0.1%	0.1%
526	**Not in store**	49016	43838	1100	835	2.5%	1.8%
527	**Repair**	4340	6691	953	958	0.2%	0.3%

Notes: The table reports averages taken on the population of retail stores active in the UK. Cr15 is the concentration ratio calculated over the top 15 retail firms in the sample.

Table 2: Share of Employment in Stand Alone Stores, Small and Large Chains.

	Employment Shares					
	Stand Alone Shops		Small Chains		Large Chains	
	1998-1999	2002-2003	1998-1999	2002-2003	1998-1999	2002-2003
Supermarkets	0.14	0.12	0.23	0.18	0.63	0.70
Food, Bev, Tob	0.62	0.60	0.28	0.29	0.11	0.11
Pharmaceutical	0.33	0.31	0.24	0.24	0.43	0.45
Other	0.36	0.33	0.25	0.21	0.40	0.46
Second-hand	0.85	0.79	0.08	0.10	0.14	0.11
Not in store	0.42	0.50	0.47	0.30	0.11	0.20
Repair	0.74	0.75	0.16	0.10	0.09	0.16

	Store Shares					
	Stand Alone Shops		Small Chains		Large Chains	
	1998-1999	2002-2003	1998-1999	2002-2003	1998-1999	2002-2003
Supermarkets	0.72	0.66	0.13	0.11	0.15	0.23
Food, Bev, Tob	0.79	0.76	0.15	0.16	0.06	0.07
Pharmaceutical	0.47	0.44	0.27	0.26	0.26	0.30
Other	0.61	0.62	0.22	0.18	0.18	0.20
Second-hand	0.88	0.79	0.06	0.09	0.12	0.12
Not in store	0.89	0.94	0.08	0.04	0.03	0.02
Repair	0.80	0.87	0.08	0.04	0.12	0.09

Notes: Stand-alone are retail firms comprising of a single store. Small Chains are multi-store firms operating in at most nine (out of the UK's 11) regions. Large Chains are shops belonging to firms in which are active in at least 10 of all 11 regions. Source: Authors' calculations from ARD

Table 3: Store Distributions, Small and Large Chains

Small Chains

	P25		Median		P75		Standard Deviation		Percentage Small (emp weighted)		Percentage Small	
	98-99	02-03	98-99	02-03	98-99	02-03	98-99	02-03	98-99	02-03	98-99	02-03
521	12.17	14.98	25.22	29.27	64.29	64.07	25.22	29.27	0.40	0.39	0.59	0.53
522	3.82	4.25	6.28	6.75	12.38	11.75	6.28	6.75	0.43	0.40	0.61	0.55
524	3.89	4.43	6.46	7.54	11.98	14.02	6.46	7.54	0.44	0.40	0.61	0.55
Rest	4.81	5.28	9.47	9.20	27.01	21.08	9.47	9.20	0.48	0.45	0.63	0.58

Large Chains

	P25		Median		P75		Standard Deviation		Percentage Small (emp weighted)		Percentage Small	
	98-99	02-03	98-99	02-03	98-99	02-03	98-99	02-03	98-99	02-03	98-99	02-03
521	31.14	22.51	72.45	56.82	140.52	117.52	72.45	56.82	0.43	0.51	0.61	0.67
522	3.94	3.94	6.09	5.93	8.77	9.04	6.09	5.93	0.52	0.41	0.65	0.54
524	6.72	7.54	11.58	13.44	23.22	29.36	11.58	13.44	0.37	0.30	0.57	0.47
Rest	4.85	4.96	8.83	8.58	27.04	19.50	8.83	8.58	0.37	0.35	0.60	0.52

Notes: The table summarises the characteristics of the store distribution of small and large retail chains. Small Chains are multi-store firms operating in at most nine (out of the UK's 11) regions. Large Chains are shops belonging to firms in which are active in at least 10 of all 11 regions. Percentage small is the fraction of shops below the median size of the chain in the base period (1997 and 1998).
Source: Authors' calculations from ARD

Table 4: Productivity and Chains' Stores Size

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	**ln(GO)**	**ln(GO)**	**ln(GO)**	**ln(GO)**	**ln(GO)**
Fixed effects	**NO**	**YES**	**YES**	**YES**	**YES**
ln(N)	0.2279***	0.2793***	0.2770***	0.2746***	0.2749***
Ln(Employment)	(0.0101)	(0.0278)	(0.0278)	(0.0274)	(0.0274)
ln(K)	0.0955***	0.0555***	0.0535***	0.0527***	0.0530***
ln(Capital)	(0.0082)	(0.0144)	(0.0144)	(0.0143)	(0.0143)
ln(M)	0.6581***	0.5024***	0.5026***	0.5026***	0.5023***
ln(Materials)	(0.0150)	(0.0405)	(0.0405)	(0.0403)	(0.0403)
Nat Chain	0.0030	0.0727***	0.0728***	0.0708***	0.0730***
National Chain dummy	(0.0127)	(0.0252)	(0.0249)	(0.0248)	(0.0251)
ln(median emp)	-	-	0.0261***	-	-
ln(Stores median employment)			(0.0095)		
Pct_N_small	-	-	-	-0.0712***	-
Percentage of small stores				(0.0193)	
Pct_emp_small	-	-	-	-	-0.0669***
Percentage of employment in small stores					(0.0198)
Observations	7469	7469	7469	7469	7469

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 1997-2003. The dependent variable in all columns is the log of gross output. All columns include year dummies and controls for region, age, multinational and multi-group status. All columns except 1 include firm level fixed effects. Standard errors in brackets clustered at the reporting unit level to correct for autocorrelation and heteroskedasticity of unknown form. National Chains are firms which are active in at least 10 of all 11 regions. Pct_emp_small and Pct_N_small are defined, respectively, as the share of employment and the share of stores below firm level median employment in the first year the firm is observed.

Table 5: Industry Breakdown

	(1)	(2)	(3)	(4)
Dependent Variable	**ln(GO)**	**ln(GO)**	**ln(GO)**	**ln(GO)**
Fixed effects	**YES**	**YES**	**YES**	**YES**
Sector	**521**	**522**	**524**	**Rest**
ln(median emp)	0.0394***	-0.0187	0.0379***	0.0022
ln(Stores median employment)	(0.0106)	(0.0320)	(0.0142)	(0.0156)
Pct_emp_small	-0.0355	-0.0496	-0.0654***	-0.0258
Percentage of employment in small stores	(0.0252)	(0.0520)	(0.0232)	(0.0438)
Pct_N_small	0.0189	-0.0876	-0.0623**	-0.0623
Percentage of small stores	(0.0259)	(0.0649)	(0.0298)	(0.0491)
Observations	1109	998	4292	1070

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 1997-2003. Each line corresponds to a different regression. The dependent variable in all columns is the log of gross output. All columns include year dummies and controls for capital, employment, materials, region, age, multinational and multi-group status. All columns include firm level fixed effects. Standard errors in brackets clustered at the reporting unit level to correct for autocorrelation and heteroskedasticity of unknown form. National Chains are firms active in at least 10 of all 11 UK regions. Pct_emp_small and Pct_N_small are defined, respectively, as the share of employment and the share of stores below firm level median employment in the first year the firm is observed.

Table 6: Robustness Checks

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	**ln(GO)**	**ln(GO)**	**ln(GO)**	**ln(GO)**	**ln(GO)**
Fixed effects	**YES**	**YES**	**YES**	**YES**	**YES**
ln(N)	0.2770***	0.2746***	0.2763***	0.2737***	0.2324***
Ln(Employment)	(0.0278)	(0.0274)	(0.0277)	(0.0274)	(0.0302)
ln(K)	0.0535***	0.0527***	0.0532***	0.0523***	0.0624***
ln(Capital)	(0.0144)	(0.0143)	(0.0144)	(0.0143)	(0.0117)
ln(M)	0.5026***	0.5026***	0.5022***	0.5021***	0.5865***
ln(Materials)	(0.0405)	(0.0403)	(0.0404)	(0.0402)	(0.0433)
Nat Chain	0.0728***	0.0708***	0.0726***	0.0705***	0.0295
National Chain dummy	(0.0249)	(0.0248)	(0.0247)	(0.0245)	(0.0206)
ln(median emp)	0.0261***	-	0.0263***	-	-
ln(Stores median employment)	(0.0095)		(0.0096)		
Pct_N_small	-	-0.0712***	-	-0.0731***	-0.0573***
Percentage of small stores		(0.0193)		(0.0194)	(0.0222)
Vt	-	-	0.0213**	0.0235**	-
Vertical Integration Dummy			(0.0106)	(0.0106)	
ln_T	-	-	-	-	0.0030
ln(Transport costs)					(0.0030)
Observations	7469	7469	7469	7469	5248

Notes:* significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 1997-2003. The dependent variable in all columns is the log of gross output. All columns include year dummies and controls for region, age, multinational and multi-group status. All columns include firm level fixed effects. Standard errors in brackets clustered at the reporting unit level to correct for autocorrelation and heteroskedasticity of unknown form. National Chains are firms active in at least 10 of all 11 UK regions. Pct_emp_small and Pct_N_small are defined, respectively, as the share of employment and the share of stores below firm level median employment in the first year the firm is observed. The vertical integration dummy takes value 1 if the firm has establishments active in wholesale (SIC51)

Table 7 - Growth Accounting

1	**SIC**	521	522	524	Rest	Total
2	**Industry weight**	58.17%	3.25%	33.19%	5.38%	
3	**Weighted TFP growth**	-0.28%	0.10%	0.56%	0.84%	0.07%
4	**Coefficient on log median employ**	0.0394	-0.0197	0.0379	0.0022	
5	**Median employ, 1997/8**	58.5	6.9	12.3	9.5	
6	**Median employ, 2002/3**	49.7	7.3	14.2	10.0	
7	**Coefficient * change in median employ**	-0.64%	-0.10%	0.54%	0.01%	
	Counterfactuals:					
8	**TFP growth, no change in med emp in 521**	0.36%	0.10%	0.56%	0.84%	0.44%
9	**TFP growth, no change in med emp all inds**	0.36%	0.20%	0.02%	0.83%	0.27%

Notes: Data are for SICs shown with total the employment weighted sum of the rows, using employment weights in Row 2. Row 4 is coefficient on median employment from Table 5. Growth rates are average annual growth rates between 1997 and 2003. Numbers in row 7 do not correspond exactly to row 4 *(row 6 – row 5) due to rounding in rows 5 and 6. Rows 8 is row 3 less row 7 for SIC521 and row 3 otherwise, row 8 is row 3 less row 9.

Chapter V: Retail Market Structure and Dynamics: Comparison of Japan, the UK and the US[1]

I. Introduction

Recent years have seen a revival in studying the economics of retailing. The emergence of large chains and allegations of possible market dominance have spurred interest on the IO side. The treatment of workers has been the subject of interest for labor economists. The stellar productivity performance of US retailing, and disappointing EU and Japanese performance have been studied by productivity economists.

On the productivity side, there are at least two broad hypotheses of interest. First, to the extent that productivity is affected by technology, there is renewed interest in economies of scale and scope in retailing. For example, it is suggested that smaller stores might be below minimum efficient scale, or that large retail chains can experiment with methods of selling, supply and HR practices and then transfer this knowledge across stores. In the UK, a major recent development has been the opening of many small stores by large chain retailers, which might lose economies of scale at each small store and scope. Second, recent work suggests that productivity growth is a function not only of technology and other shocks, but how firms and markets respond to these shocks. For example, a recent literature stresses the role of firm and establishment turnover in reallocating resources from less to more efficient producers – Foster,

[1] This chapter draws from joint work with J. Haskel, R. Jarmin and K. Motohashi.

Haltiwanger and Krizan (2003), Haskel and Sadun (2005) and Matsuura and Motohashi (2005). This suggests investigating the dynamics of competition and sorting, which might be affected by regulation: restrictions on opening hours in Germany, on out of town building in the UK, on zoning in the US.

Micro level data on stores and chains can be used to describe within-industry dynamics, and the role of firm and store size for. Furthermore, cross-country data is needed to take into account the fact that the institutions shaping the retail industry vary across countries. Therefore, we assemble comparable cross country micro data on market structure and dynamics to see how they might help explain differences in the productivity performance of the retail sectors in Japan, the United Kingdom and the United States.

We use a common research protocol applied to confidential micro data on retail firms and establishments for all three countries. The source of the data is that collected by national statistical offices in compiling the national accounts and other official statistics. The operational problem is that the data we use cannot leave the national statistical offices where they are collected and processed. This prevents us from pooling the micro data together. Instead, we perform our analysis on comparable and disclosable aggregations of the micro records, or in similar empirical exercises conducted at the firm or establishment level within each country for the 1997 to 2002 period. To the best of our knowledge, whilst there are micro studies on individual countries, this is the first paper to attempt a cross-country study for retailing using comparable micro data.

Our main findings are as follows. First, regarding statics, Japan has a relatively large number (per head of the population) of small stores (10 per head), with the US many fewer (4) and the UK in between (5). The US has bigger stores all round (average sizes are 13 in the US, 9 in the UK and 6 in Japan), so that small single unit shops are small in all countries, but the biggest single unit shops are largest in the US. Finally, chains, or multi-unit stores, are bigger in the US at all points in the size distribution of stores within the chain.

We also have some interesting findings regarding within-chain store sizes. Between the mid-1990s and early-2000s, the median store size in a US non-specialized store chain rose from about 140 to 155 employees. In the UK, it fell from about 80 to 40. Japan is dominated by continuing stores and chains with little churn. In the US and the UK there has been a long run fall in shares of mom-and-pop stores. We also look at changes of market shares over 5 years for chains in the US and the UK. The major difference is that there is very substantial churn in the US around entrants and initially small chains. In the US, such firms either gain market share or exit. In the UK, they are much more likely to stick where they are, typically in the bottom of the market share distribution and not exit.

Finally, to understand the possible implications for productivity, we look econometrically at whether chain productivity is lowered by having more small stores within the chain, for given overall chain employment. The same regression in both the US and the UK reveals a consistent answer, namely a positive and statistically significant association between chain productivity and median within-chain store size. To the extent this is causal, this suggests that the UK trend to smaller stores within chains would have lowered UK retailing productivity and the US trend to larger will have raised it.

The rest of the paper proceeds as follows. The next section sets out some overall productivity data to help motivate what we do. Section three sets out our data, section four our findings on statics and dynamics. Section five looks at chain productivity and within chain store size and section six concludes.

II. International productivity differences

To help motivate our investigation, we review retail sector productivity differences across Japan, the UK and US in both levels and growth rates. In Table 1, we show results from Timmer and Ypma (2006) on labor productivity (measured in terms of gross value added per person engaged) for the three countries between 1980 to 2002. First, note that both British and Japanese retailers are less productive than US retailers, and that the differential is growing over time. Second, while the U.S. exhibits a remarkable acceleration in productivity growth post 1995, in the U.K. retail sector the growth of productivity did not experience any major improvements, while the Japanese retail sector experienced negative productivity growth (Motohashi, 2002; Stiroh, 2003; and Doms, Jarmin and Klimek, 2004),

A variety of factors may underlie the differences in productivity levels and growth rates across the three countries. Differences in the regulatory and business environment (McKinsey, 1998) may restrict retailers, especially in Japan, from building stores and/or distribution networks that allow them to benefit from the same scale and scope economies as U.S. retailers enjoy. Foster, Haltiwanger and Krizan (2006) focus on the role of entry, exit and reallocation in driving industry level retail productivity growth in the U.S. In particular, they stress the role of large national retail chains that open new stores that replace smaller less efficient non-chain stores. Jarmin, Klimek and Miranda (2005) demonstrate the restructuring of retail markets – increasing dominance of larger national retail chains at the expense of small mom-and-pop shops – has been occurring for many decades and clearly predates the use of IT.

III. Data

Given the prevalence in retailing of multi-unit shops under common ownership it is useful to start with some nomenclature. We define a retailing entity at a single geographical address as a "store". A group of retail stores under single ownership is a "chain". A "firm" may be a single store, or a chain, depending on context, see below. Some country-specific issues are set out below.

III.A Japan

Data on the Japanese retail sector comes from the Retail and Wholesale Census (RWC) conducted by the Research and Statistics Department, Minister's Secretariat, Ministry of Economy, Trade and Industry (METI). This census survey covers all establishments in wholesale and retail trade. This survey started in 1952, and has been conducted every

3 or 5 years. The latest data available are from 2002. At this point, we do not yet have firm identifiers for Japan so in what follows we can carry out store-level analysis but not chain-level.

III.B UK

The UK business data come from multiple sources. The main source is the business register, called the Interdepartmental Business Register (the IDBR). This is compiled using a combination of tax records (on value added and payroll tax), information lodged at Companies House, Dun and Bradstreet data and data from other surveys. The IDBR tries to capture two broad measures. First, it tries to measure the structure of ownership of businesses using three aggregation categories: local units (LUs), enterprises and enterprise groups. A local unit is a single mailing address, which in the retailing context is a store. An enterprise is a chain of local units/stores under common ownership (e.g. a chain of supermarkets). An enterprise group is a group of enterprises under common ownership (e.g. a chain of supermarkets who also own a chain of garden centers). The second part of data provided by the IDBR is on turnover and employment[2].

Retail firms are required to provide details on turnover (total and broken down in retail and non-retail components, and by commodity sold), expenditures (employment costs, total materials and taxes), work in progress, and capital

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[2] Output information on the IDBR comes from Value Added Tax (VAT) records if the original source of business information was VAT data. Employment information comes from payroll tax data (called Pay As You Earn, PAYE) if that is the source of the original inclusion. If a single-local unit enterprise is large enough to pay VAT (the threshold was £52,000 in 2000/01) it would have turnover information at the enterprise and local unit level. On the other hand, if it does not operate a PAYE scheme, it will have no employment information. For the multi-local unit enterprise, no turnover information will be available for local units, since most multi-local unit enterprises do not pay VAT at the local unit level. If the PAYE scheme is operated at the local unit level, it would have independent employment data. There are two other ways in which more employment and output data are gathered. The first is if the business is included Annual Register Inquiry and the second if it is included in the Annual Business Inquiry (ABI). The Annual Register Inquiry (ARI) is designed to maintain the business structure information on the IDBR (Jones, 2000, p.51). The ARI currently covers around 68,000 enterprises, consisting of about 400,000 local units. It asks each enterprise for employment, industry activity and the structure of the enterprise. Most importantly for our work, it asks for employment of an enterprise's stores (local units). The ABI is the official ONS business survey, based on the IDBR, to ask for inputs and outputs and so generate value added for the national accounts (the Annual Respondents Database, ARD, consists of the panel micro-level information obtained from successive cross-sections of the ABI). The ABI is not a Census of all local units. This is in two regards: aggregation and partial sampling. Regarding aggregation, enterprises normally report on all their local units jointly. This is called a "reporting unit" (RU) but is typically an enterprise; for convenience we shall call it a firm.

expenditures (separately for acquisitions and disposals). Also, in the long format, firms answer on questions such as the total number of sites and the amount of squared meters they consist of. Other reported data at the RU level are total employment, wages and input costs and investment. The investment data are used to build up a capital stock database using the perpetual inventory method.

Usable UK retailing microdata is available for all year 1997-2003. Before 1997, the data are simply not available in electronic form. Since 1997 was the first year available, the data are quite noisy and so we will typically either begin our UK analysis in 1998 or average the 1997 and 1998 data.

III.C US

Data for US. retailers come from four sources. First, basic establishment (retail store or local unit) and firm (enterprise group in the UK context) demographic information is taken from the Longitudinal Business Database (LBD) maintained by the Census Bureau's Center for Economic Studies (Jarmin and Miranda [2002]). The LBD contains information for the entire universe of private business establishments with paid employees and is sourced from the Census Bureau's Business Register and is available annually from 1975 to the present. The LBD does not contain sufficient information to permit computation of productivity. Establishment data on retail sales are available from the quinquennial Census of Retail Trade conducted for reference years ending in 2 and 7. Given the availability of data from the other two countries, our focus here will be on 1997 and 2002. Unfortunately, the Census of Retail Trade does not inquire about gross margins, nor does it collect information about intermediate inputs, capital stocks or investment. The Business Expenditures Survey (BES) is conducted as part of the quinquennial Economic Censuses and collects information on purchases of intermediate inputs and services for the retail sector. However, the survey utilizes a hybrid reporting unit that roughly corresponds to a line of business within a firm. Linking micro records from the BES to the LBD or Census of Retail trade is feasible but subject to error as discussed in Doms, Jarmin and Klimek (2004). Finally firm level information on book values of capital stocks and capital expenditures is available at the firm level from the Annual Capital Expenditures Survey.

III.D Further data issues

In retailing there are a number of definitional issues that arise. First, on the definition of a chain, note that some firms change chain status between the base and final year. We use the final year to assign chain status. Second, in both the UK and the US data, a vertically integrated firm's stores are assigned to the industry they operate in (e.g. if local unit A is a supermarket and local unit B is a distribution centre, they have different industry codes). Thus we define the local unit according to the industry it is in and the firm according to the industry that the majority of local units are in. Third, there is a slight complication since a firm might have a number of stores in, say retailing, making it a chain in retailing, but only one local unit in say, wholesaling, making is a non-chain in wholesaling. We defined the firm as a chain if it was a chain in any of its industries. Fourth, in the UK and US data, a small number of stores have an employment of zero. We dropped these stores. Finally, we classify the data to ISIC industry definitions.

IV. Basic Facts on Retail Market Structure and Dynamics

IV.A Market structure and size distribution

Table 1 shows the basic structure of the retail trade sector for each country as of 2002. A number of features are worth noting. First, Japan has many more retail stores per person than does the UK or the US Second, US establishments and firms are on average the largest and Japanese establishments are the smallest. Third, the US also has the highest proportion of retail stores owned by multi location retail chains.

Table 2 focuses on non-specialized stores (ISIC 521). These data are of interest since they include large supermarkets and general merchandise stores, which have been the focus of much interest and in practice account for a large share of total retailing employment. The data here are employment-weighted, that is they are computed by (a) computing the average store size within all chains and (b) computing the median of that average, weighted by overall chain employment. This makes the data (in the UK at least) somewhat sensitive to very large chains, but also more representative of what the typical retail consumer or employee would encounter.

The data show a rise in all at all points in the distribution in the US, but a fall in the median and 10th percentile size in the UK. The rise in size in the UK at the 90th percentile is due to a very large 90th percentile point in 2003. If the UK data are not weighted, they show falling sizes at all points in the distribution and a less noisy pattern (due to the omission of very large weights on some high employment stores). UK results also show a decline at all points if weighted by the number of stores in the firm rather than total employment. Regarding weighting and US numbers, the unweighted numbers trend upwards for chain stores if restricted to those firms in NAICS 445110 (Supermarkets) that were classified as "national" chains in both 1997 and 2002. However, if one takes the medians for those national in 1997 and separately for those national in 2002, median store size falls. This is due to the fact that newly "national" chains are smaller, thus reducing the median by a compositional effect.

IV.B Dynamics

Having looked at the size distribution we turn now to dynamics. We look at a number of different dynamic measures: entry, exit, employment growth and transitions. Our main interest is to see if transitions look different across countries.

IV.B.1 Births and deaths

We show establishment birth and death rates for the retail sector as a whole for each country in Table 3. We report both establishment and employment weighted results and use the birth and death rate measure as in Davis, Haltiwanger and Schuh (1996).

Some interesting results emerge. In the U.S. and the U.K, establishment weighted birth and death rates are higher than employment weighted rates. This reflects that fact that larger establishments are less likely to have birth and death events, so that market churn is largely concentrated among smaller units. In Japan, this holds for death rates, but not for birth rates indicating relatively high entry for larger establishments and exit rates for smaller retail stores that are comparable to those in the U.S. and U.K.

More information on the average size of establishment births and deaths is given in Table 5. The first and last rows of the table provide the average number of employees at retail stores in the beginning and end of the 1997 to 2002 period for which we have comparable data at the micro level. The average size of retail establishments is increasing in all three countries. But we see a much larger role for new establishments in increasing the average retail store size in Japan, where new establishments are even larger than surviving establishments. In the U.S., new retail stores are slightly larger than exiting stores but are much smaller than continuing retail stores. In addition, continuing retail establishments exhibit substantial growth in the U.S. (nearly 47%), much more moderate growth in the U.K. (6%) and negligible growth in Japan (3%)

Table 4 suggests that the entry and exit of retail stores play a different role in changing the structure of retail markets across the three countries. In the U.S. market churn is characterized by many small units entering. Exits are also small, and there is substantial growth for continuers. In Japan and the U.K, we see that entrants are large relative to the average store size for the sector as a whole. More work is needed to confirm, but these patterns are suggestive that churning in the U.S. is consistent with market experimentation and selection, whereas churning in Japan and the U.K. is simply to replace less efficient mom-and-pops with large chain stores based on models first tested in the U.S. or elsewhere.

To compare retail sector churn across the three countries more systematically, we employ cell based regressions of the cross sectional dispersion of establishment and firm growth rates. To do this we proceed as follows. First, in the micro data we follow Davis, Haltiwanger, Jarmin and Miranda (2006) and for each store or chain, we compute employment growth between 1997 (1998 for the UK) and 2002 as:

$$\gamma_{it} = \frac{(x_{it} - x_{it-s})}{((x_{it} + x_{it-s})/2)} \tag{IV.1}$$

where x is employment. This has the advantage of using data on birth and death in the computation of employment growth rates. However, since we cannot use micro data we then aggregate these data into cells, defined by country, 3-digit ISIC, size class (8 size band classes) and single/multi-unit status groupings. We then calculate the average for each cell and the standard deviation of γ_{it} for all observations within the cell. Our objective to then compare formally how much cross-country difference there is. To do this, we then run the following regression, where the left hand side is the standard deviation of employment growth rates for cell i, country j in time t

$$sd(\gamma)_{ijt} = \beta_{JA} + \beta_{UK} + \sum_{k=1} \theta^k SIZEBAND^k{}_{ijt} + \mu MULTI + \lambda_I + \lambda_T + \varepsilon_{it} \tag{IV.2}$$

and the right hand side consists of our main variables of interest, namely country dummies for Japan and the UK (the omitted country is the US). We also include other controls (8 size band dummies, a single/multi-unit status, 3 digit ISIC dummies).

Results from establishment and firm level regressions using both the full and continuers only samples are shown in Table 5. The first column shows the establishment results when growth rates are computed for births and deaths as well as continuers. Our main interest is on the country dummies. Here we see that the Japanese retail sector exhibits dramatically less churn at the establishment level than either the U.S. or the U.K. Perhaps unexpectedly, the cross sectional dispersion of establishment growth rates is higher in the U.K. than in the U.S. Interestingly, however this is reversed when we consider only continuing establishments, where the standard deviation of employment growth is less than in the US, but more than Japan. One possibility is that there are some data error problems with large UK retail chains that have undergone mergers and acquisitions which can generate spurious entry and exit.

This would be particularly noticeable at the establishment level, since the chains operate many stores.

Column 2 and 4 show regressions where the micro unit of observation is the firm, defined as all retail stores operating under common ownership and control within a 3-digit ISIC code, and so the cells are the standard deviation of firm growth. We can only compare the U.K. and the U.S. since we currently do not have longitudinally linked firm level data for Japan. It is interesting to note that the difference in dispersion is much larger when looking only at continuing firms, where the standard deviation of growth rates for the U.S. retail sector is 7.8% greater than in the U.K. This is relative to a mean standard deviation of continuing firm growth rates of 60.4%. This compares to a 6.1% differential that is relative to a mean standard deviation of growth rates for all firms of 145.2%. Again, this may be partly due to errors in the U.K. data.

IV.B.2 Dynamics using transition matrices

We now study dynamics using transition matrices. Our method is as follows. We take firm employment for 1998 and 2002 in the UK and 1997 and 2002 in the US (so far we can only do this for the US and UK). There are n0 and n1 firms in the beginning and final cross sections, respectively, for which we compute employment based market shares within 3-digit ISIC industries. Thus, in the initial year we have n0 market shares, and in the final year we have n1. We then rank all the firms in each year and allocate each firm to a market share quintile (we tried deciles but cell sizes were too small). We deal with entry and exit as follows: if any firm was not present in the initial year but was in the final year, i.e. an entrant, we allocate them to a "birth" group in the initial year and they migrate to whichever group they're observed in for the final year. Likewise for exitors, in the final year they're classified as a death with the initial year classification being what they were last observed in. Therefore, every firm in the data set, including entrants and exitors, will have two markers from 1 to 6 in both the base and final year. We then tabulate the base against the final year, which gives us the numbers in each cell. We can then express this as a fraction of the total number of firms over the period, i.e. the sum of continuers, entrants and exitors.

The results for the transition matrix of market shares are set out in Table 6. Each cell is the fraction of the total number of firms. The top row shows the final year market share quintiles where of the firms who entered after the initial year. The first column shows the initial year market share quintiles of the firms who exited before the final year. Moving to the rows and columns 1 to 5 which refer to the stayers, the diagonal elements show the fractions of the total remaining in the same quintile over the years. The upper off diagonal elements show the fraction of the total moving upwards and the lower-off diagonal the fraction of the total moving downwards. The sums of these three groups are shown as well.

The matrices suggest that in comparing the US and the UK, there is (a) overall more "fluidity" in the US and that (b) this is concentrated in the small market share US firms being able to become large market share firms. First, the sum of the diagonal elements in the UK (27%) exceeds that of the US (21%), suggesting that UK firms are more likely to stick in their market shares. Second, looking at the elements themselves, it is apparent that the high market share firms in the US and UK are both equally likely to keep their market position. The reason that UK diagonal sum is higher is because the low market share firms are more likely to remain low market share in the UK. Third, the proportion of firms moving up the distribution in the UK and US is about the same, whereas the proportion moving down is less in the UK (38% of US firms move up, 36% of UK, 41% of US firms move down, 37%of UK). Thus, market selection of poorly performing firms seems less pronounced in the UK (market selection in the sense of firms moving down the distribution but still remaining in business). Fourth, the top row suggests that entrants in the US are more likely to progress into the top quintile of market share whereas in the UK they are more likely to remain in lower quartiles.

We now analyse in Table 7 how employment grows by the employment share quintiles. This enables us to see whether employment growth is in the firms who stay in the top quintiles, in those who are rising up the distribution etc. To do this, we took all employment in 1997 and assigned it to quintiles of the market share distribution in 1997 and 2002. Thus, for exitors we assigned, just as we did above, each exitor to its five market share quintile and calculated five total employment numbers. For firms who remained in quintile 1, we calculated the total employment in 1997 of those firms, likewise for other quintiles. We then did the same for employment in 2002: e.g. for firms who remained in quintile 1, we calculated the total employment in 2002 of those firms. We then calculated employment growth numbers for each quintile and also the employment growth rates (using the DHS formula).

An important feature of the data for each country is that employment change, positive or negative is concentrated in births and deaths. The single exception to this is the large increases in employment at firms that are in the top employment quintile in both the initial and final periods. Comparing the US and UK, we again get a picture of increased dynamism at the bottom in the US. Looking at the employment growth numbers, great part of employment growth is accounted for in both countries by entrants who get to the top and stayers who remain at the top. Looking at the employment growth rate numbers, the top stayers on the diagonal have similar growth rates. However, in the UK it is notable that the middle stayers on the diagonal have been contracting, whereas the lowest diagonal quintile has been growing. This contrasts with the US where the lowest diagonal quintile has been falling with growth in the other quintiles.

V. Impact of Structure and Dynamics on Retail Productivity

Given the evidence presented on scale and on market churn for the three countries, we now want to see how this impacts the productivity differences that motivate the paper. There are at least two ways to do this. First, we might consider that store size matters for economies of scale at the store level, but also for economies of scope for chains. The former is due to the kind of fixed cost effects discussed in Oi (1992). The latter might be due to the idea that large chains use organizational capital across stores (an economy of scope). When they learn how to use bigger stores, they gain a scope economy when opening additional large stores. But if they open a small store they might not be able to use that knowledge as effectively.

Second, we would like to see how differences in retail market dynamics across the countries affect productivity growth. The usual method is to try decompositions as in Foster, Haltiwanger and Krizan (2002) (FHK) and compare them across countries. The problem here is that productivity can only be computed at the firm level for the UK, as is TFP for US retailers. Receipts per worker (crude proxy for labor productivity) can be constructed for U.S. establishments. But most of the data needed for compute productivity are at the firm level. This and the short time period would reduce the effectiveness of FHK type decompositions in examining the impact of retail market dynamics on productivity.

Therefore we confine ourselves here to study scale issues. We do this following the methodology exposed in Chapter IV, by running the following regression for chain c in year t,

$$\ln Q_{ct} = \gamma_1 \ln N_{ct} + \gamma_2 \ln MEDSIZE_{ct} + \gamma_3 CHAINTYPE_{ct} + \lambda_t + \lambda_I + \varepsilon_{ct} \qquad \text{(V.1)}$$

where Q is sales of the chain, with total employment N, CHAINTYPE is a dummy indicating a national or sub national chain (not essential), and the other terms are fixed effects for the industry and year. The crucial variable is MEDSIZE, some measure of the within-chain employment distribution. Our experiments suggested that log median size of the within-chain store seemed to give the most robust findings. We also looked at the fraction of within-chain stores who are small, where small is defined as the fraction of shops below the median size of the chain in the base period (1997-8). We also looked at regressions with fixed effects and obtained similar results. The results using log median size (logMSS) are set out in Table 8. The table shows that the coefficient on logMSS is positive and significant for the UK and both US data sets using long and short time periods. This positive association between store size and chain productivity is consistent with the idea that a move to smaller-sized stores within chains lowers measured productivity.

A number of points are worth making. First, these are of course associations in the data and should not be interpreted causally (although it might be interesting to use US logMSS in like regions as an instrument for UK logMSS and vice versa). Second, due to data availability we do not have current Japanese data or data on other inputs. Third, measured productivity in retailing might change due to changing assortment and ambience rather than changes in physical outputs per person (Betancourt 2004). Fourth, it is of interest that the coefficient varies between the UK and US, being higher in the UK. One possibility is that UK chains, whose median size is smaller, have a greater marginal effect on productivity.

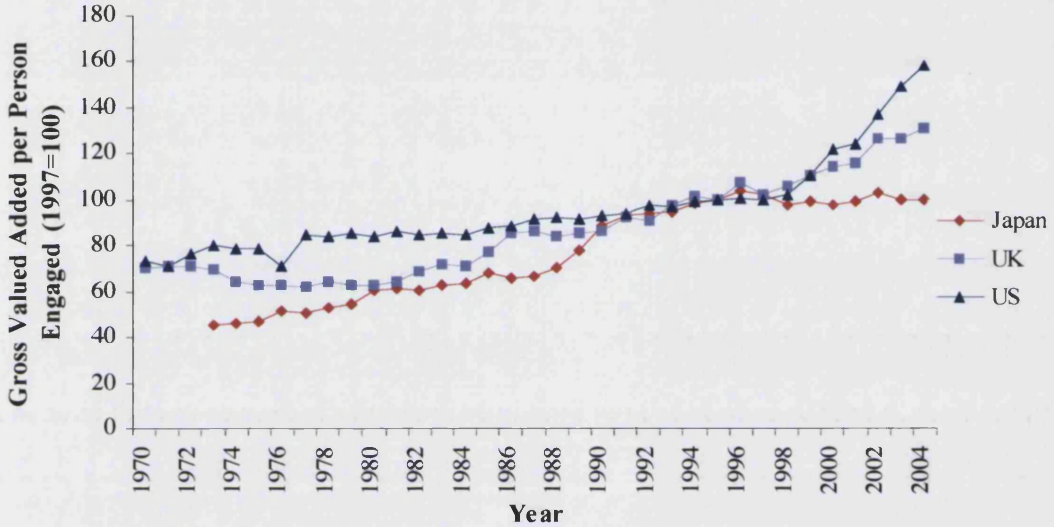
VI. Conclusion

This paper uses internationally comparable microdata to document features of the retail sectors in Japan, the United Kingdom and the United States. We study store and chain sizes, entry, exit and market share transitions. Our main findings are of the relative dominance of small single stores in Japan and large chains in the US. For example, in 2002, stores per 1000 of the population are 4 in the US, 6 in the UK and 10 in Japan. Chains account for 39% of US retail stores, 32% in the UK and 26% Japan. The US also seems to have larger churn of stores and, relative to the UK, an increased propensity of chains to show "up or out" behavior: low market share chains either gain market share or exit. Of all US chains in 1997, 21% are in the same market share ranking 5 years later and 27% in the UK, 41% in the US have moved down or exited and 37% in the UK. Of entrants, 27% of US entrants are in the bottom market share quintile 5 years later, but 46% of UK entrants.

We have also seen increases in the median size of stores in non-specialized store chains in the US, but decreases in the UK. Between 1998/9 and 2002/3, the median store size in a US food chain rose from about 140 to 155 employees. In the UK, it fell from about 80 to 40. Our econometric work suggests a positive and statistically significant association between chain productivity and median within-chain store size. To the extent this is causal, this suggests that the UK trend to smaller stores within chains would have lowered UK retailing productivity and the US trend to larger will have raised it.

There are clearly a number of areas to explore further. First, on data, we currently have somewhat incomplete Japanese data, and there are always data problems in ensuring comparability across countries. Second, it would be of interest to explore more how competition from large chains has affected single stores in different countries.

Figure 1: Retail Sector Gross Value Added per person engaged.



Notes: The graph shows the evolution of labour productivity (gross value added per person engaged over time, 1997=100), across the US, UK and Japan. Source: Timmer and Ypma (2006)

Table 1. Retail Market Structure, year=2002

	Japan	US	U.K
Number of Establishments	1,273,904	1,114,637	334,627
Establishments per 1,000 people	10.03	3.94	5.64
Number of Firms	n.a.	717,553	241,634
Single Unit Establishments	839,993	685,044	228,189
Multi Unit Establishments	326,167	429,593	106,438
Total Employment	7,146,228	14,647,675	2,984,376
Average Establishment Employment	6.13	13.14	8.92
Average Firm Employment	n.a.	20.41	12.35

Notes: The table refers to the population of retail establishments in Japan, the US and the UK in 2002.

Table 2. Store distributions, Non-specialized Retail Chains (ISIC 521)

		1998/9	2002/3
US	90th	233	282
	Median	142	152
	10th	79	82

		1998/9	2002/3
UK	90th	343	374
	Median	61	43
	10th	22	18

Notes: columns are averages of 1998/9 and 2002/3 data. Data are calculated by (a) computing the average store size within all chains and (b) computing the median of that average, weighted by overall chain employment.

Table 3. Basic Results on Dynamics

DHS Establishment birth and death rates

	Japan	US	UK
	% of Establishments		
Death Rate	34.89%	40.85%	37.53%
Birth Rate	17.14%	40.14%	35.68%
	Employment weighted		
Death Rate	28.30%	26.19%	31.57%
Birth Rate	25.24%	27.99%	32.78%

Notes: The table is calculated over the population of retail stores in 2002 and 1997 (1998 for the UK). Death and birth rates are calculated using the Davis, Haltiwanger and Schuh (1996) formula.

Table 4. Beginning and End Year Average Establishment Size Births, Deaths and Continuers (1997-2002)

	Average Establishment Size		
	Japan	US	UK
avg. employment of all establishments in year 1	5.02	12.51	7.97
avg. emp of estabs in both years (continuers) year1	5.47	15.59	8.74
avg. emp of estabs in both years (continuers) year2	5.63	22.90	9.32
avg. emp of estabs in year 1 but not year 2 (deaths)	4.55	8.22	6.71
avg. emp of establs in year 2 but not in year1 (births)	8.26	8.94	8.19
avg. employment of all establishments in year 2	6.32	13.14	8.92

Notes: The table refers to the population of retail establishments in Japan, the US and the UK in 1997 (1998 for the UK) and 2002.

Table 5. Growth rates by Size Bands and Industry, UK and US

Dependent Variable: standard deviation of employment growth

	(1)	(2)	(3)	(4)
	All Establishments	**All Firms**	**Continuing Establishments**	**Continuing firms**
Multi-Unit	0.023*	-0.179***	-0.03***	0.049***
	(0.015)	(0.019)	(0.007)	(0.014)
Emp<2	0.38***	0.217***	0.007	-0.122***
	(0.039)	(0.046)	(0.024)	(0.042)
2<=Emp<5	0.203***	0.122***	0.02*	0.006
	(0.026)	(0.027)	(0.014)	(0.022)
5<=Emp<10	0.196***	0.049***	0.051***	-0.025*
	(0.024)	(0.025)	(0.012)	(0.019)
10<=Emp<25	0.174***	0.037**	0.07***	-0.056***
	(0.022)	(0.022)	(0.011)	(0.016)
25<=Emp<50	0.133***	0.039**	0.067***	-0.047***
	(0.024)	(0.023)	(0.012)	(0.017)
50<=Emp<75	0.082***	-0.0002	0.048***	-0.073***
	(0.027)	(0.028)	(0.013)	(0.02)
75<=Emp<100	0.08***	-0.002	0.034***	-0.075***
	(0.03)	(0.033)	(0.015)	(0.024)
Emp>=100	omitted	omitted	omitted	omitted
Dummy Japan	-0.927***	NA	-0.246***	NA
	(0.016)	(NA)	(0.008)	(NA)
Dummy UK	0.044***	-0.061***	-0.047***	-0.078***
	(0.018)	(0.012)	(0.011)	(0.009)
Dummy US	omitted	omitted	omitted	omitted
Observations	351	279	333	260
3 Digit ISIC Controls	yes	yes	yes	yes

Notes:* significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all columns is the standard deviation of employment growth between 1997 (1998 for the UK) and 2002. The unit of observatio is a size band within an ISIC 3 retail sector.

Table 6. Transition Matrices, Market Share

Firm Size Class Transition Matrices
% of Firms

1998 Size Quintile (based on Employment)	UK - 2002 Size Quintile (based on Employment)						
	Deaths	**1**	**2**	**3**	**4**	**5**	**1997 Total**
Births	**0.00%**	10.99%	4.50%	3.09%	2.94%	2.61%	24.13%
1	10.08%	**8.09%**	1.31%	0.91%	0.74%	0.30%	21.42%
2	6.81%	2.20%	**4.74%**	1.75%	1.28%	43.00%	17.21%
3	3.91%	0.66%	1.09%	**3.19%**	2.60%	73.00%	12.17%
4	3.40%	0.38%	0.63%	1.48%	**3.88%**	1.64%	11.41%
5	3.91%	0.19%	0.21%	0.45%	1.53%	**7.37%**	13.66%
2002 Total	28.11%	22.50%	12.48%	10.87%	12.96%	13.07%	**100.00%**

1998 Size Quintile (based on Employment)	US - 2002 Size Quintile (based on Employment)						
	Deaths	**1**	**2**	**3**	**4**	**5**	**1997 Total**
Births	**0.00%**	8.55%	7.16%	6.34%	5.61%	4.55%	32.21%
1	9.45%	**2.48%**	0.99%	0.34%	0.16%	0.06%	13.49%
2	7.36%	1.31%	**3.19%**	1.27%	0.33%	0.10%	13.56%
3	6.30%	0.50%	1.49%	**3.67%**	1.44%	0.22%	13.62%
4	5.54%	0.25%	0.37%	1.42%	**4.56%**	1.42%	13.56%
5	5.01%	0.10%	0.12%	0.24%	1.17%	**6.94%**	13.57%
2002 Total	33.65%	13.19%	13.34%	13.27%	13.28%	13.28%	**100.00%**

Notes: The table refers to the population of retail firms between 1998 and 2002 in the UK and 1997 and 2002 in the US. The numbers represent the percentage of retail firms moving across the different portions of the employment distribution.

Table 7 Transition Matrices, Employment

Firm Size Class Transition Matrices
Change in Absolute Number of Jobs

1998 Size Quintile (based on Employment)	UK - 2002 Size Quintile (based on Employment)						
	Deaths	**1**	**2**	**3**	**4**	**5**	**1997 Total**
Births	**0**	40,924	30,496	28,513	44,228	468,148	612,309
1	-33,895	**855**	4,539	5,103	7,965	8,235	-7,198
2	-46,503	-3,258	**-134**	5,725	10,686	10,166	-23,318
3	-39,209	-3,276	-3,731	**-1,658**	9,374	16,386	-22,114
4	-52,095	-3,713	-4,598	-6,730	**-383**	22,465	-45,294
5	-654,502	-5,128	-5,246	-8,854	-19,688	**401,612**	-291,806
2002 Total	-826,204	26,404	21,326	22,459	51,582	927,012	**222,579**

1998 Size Quintile (based on Employment)	US - 2002 Size Quintile (based on Employment)						
	Deaths	**1**	**2**	**3**	**4**	**5**	**1997 Total**
Births	**0**	99,991	183,998	263,666	407,240	1,288,299	2,243,194
1	-151,718	**347**	12,221	10,187	8,246	6,894	-113,823
2	-215,932	-11,144	**2,430**	18,802	14,793	14,301	-176,750
3	-295,697	-11,678	-12,921	**7,777**	33,658	21,823	-257,038
4	-466,117	-12,374	-12,254	-19,047	**19,583**	86,002	-404,207
5	-2,462,301	-14,390	-17,518	-21,803	-60,297	**1,802,537**	-773,772
2002 Total	-3,591,765	50,752	155,956	259,582	423,223	3,219,856	**517,604**

Notes: The table refers to the population of retail firms between 1998 and 2002 in the UK and 1997 and 2002 in the US. The numbers represent the change in the number of jobs associated with retail firms moving across the different portions of the employment distribution.

Table 8 Gross Output Regressions - Chain Stores Only

	Dependent Variable is Log(sales)					
	U.K.		U.S.-1		U.S.-2	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
log(N)	0.972	0.009	0.994	0.002	0.99	0.003
log(MSS)	0.081	0.014	0.009	0.002	0.017	0.003
Chain Dummies	Yes		Yes		Yes	
Year Dummies	Yes		Yes		Yes	
ISIC Dummies	Yes		Yes		Yes	
R-Squared	0.929		0.849		0.85	
Observations	7478		366667		115003	

Notes: U.S.-1 model estimated on all available Economic Census Observations for 1977, 1982, 1987, 1992, 1997 and 2002. U.S.-2 moded estiamted on 1997 and 2002 data only.

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