Analysis of firm structures and outsourcing in Great Britain

Final report

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1 Summary

This project provides empirical evidence on firms' demographic characteristics and the extent of specialisation and vertical integration of British firms across industries. Our interest in conducting this descriptive analysis lies in answering the questions:

- How much of the shift in aggregate activity in Great Britain from production to services can be accounted for by reorganisation and outsourcing of the provision of goods and services?
- What fraction of business-to-business transactions are conducted within firms versus in the market?
- How does this vary across industries and over time?
- How feasible is it, with the available data, to learn more from further work investigating the correlations between vertical integration with other firm and industry characteristics? To what extent would such work shed light on the role of globalisation and technical change on those changes?

We provide empirical evidence on the aggregate growth of the service sector and the role of increasing specialisation; on firms' demographic features and the extent of vertical integration of British firms across industries. We discuss the last point in the concluding section. Here we summarise our main findings.

The main features regarding the increasing importance of the service sector and the role of specialisation in the last two decades are:

- Manufacturing industries account for most of the decline in the share of production industries in employment; whilst business services account for most of the growth in the share of services activities in employment.
- Business services have been one of the fastest growing sectors in terms of employment in the UK between 1984 and 2001 and accounted for around one-third of total UK gross output growth. UK-based firms' purchases of business services accounted for a half of this, of which one-third was due to firms increasingly using business services produced in specialised plants. These figures suggest a big increase in the extent to which UK firms are restructuring the production of business services, either by specialising within the firm, or by outsourcing to other UK firms.

- The biggest shift from manufacturing to business services due to outsourcing and specialization happened between 1984 and 1990. Over the 1990s, the increase in specialisation and outsourcing of business services was driven mainly by business services themselves and other service sectors, such as financial intermediation.

The main findings regarding firms' demographics are:

- Most firms are stand alone establishments
- Firms that are part of a group account for over half of total employment among private enterprises.
- The proportion of firms that are part of a group is higher in "manufacturing", "electricity, gas and water supply" and "financial intermediation".
- The proportion of active firms in 2005 that changed ownership between 2005 and 2004 is 2% and the proportion that changed industry is 3.5%; most of them were stand alone firms in 2005.
- Comparing these figures (for 2005) with firms' demographic characteristics in 1998, the picture is very similar.

Regarding the extent of vertical integration:

- We first discuss important methodological issues related to what we mean by specialisation and vertical integration and how we can measure it given the data we have available.
- We start by considering which industries are potentially vertically linked; from the Input Output table there are 10,071 vertically linked industry pairs, and 1,488 where intermediate purchases from that supplier account for over 1% of total costs of that producing industry.
- On average a producing industry sources inputs from 83 different supplying industries out of 122. Industries vary in the importance of intermediate inputs relative to total costs (the sum of intermediate inputs and employees' costs). On average, intermediates inputs account for two-thirds (67%) of costs (with a standard deviation of 11%).
- Looking at firms' vertical linkages summed up across all suppliers, we see that "Telecommunication" and "Banking and Finance" are among the producing

industries with the highest percentage of intermediate costs that are supplied from within the firm, by vertically integrated suppliers (around 35% and 30% respectively).

- "Agriculture", "Hotels, catering and pubs" and "Legal activities" industries are among the producing industries with the lowest percentage of intermediate costs that are supplied from within the firm, by vertically integrated suppliers (less than 1% in all cases).
- Comparing the ranking of industries with the highest vertical linkages in 2005 to those in 1997, most (six out of ten) of the top ten industries in 2005 are also among the ten industries with the highest vertical linkages in 1997.
- Looking at the whole economy by aggregate producing sector over time (years 1997, 2001 and 2005), it seems that there has been a decrease in the degree of vertical integration in manufacturing industries and also in electricity, gas and water supply. Simultaneously, we see an increase in the degree of vertical integration in financial intermediation.

2 Research aims and background

This report provides a descriptive analysis on existing corporate structures in Great Britain with regard to vertical integration and outsourcing. This descriptive analysis directly addresses the question: to what extent do UK based firms source intermediate inputs from within the firm versus in the market, and how does this vary across industries?

The recent economics and business literatures and the popular press have emphasised the idea that recent technological developments (in particular, the rapid decline in the cost of information and communication technologies) and globalization have transformed the internal organization of the firm. For example, it is argued that new technologies are creating a shift from the old integrated firms towards more de-layered organizations, greater specialisation and increased sourcing of non-core activities from outside the firm (outsourcing).[1] It is also often maintained that the greater competitive pressures created by

[1] Breshanan, Brynjolfsson and Hitt (2003) find that IT use is associated with more decentralized decision-making within firms. Similarly, Acemoglu et al. (2005) show that in a sample of French firms, higher productivity firms are more likely to be decentralized. Helper (1991), on the other hand, documents the increase in outsourcing in the U.S. automobile industry.

both globalization and advances in information technology favour smaller firms and more flexible organizations that are more conducive to innovation.[2]

Despite the importance of these issues in the public debate and a large theoretical literature on vertical integration,[3] there is still little comprehensive empirical evidence on the way that firms are structured, how they have changed, and what the key drivers of these changes are.

We start by providing a description of changes in the degree of specialisation using aggregate level data. The bulk of the report is concerned with providing a comprehensive descriptive analysis of the structure of corporate activity undertaken in the Great Britain using plant level data. Specifically, we describe the extent to which firms are vertically integrated with their suppliers.[4] We discuss measurement issues, and what we can learn from the existing data, in detail. We pay most attention to the situation in 2005 (the latest year for which data is available), and report how this differs from the situation in 1997 (the earliest date for which data on the whole economy are available).

Our interest in conducting this descriptive analysis lies in answering the questions:

- How much of the shift in aggregate activity in Great Britain from production to services can be accounted for by reorganisation and outsourcing of the provision of goods and services?
- What fraction of business-to-business transactions are conducted within firms versus in the market?
- How does this vary across industries and over time?
- How feasible is it, with the available data, to learn more from further work investigating the correlations between vertical integration with other firm and industry characteristics? To what extent would such work shed light on the role of globalisation and technical change on those changes?

This final report summarise the research findings on these issues. The code and secondary data is lodged in the ONS data laboratory.

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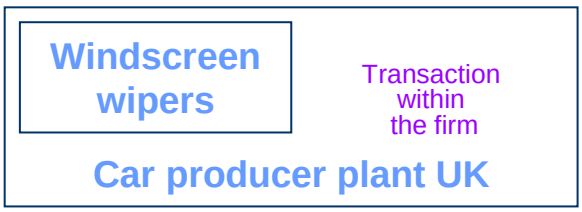
[2] See, for instance, Milgrom and Roberts (1990), Athey and Schmutzler (1995) and Marin and Verdier (2002, 2003). See also Feenstra and Hanson (1996, 1999), and Feenstra (1998) on trade and decentralization.
[3] See, among others, Klein, Crawford and Alchian (1978), Williamson (1975, 1985), Grossman and Hart (1986), Hart and Moore (1990), Bolton and Whinston (1993), Aghion and Tirole (1994a,b and 1997) and Legros and Newman (2003), and the surveys in Holmstrom and Tirole (1989) and Hart (1995).
[4] We follow the methods used in Acemoglu, Aghion, Griffith and Zilibotti (2005).

Before turning to our analysis it is useful to clarify what we mean by vertical integration and what our measures are capturing. Consider the following example. To produce a car a producer needs windscreen wipers. There are alternative ways of organizing the provision of windscreen wipers to produce cars:

Case 1: Windscreen wipers are produced within the same plant

→ vertical integration (in-house production)



Case 2: Windscreen wipers are produced in a specialised plant, owned by the same firm

→ vertical integration

Case 3: Windscreen wipers are produced in a specialised plant, owned by a different firm

→ no vertical integration / contracting out / outsourcing

In the next section we use aggregate data to look at the extent to which the organisation of activity has shifted from case 1 to cases 2 and 3. We can do this using data from the Input-Output tables. The Input Output tables provide information about the demand for and supply of products in terms of 123 industries and 123 products. The data underlying the Input Output tables are micro-level data on the transactions between establishments, either owned by the same firm or unrelated establishments (see Appendix B for more information regarding the

Input Output tables). In order to distinguish between cases 2 and 3 we also need to have information on ownership - for this we need to use the micro data held at the ONS.

In these data we do not observe plant's usage of inputs (windscreen wipers in our example), nor do we observe whether it produces them in-house, purchase them from the market or source them from another plant within the firm. We observe the average usage of all inputs sourced from outside the plant for all producing industries from the Input Output tables. This includes all inputs that are not produced in-house, so they could be produced within the firm or bought in the market. This determines whether industries are vertically linked, but does not tell us whether a firm is vertically integrated or not; we call this "producers' technology".

We observe the ownership structure of all firms and plants in the Great Britain from the BSD; so we can determine whether a firm that owns a plant that produces a good, also owns a plant that produces an input. We assume that if a firm in owns a plant in both producing and supplying industries it can supply the full quantity of inputs it needs. In our analysis using the Input Output Table we assume that firms in an industry produce a single product, so that we refer to products and industries in an interchangeable way.

It is worth mentioning that our measure does not capture when a firm based in the UK is vertically integrated outside the UK. This is because, although the Input Output table includes imported inputs (both intra-firm trade and trade between firms), we do not observe from where these inputs were imported, and whether firms based in the UK have activities abroad. Hence, our measure captures the extent to which firms in the UK outsource intermediate inputs from other firms based in the UK, and does not consider the extent to which firms in the UK source inputs offshore from vertically related affiliates.

The next section gives an aggregate picture of the growth in services and the extent to which production has become more specialised over the past two decades. In section 4 we describe the data use and some demographic features. Section 5 explains how we measure vertical linkages between firms and discusses the descriptive statistics. Section 6 provides some conclusions and a discussion for further work. In the Appendices we provide a discussion of some of the literature on vertical integration, provide detailed information about the datasets we use and how we use them, and present some additional results.

3 Aggregate growth in services and increased specialisation

One of our main interests in conducting this descriptive analysis lies in answering the question: how much of the shift from production activities to services can be accounted for by reorganisation and outsourcing of the provision of goods and services? In this section, we discuss some aggregate trends and calculate how much of this economic shift from production to services is accounted for by reorganisation and outsourcing of the provision of goods and services. This analysis draws on Abramovsky, Griffith and Sako (2004).

3.1 Aggregate trends

Most developed economies have experienced a shift in economic activity towards the service sector over the last two decades, as revealed in a number of output and employment statistics.[5] In Great Britain aggregate civilian employment figures show that there has been a continuous shift of economic activity from the production industries towards services during the last two decades. Figure 1 shows that the employment share in the production industries has declined from 35% in 1982 to just over 20% in 2005; at the same time the share in the service sector has reached almost 80% in 2005, from around 63% in 1982.[6]

The decline in production industries can be accounted for to a large extent by the decline in manufacturing activities. At the same time, one of the most rapidly growing services activities in the last two decades has been the production of intermediate services (services consumed by other firms rather than final consumers). Figure 2 shows that the employment share in manufacturing industries has declined from 25% to under 15%; whilst the employment share of services such as financing, insurance and intermediate business services has increased from less than 10% to over 15%.

What is driving these changes? In part it is due to changes in technology that have led to changes in the importance of labour, capital and technology in the production process - these changes may have been different across industries. Producers of final goods and services are

[5] See, for instance, "Labor Statistics" (OECD, 2006); and "The Service Economy" (OECD, 2000) for a discussion of the major role the service sector is playing in OECD economies.

[6] Agriculture includes the activities "Agriculture, hunting, forestry and fishing" and "Mining and quarrying"; production includes "Manufacturing"; "Electricity, gas and water" and "Construction"; and services include "Wholesale and retail trade; restaurants and hotels"; "Transport, storage and communication"; "Financing, insurance, real state and business services" and "Community, social and personal services".

increasingly using intermediate services and intangible assets in production.[7] For example, figure 3 shows that software investment has significantly increased in the last two decades, as a percentage of UK gross domestic product, from 0.4% in 1982 up to 2% in 2003. Related to this, firms also may be changing the way they source these services, from in-house production towards more specialised and independent providers. In the next section, we calculate how much of the increase in the economic importance of business services is associated to changes in the way firms organise the production and provision of services.

3.2 The role of specialisation and outsourcing

We start by using industry level data from the Input Output tables to calculate how much of the growth in business services is associated with changes in the way firms organise the production and provision of services. In Abramovsky, Griffith and Sako (2004) we documented that business services[8] have been one of the fastest growing sectors in terms of employment in the UK over the past two decades and accounted for around one-third of total UK output growth between 1984 and 2001. In order to calculate how much of the growth in each sector is accounted for by increased specialisation and outsourcing we carry out the following decomposition of total UK gross output growth:

$$\Delta Y_{kt} = \sum_j \Delta DID_{jkt} + \Delta DFD_{kt} + \Delta X_{kt} \quad (1)$$

where Y denotes UK domestically produced gross output; j denotes producing industry; k, supplying industry; DID is demand by UK-based firms for intermediate consumption and investment; DFD is domestic final demand; X refers to exports. The difference operator Δ denotes the difference between periods t and t-1. The total UK gross output growth in any period is given by $\sum_k \Delta Y_{kt}$. Note that Y measures gross output and hence we are not measuring UK total gross domestic product in this calculation, but the sum of the growth in each sector's gross output (which includes both the sector's value added plus the sector's value of its use of intermediate inputs).

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[7] See, for example, Haskel and Giorgio Marrano (2006) for an estimate of how much the UK economy invest in intangible assets.

[8] Abramovsky, Griffith and Sako (2004) define "Business Services" as services that are provided to other business, rather than directly to the public. They include Computer Services, Professional Services (Legal, Accountancy, Market Research, Technical, Engineering, Architectural, Advertising and Consultancy), Research and Development, as well as other services such as Labour Placement Agencies and Call Centres. They exclude financial services.

The first term of equation (1), $\sum_j \Delta DID_{jkt}$, refers to an increase of other businesses' demand for product k for intermediate consumption and for capital goods. The part related to intermediate consumption can be decomposed in two main components: i) a change in intermediate demand for product k from businesses in sector j due to a change in the total demand for (or gross output of) sector j; and ii) given the demand for sector j, a change in the intensity with which businesses in sector j uses product k as an intermediate input. Then the first term of equation (1) can be written as follows:

$$(2) \qquad \sum_j \Delta DID_{jkt} = \sum_j \Delta Y_{jt} S_{jkt-1} + \sum_j Y_{jt-1} \Delta S_{jkt} + \sum_j \Delta Y_{jt} \Delta S_{jkt} + \Delta I_{kt}$$

where Y refers to gross output; S is share of good k in costs of production of j; and I refers to demand for investment (or gross fixed capital formation).[9] The second term in equation (2) measures the change in gross output in supplying industry k that is associated with changes in the intensity with which firms in industry j use good or service k, as an input to produce good or service j. This is what we refer to as a change in specialisation and outsourcing. The term ΔS_{jkt} captures changes in specialisation and outsourcing, and these can be associated to both changes in technology (firms use more intensively these specialised inputs) and changes in the ways firms organise the production and provision of these inputs (firms use these inputs to the same extent as before, but previously they generated product k in-house). Note that this includes specialisation within the firm (case 2 in our example above) as well as outsourcing (case 3 in our example above).

The second term in equation (1) refers to changes in domestic final demand, and this includes demand of consumption goods by households, government, and other final consumers and demand of capital goods by households, government and businesses. The third term in equation (1) refers to exports and these are goods and services sold to firms based outside the UK.[10]

[9] We assume that the demand for capital goods (I) comes mainly from other businesses, which is reasonable in the case of business services. This would not be the case for the supplying sector construction, where an important proportion of the demand for capital goods comes from households.

[10] The Input Output tables provide the total value of exports for each supplying industry k, which could be sales to both final consumers and businesses. In the case of business services, it is reasonable to assume that most of these exports are sold to other businesses.

3.2.1 The aggregate picture

Over the period 1984 to 2001, UK gross output grew from approximately £1,000 billion to £2,000 billion;[11] and growth in business services represented 32% of this. The first column of Table 1 shows how the share of business services gross output growth breaks down over the full period 1984 and 2001. Subsequent columns consider three sub-periods. The first row shows the amount that is due to increased purchases of business services by UK-based firms, this is the first term in equation (1). The second row shows the value of the second term in equation (2). Row (4) shows the value of the second term in equation (1), which refers to changes in domestic final demand for business services and row (5) shows the value of the third term, which is changes in sales to foreign-based firms.

Around a third of total UK output growth between 1984 and 2001 was accounted for by business services (row 6). Over half of this was accounted for by other UK-based firms' purchases of business services (row 1, as opposed, for example, to direct purchases by consumers or purchases by foreign-based firms); and of this, one-third (or 6.5%) was due to these firms increasingly using business services produced in specialised plants. These figures suggest a significant increase in the extent to which UK firms are restructuring business services, either by specialising within the firm, or by outsourcing to other UK firms.

[Table 1 and figure 4 here]

Table 1 also shows how this decomposition varies over three sub-periods, 1984-1990, 1990-1995, and 1995-2001. First, note that 44.5% of the total absolute change in gross output between 1984 and 2001 is accounted for by changes between 1995 and 2001, and the rest splits evenly between sub-periods 1984-1990 and 1990-1995 (this is displayed in the last row of table 1). Although the sub-period 1984-1990 accounts for a lower share of total UK output growth between 1984 and 2001; the role of business services growth was relatively most important in this sub-period. This is reflected in that the share of growth of business services in total growth over the whole period is very similar in the sub-periods 1984-1990 and 1995-2001, around 13% (row 7). Row 6 shows that business services account for almost half of the growth in business services in 1984-1990; and a quarter of this, or 12.7%, was due to these firms increasingly using business services produced in specialised plants (row 2).The role of outsourcing of and specialisation towards business services played an important role between

[11] All figures in this section are expressed in terms of 2001 prices; we used the GDP deflator to transform nominal figures in figures in terms of 2001 prices. Note again that these figures refer to the sum of gross output across different industries in the UK. Hence, this is not the change the UK experienced in terms of GDP growth.

1995 and 2001 as well, accounting for 8% of the output growth within this sub-period. The figures displayed in table 1 are represented in figure 4.

3.2.2 Variation by purchasing sector

We can decompose the increase in intermediate demand for business services by purchasing sector. We focus on the component that represents specialisation. Column 1 of table 2 shows this for the whole period 1984-2001. Financial intermediation is the purchasing sector that accounted for the biggest share, its share is 1.3% or a fifth of the total. This is followed by manufacturing (0.9%), and then by wholesale and retail trade; transport and communication; business services and real estate; and other services, each accounting for 0.8%. Looking at the importance of each purchasing sector across sub-periods, it is interesting to note that manufacturing plays a more important role in the sub-period 1984-1990 than in the other sub-periods. In fact, manufacturing shows a decline in specialisation and outsourcing of business services between 1990 and 1995**.**

[Table 2 here]

It is also interesting to look at how important are the intermediate consumption of business services across purchasing sectors; that is the share of purchases of business services in total gross output across periods and sectors (S_{jkt}), where *k* refers to business services in particular and *j* to the 10 different purchasing sectors. Table 3 suggests that the economy as a whole is increasingly using business services provided by specialised establishments as inputs (the last row). This figure went from 3.7% in 1984 to 11.5% in 2001. In 2001, financial intermediation is the sector that uses business services more intensively, with a share of almost 28%, much higher than 6.7% in 1984. Figure 5 shows the same figures for each of the sectors.

[Table 3 and figure 5 here]

Finally, we can look at who are purchasing these services. Table 4 shows the percentage of total business services purchased by each industry from 1984 to 2001. Business services themselves are now the most important purchaser of business services. This was not the case two decades ago, when manufacturing was the biggest purchaser, followed by wholesale and retail. Outside business services, other services and transport and communication are the other two services sectors that have increased the demand for business services the most over the last two decades. In 1984, services as a whole accounted for just less than half of total purchase of UK business services. By 2001, purchases of intermediate business services by

the services sector reaches up 80% of the total, which is associated with an increase in services share in the economy and an increase in the intensity with which they use intermediate business services. Figure 6 shows the same figures.

[Table 4 and figure 6 here]

This aggregate analysis helps us to better understand the role of specialisation and outsourcing in the decline in the size of manufacturing industry and the contemporaneous growth of sectors producing intermediate services. We saw that there has been an increase in outsourcing and specialisation in the UK economy that lead to an increase in the demand for the business services sector. Part of this is related to an increased use of contracted-out services to replace activities previously conducted in-house. Another part is related to the fact that due to technology change intermediate services represent a more important input into production of other goods and services. This increase in demand came from all sectors of the economy, not only from manufacturing. The biggest shift from manufacturing to business services due to outsourcing and specialisation happened between 1984 and 1990. In the last decade, we still see a shift from manufacturing towards the services sectors, but the extent to which this is related to reorganisation within firms and increase use of intermediate services is less important. What this analysis suggests is that over the last decade the increase in outsourcing of business services was driven mainly by business services themselves and other service sectors, such as financial intermediation.[12]

Using these aggregate data we are not able to distinguish specialisation from outsourcing. To do this we need micro data. The next section describes the micro data, while section 5 considers measures of vertical integration using these data. These micro data are available over the period 1997 to 2005. We describe both the cross-sectional variation in vertical integration and the variation over time. However, the aggregate data showed that most of the change in manufacturing sector's outsourcing of and specialisation towards business services happened in the 1980s, so we are not able to pick up these big changes in ownership structures.

[12] See Greenhalgh and Gregory (2001) for a similar analysis using the Input Output tables for 1979 and 1990. They also find an increase demand for intermediate services in that period, and not only from the manufacturing sector but also from other services sector.

4 Micro data and firm demographics

The main data that we use to look at firms' structure comes from the Business Structural Dataset (BSD). We combine this with data from the Input Output (IO) Annual Supply and Use Table for 2001. The BSD allows us to analyse firms' ownership structure and demographics. The main information we use is the 5-digit industry code, ownership information and employment. The data currently available in the BSD covers the years 1997 to 2005. An Appendix contains more detailed information about how we set up the BSD data and the complementary datasets we use in our analysis.

Table 5 shows the number of enterprises that are in the BSD in 2005. In the first column we show the number of active enterprises in the raw data. In our analysis we focus on private enterprises. The second column shows the number of private sector active enterprises with positive employment (we exclude public sector enterprises and enterprises that have zero employment). The third column shows the number of these that are within groups (i.e. share a common owner with other enterprises). The final column shows the percentage that belongs to a group.

[Table 5 here]

'Manufacturing', 'electricity, gas and water supply' and 'financial intermediation' firms are more likely to be part of a group whereas 'agriculture, mining and quarrying' firms are the least likely to be part of a group.

Table 6 shows that, while most private enterprises are stand-alone, over half of employment is accounted for by enterprises within groups. The worksheet entitled "Producer Industries" shows further details by 2/3-digit industry.[13] In the rest of our analysis we use this population of active private sector enterprises with positive employment.

[Table 6 here]

The first two columns of table 7 show the demographic characteristics of enterprises in 2005, and the extent to which enterprises' characteristics changed between 2005 and 2004; the last two columns show the same descriptive statistics for changes between 1998 and 1997. We

[13] The column sums for the demographic variables *n* (total number of enterprises) and *n_group* (total number of enterprises that belong to a group) do not match this total sum (2,020,648 and 100,211) because there are some disclosive 2/3 digit industries as considered by the ONS disclosure rules (i.e. there are less than 10 enterprises in that industry). The same is true with the column sums for the demographic variables *emp* (total employment) and *emp_group* (total employment of group enterprises), compared to table 6.

consider whether an enterprise is part of a group or stand-alone, whether their ownership has changed (i.e. they have been taken over, sold off or merged); and whether they changed industries between two consecutive years. It is worth mentioning that sometimes a change in industry classification is simply a question of the product mix in the output flipping for example from 51%-49% to 49%-51% for a two-product establishment.

[Table 7 here]

The first two rows show exit, i.e. those that existed in t but not in t+1, and the next two show entry, those that existed in t but not in t+1. These are similar in magnitude, and it is mostly stand-alone firms that enter and exit. The proportion of firms that enter and exit are similar in 2005 and 1998. Around 79% of the enterprises in 2005 were stand-alone, as in 2004. Of these, most do not change owner nor change industry, very few changed ownership and around 3% of these changed industry they operate in (5-digit level). Only a small proportion of firms (0.37%) went from being part of a group to stand-alone. A slightly higher proportion of firms in 2005, 0.80%, went from single to part of a group. Finally, around 5% of the firms belong to a group in both years, and most of these remained part of the same group and operated in the same 5-digit industry.

Comparing changes in 2004-2005 with those in 1997-1998, things look similar. However, one prominent difference is that a higher proportion of firms changed industries in 1998 compared to 2005. The proportion of stand-alone firms that were also stand-alone in the previous year and changed industry is 7.54% in 1998 compared to 3.09% in 2005. The proportion of group firms that were also part of a group in the previous year is 0.84% in 1998 compared to 0.19% in 2005.

Table C1 and table C2 in the appendix show the same descriptive statistics broken down into eleven sectors. We omit ownership changes because they are disclosive.

5 Vertical integration

One of the main aims of this project is describing the extent to which firms carry out transactions within the firm, versus in the market. A vertically integrated firm is one that both produces an intermediate good and uses that intermediate good in the production of a downstream product. This is in contrast to a non-integrated firm which purchases the intermediate good in the market. For example, a firm that owns a car assembly plant and a car

parts manufacturer is vertically integrated, while a stand alone assembly plant that buys all of the car parts on the market would not be vertically integrated.

A single producer firm can be vertically integrated into some supplying industries, and not into others. We consider each producer-supplier pair - that is, for each producing firm we consider all of the supplying industries from which it needs inputs, and ask: is that producer vertically integrated into that supplying industry?

Our measure of vertical integration combines information from the Input-Output table with information on firms' ownership structure from the BSD. The information from the Input Output table is on the average level of intermediate purchases of inputs between each producing and supplying industry pair at the 2/3-digit industry level. A second measure uses information on purchases of intermediate inputs of individual establishments combined with information on these establishments' ownership structure from the ARD. These data are limited to only a few inputs.

The advantage of the first measure is that it provides information on all inputs, the main disadvantage is that it assumes that all firms within an industry use the same technology (i.e. use inputs in the same proportions). The advantage of the second measure is that it uses data on actual purchases by firms, and thus allows inputs to vary across firms within an industry, but the disadvantage is that we only have information on a very few specific inputs. Both measures share some drawbacks, which mainly derive from the data that we have available to us. Neither takes account of firms' activities abroad; that is firms' ownership structure outside the UK. Another drawback is that intermediate inputs produced within the establishment are not measured. We now discuss the specifics of the measures we use.

5.1 Measuring vertical integration using the Input Output Tables

Our main measure of vertical integration is defined from the producer-side and combines information at the 2/3-digit industry level from the Input-Output table with information on firms' ownership structure from the BSD. What we observe is:

- the ownership structure of all firms (from the BSD),
- each firm's employment share in producing industry *j* (from the BSD),
- the average level of purchases by producers in each 2/3-digit industry from suppliers in each 2/3-digit industry (from the Input-Output Table).

We do not observe each individual plant's usage of inputs, nor do we observe whether it produces them in-house, purchase them from the market or source them from another plant within the firm.

We observe the average usage of all inputs sourced from outside the plant for all producing industries from the Input Output Tables. This includes all inputs that are not produced in-house, so they could be produced within the firm or bought in the market. This determines whether industries are vertically linked, but does not tell us whether a firm is vertically integrated or not; we call this "producers' technology".

We observe the ownership structure of all firms and plants in the UK from the BSD, so we can determine whether a firm that owns a plant that produces a good j, also owns a plant that produces an input in supplying industry k. We assume that if a firm in producing industry j owns a plant in a supplying industry k, it can supply the full quantity of good k it needs to produce j from within the firm. Even if in practice vertically integrated firms do not source all of their inputs from within the firm, they have the potential to, and this may be what is most interesting.

We now describe how we use this information more formally. We use the information on demand for intermediate inputs from the Input-Output table to determine whether each pair of producer-supplier industries is vertically linked. For each industry pair we use the Input-Output table to calculate the proportion of total costs of producing good *j* that are made up of input *k*, denote this $w_{jk} = q_{jk} / c_j$. The quantity w_{jk} includes transactions within the firm and in the market. We assume that inputs are not sourced from within the establishment (i.e. that the 5-digit level is disaggregated enough to identify separate products). It does not vary at the firm level, so we are assuming that all producing firms use the same technology (they use inputs in the same proportions).

From the BSD we have information about whether a firm in producing industry *j* owns a plant in supplying industry *k.* We use this to construct an indicator variable d_{ijk}, which equals 1 if firm *i* owns an establishment in producing industry *j* and supplying industry *k*.

A firm is vertically integrated in the industry pair *j*-*k*, if it owns at least one establishment operating in each industry, that is, $d_{ijk} = 1$, and the industry pair is vertically linked as indicated by the Input Output table, that is, $w_{jk} > 0$. We define a one-zero measure of vertically integration at the firm level, which can be written as:

$$v_{ijk} = \begin{cases} 1 & (d_{ijk} = 1) \,\&\, (w_{jk} > 0) \\ 0 & otherwise \end{cases}$$

To calculate the extent to which firms in producing industry *j* are vertically integrated in a supplying industry *k*, we would like to sum the total amount of inputs *k* demanded by each firm from within the firm, and relate this to total inputs purchased in industry *j*. However, as we mentioned above, this information is not available at the firm level. Instead we weight firms by their employment (denote the employment of firm *i* in industry *j* as e_{ij} and total employment in industry *j* as E_j) to approximate how much of the average usage of input k by firms in producing industry j (w_{jk}) is transacted within the firm. Hence, we have a variable that varies between 0 and 1,

$$(3) \qquad v_{jk} = \left(\frac{1}{E_j} \sum_i v_{ijk} e_{ij} \right) w_{jk}$$

We aggregate equation (3) to the producing industry level to get the industry level of vertical integration, which is an approximation of the total amount of inputs used by producers in that industry that they can provide from within the firm from all potential supplying industries, weighting firms by their employment. This can be written as follows

$$(4) \qquad v_j = \sum_k v_{jk} \,.$$

We are interested in how vertical integration (the quantity (3)) compares to the share of total intermediate purchases, which can be written as:

$$(5) \qquad W_j = \sum_k w_{jk} \,.$$

That is, we are interested in the percentage of intermediate costs that are supplied by vertically integrated suppliers. Using equations (3), (4) and (5), this can be written,

$$(6) \qquad \frac{v_j}{W_j} = \frac{\sum_k \left(\frac{1}{E_j} \sum_i v_{ijk} e_{ij} \right) w_{jk}}{\sum_k w_{jk}} \,.$$

5.2 Evidence

The full set of tables is contained in an accompanying spreadsheet. We highlight some of the most interesting statistics from these spreadsheets and extract them into extra tables in this report.

5.2.1 Vertically related industries

The worksheet entitled "w_{jk}" is derived from the Input Output Annual Use Table 2001. Each row represents a producing industry, each column a supplying industry. The value in each cell is the amount that producers in that industry purchases from suppliers in that industry, as a share of total intermediate purchases plus labour costs in that producing industry. The diagonal is indicated in bold. The final column (W_j) shows the share of all intermediate purchases in costs (100 minus this equals the share of labour in total costs), defined by equation (5) above.

Of the 14,884 pairs of producing-supplying industries (122x122) there are 10,071 (around 70%) that have some vertical link; 2,539 where intermediate purchases from that supplier account for over 0.5% (around 17%); and 1,488 (around 10%) where intermediate purchases from that supplier account for over 1% of total costs of that producing industry.

The worksheet entitled "Producer Industries" provides some other descriptive statistics for each producing industry in relation to its supplying industries- the total number of supplying industries, the number of supplying industries that account for more than one half of a percent of total costs, total intermediate inputs as a share of costs, total intermediate imported inputs as a share of costs, the single largest supplying industry and the share of costs that the largest supplying industry accounts for.

On average a producing industry sources inputs from 83 different supplying industries out of a total of 122 supplying industries from the Input Output table. Industries vary in the importance of intermediate inputs - fishing uses intermediates most intensively, accounting for 91% of costs, while education uses labour inputs most intensively, with intermediates accounting for only 30% of costs. On average, intermediates account for two-thirds (67%) of costs (with a standard deviation of 11%). The industry with the highest share of imported intermediates is office machinery and computers, accounting for 40% of costs, while real estate activities is the industry with the lowest share of imported inputs, accounting only for

less than 1%. On average, imported intermediates account for 15% of total costs (with a standard deviation of 8%).

For 48 of the producing industries the most important supplying industry is the same (industries that source the largest value of its inputs from within the same industry). "Accountancy services" is the industry with the least specific input, its most important supplier (which is the same industry in this case) provides it with only 4% of its costs. "Coke ovens, refined petroleum & nuclear fuel" are the most specific, purchasing 67% of their inputs from the same industry. "Sugar" is also very specific, with 56% of costs from agriculture, as is "Letting of dwellings", which purchases 54% of costs from construction.

5.2.2 Extent of vertical integration

The worksheet entitled "Producer Industries" also provides some descriptive statistics for each producing industry on the extent of vertical integration. The column called "v_j" shows the industry level of vertical integration, which is an approximation of the total amount of inputs used by producers in that industry that they can provide from within the firm, defined by equation (4). The column next to it shows this divided by the share of costs (v_j/W_j), which is defined by equation (6). We report this for all years, 1997-2005.

It is interesting to note that all industries have at least some firms that are vertically integrated.[14] Table 8 shows the ten industries with the strongest vertical linkages (highest v_j/W_j) for 2005. For example, in the case of the producing industry "Telecommunication", the percentage of intermediate costs that are supplied by vertically integrated suppliers (variable v_j/W_j), is around 36%. Most of this 36% is accounted for by a handful of supplying industries: almost half of it, or 17%, comes from suppliers in the same "Telecommunications" industry; around a fourth, or 9%, comes from vertically integrated suppliers of "Television and radio transmitters and line for telephony and line telegraphy" products; and over 4% from vertically integrated suppliers producing "Computer services".[15] In the same order of importance, these are the most important supplying industries in terms of intermediate inputs supplied (or in terms of w_{jk}).

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[14] We have not reported vertical integration measures for the industries 'Metal ores extraction', 'Sugar', 'Tobacco products', 'Letting of dwellings' and 'Public Administration', since these industries have less than 10 firms and so this information would be disclosive. Also, the industry "Oils and fats" also has a very small number of firms and employment, so its vertical integration measures should be interpreted with caution.

[15] For a description of how we aggregate the industries in broad sector, see the spreadsheet "correspondences".

[Table 8 here]

In the case of the producing industry "Banking and Finance", the percentage of intermediate costs that is supplied by vertically integrated suppliers is around 33%. In this case, this 33% is spread more evenly across a number of supplier industries: around 8% comes from "Other business services"; 5% comes from "Computer services"; 3% from "Owning and dealing in real estate" and other 3% from "Auxiliary financial services"; 2% from "Market research and public opinion polling; business and management consultancy activities; management activities", with only 2% from vertically integrated suppliers from the same industry "Banking and finance". The four most important industries in terms of intermediate inputs supplied are, in order of importance (w_{jk} in parenthesis) "Computer services" (9%); "Other business services" (7%); "Telecommunications" (5%) and "Postal and courier services" (5%).

Comparing the ranking of industries over time, most (six out of ten) of the industries in table 8 are also among the ten industries with the highest vertical linkages in 1997. It is interesting to note that two of the industries that are in 2005, but not in 1997, among the ten ones with the highest vertical linkages are "Banking and Finance" and "Insurance and pension funds".

[Table 9 here]

Table 9 shows the ten industries with the weakest vertical linkages (lowest v_j/W_j) in 2005. Among them are industries such as "Agriculture", "Hotels, catering and pubs" and "Legal activities". In the case of "Agriculture", a significant (77.5%) proportion of its costs are intermediate inputs (column W_j), and they come from a wide variety of supplying industries. The most important supplying industry is "Animal Feed" which provides 15% of costs, followed by "Agriculture" itself that provides 11% of the costs and then there are over 10 supplying industries that provide over 1% of the cost each. Only few (four out of ten) industries in table 9 are also among the industries with the weakest vertical linkages in 1997, and among those that were not in the lowest bottom of ranking in 1997 are three manufacturing industries.

Tables 10 and 11 show respectively the rankings for the industries in 1997 with the highest and weakest vertical linkages. In table 10, two of the industries that were among the ones with the highest vertical linkages in 1997, but not in 2005, are manufacturing industries.

[Tables 10 and 11 here]

Table 12 and figure 7 show the employment-weighted average vertical linkages indicators across 2/3-digit producing industries for each of the eleven broad producing sector. These figures suggest that there has been a decrease in the degree of vertical integration in manufacturing industries and also in electricity, gas and water supply. Both sectors experienced a decrease in the total number of employment, though electricity, gas and water supply experienced at the same time an increase in the total number of enterprises. Manufacturing firms exhibit a decrease in vertical integration in to other manufacturing industries, and similarly firms in electricity, gas and water supply experienced a decrease in vertical integration in to this same sector (see tables D1, D2 and D3 in the Appendix D).

Simultaneously, we see an increase in the degree of vertical integration in financial intermediation. This sector experienced a continuous increase in the total number of employment and in the total number of enterprises over the period. Business services sector is the supplying sector that accounts for the single largest portion of financial intermediation's costs and we see an increase in vertical integration in to business services from 1997 to 2005 (see tables D1, D2 and D3 in the Appendix D).

[Table 12 here]

It is possibly that the mechanisms associated with changes in the extent of vertical integration are different across sectors and industries, and also across firms. In the last section of this report, we discuss to what extent the data used in this analysis can be exploited to understand the characteristics correlated with firms' being vertical integrated.

5.3 Measuring vertical integration using the ARD - within and between industry variation

One important issue in constructing the measure of vertical integration described above is that we have to assume that firms within a producing industry use the same technology. This means they use intermediate inputs in the same proportion, as indicated by the Input Output table. To what extent is a reasonable assumption? The ONS Annual Respondents Dataset (ARD) contains information on purchases of a few different types of inputs and total costs (total intermediate purchases and cost of employees) for a selected sample of establishments. We observe separately the intermediate purchases of approximately a dozen intermediates inputs, of which only a few are defined at the level of disaggregation as in the Input Output table. We can use these data to investigate the extent to which there is variation within

industries in the purchases of these services. This will enable us to have an idea on how restrictive it is assuming that firms within producing industries use a homogenous technology.

Using the ARD we define w_{ijk} at the establishment level for the two industries where we have data: "hiring, leasing and renting services" (industry 106 in the IO table) and "computer services" (industry 107 in the IO table). Our second measure of vertical integration from the producer-side is at the establishment level, using information at the establishment level not only on ownership structure, but also on both purchases of inputs and total costs. This measure varies between 0 and 1 and can be written as follows:

(5) $$v^{ARD}_{ijk} = d_{ijk} w_{ijk}$$

5.3.1 Evidence

Table 13 shows the proportion of firms that are purchasing the different services (those with $w_{ijk} > 0$ for each k), weighted by size (employment), by producing sector. Most establishments (over 90%) across the different sectors purchase both services. There is some variation across sectors.

Table 14 shows the average services purchased as a share of the establishments' total cost and its standard deviation, by producing sector and weighted by size (employment). There is quite a lot of variation across establishments. But looking at the mean purchases from the ARD and the mean purchases from the IO table, they seem quite similar. Taken together, this suggests that the assumption of firms using the same technology within producing industry is reasonable.

Table 15 shows the proportion of firms that are vertically integrated into these services (they purchase it and own a plant producing it), weighted by size (employment), by producing sector. In general, the proportion of firms that are vertically integrated in to the production of either of these two services is quite low relative to the number of establishments that are purchasing these services (table 13). This is not surprising, since most of the enterprises in Great Britain are stand alone, as shown in table 5.

The question remains whether the establishment level variation we observe at the broad producing sector level is due to 2/3-digit industry variation or within industry, establishment-level variation.[16]

6 Conclusions and discussion for further work

This project provides empirical evidence on firms' demographic features and the extent of vertical integration of British firms across industries. The introduction provides a summary of the aims and findings.

The main goal of this research was to explore the possibilities for using the micro data held at the ONS - specifically the BSD and ARD - to look at the changes in firms' vertical structures and the impact this might have had on the UK economy.

What potential is there for further work in this area using these data? We have seen that the extent of vertical integration, and the industries which a firm is vertically integrated in, varies substantially across producing industries. Furthermore, some sectors have experienced a decrease in the extent to which they are vertically integrated, whilst other sectors have experienced an increase. Recent theories on vertical integration emphasise the inability of firms to write perfect contracts in uncertain environments, and the fact that transactions between firms may involve investments in assets that are specific to the relationship (i.e. the value of the investment is lower if the product is used by other parties) as the determinants of vertical integration (see literature review on vertical integration in Appendix A). The combination of imperfect contracts and asset specificity leads to the existence of what is called the 'holdup problem'. There are some industry characteristics that can affect the extent to which holdup problems exist, such as asset specificity and competition in the upstream and downstream industries.

For example, one thing we can see is that the industries that are among those with the highest vertical linkages seem to be less competitive industries (at least to the extent that they have fewer firms), while those among the industries with the weakest vertical linkages look like they are more competitive (see number of firms in tables 8, 9, 10 and 11). We do not have

[16] We were not able to look at this due to technical reasons regarding the availability of the data at the ONS.

good measures of competition to correlate these with, but it would be interesting in future work to pursue this.

Also, we see that in some cases firms are more likely to be vertically integrated in to the production of inputs that are relatively important and specific to their production activities. For example, we see that firms in "Banking and Finance" use computer services intensively and that a high proportion of these services are purchased from within the firm. This may be interesting, for example, if computer services are the main type of innovation in the financial intermediation sector. On the other hand, firms producing "Banking and finance" services are not vertically integrated into the "Telecommunications" and "Postal and courier services" sector, even though these represent a large share of costs. One reason why this could be the case is that these are not very specific service inputs; as opposed to computer services. We do not have good measures of specificity, but it would also be interesting in future work to pursue this.

Our conclusions in terms of the possibilities for using these micro datasets are that:

- The only useful way to identify vertical links between firms is by combining information from the Input-Output tables with data from the BSD. This is because the ARD does not collect data on purchases of many specific inputs, so it is not possible to identify demand for intermediate inputs at the establishment level.
- There is scope for using Input-Output tables, the BSD and ARD data combined to look at how vertical structures vary across industries and vary across firms within industries (the ARD could be used to incorporate further firms' characteristics). It would be possible to extend existing empirical work that looks at the importance of industry characteristics in determining vertical integration within manufacturing firms by looking at vertical linkages between manufacturing firms with service sector firms, and to look within service sectors firms. However, it is only possible to look at how this has changed over a relatively short time period. There are also difficulties in constructing measures of the relevant industry characteristics - for example, measures of the level of competition, technology intensity or asset specificity are not readily available. It would also be possible to look at how much variation there is within industries, and whether this variation is systematically associated with firms' characteristics.
- There is scope for using these data to look at changes in vertical structures over time in manufacturing industries, but this is of limited interest since this would only be

manufacturing firms outsourcing manufactured goods, given that micro data covering the service sector is available from 1997 onwards.

- In our view the most promising avenue for research would be grounded in theory, and could look at what factors determine the cross-sectional differences we see in vertical structures. We consider that research in this area will only be useful if it is strongly grounded in theory, and if issues to do with causality are explicitly considered; correlations between industry characteristics and vertical structures are unlikely to be informative, and may in fact be misleading in terms of the direction of causality.

One of the initial aims of this research project was to consider the role of globalisation in changes in firms' vertical structure. It was not possible to carry out this aspect of the research because the ONS was not able to make the necessary data (the AFDI) available during the time frame of this project. These data has now been made available and future research could explore this issue. However, we note that the information contained in the AFDI is limited, and in particular does not contain detailed information on the activities of foreign affiliates of UK firms.

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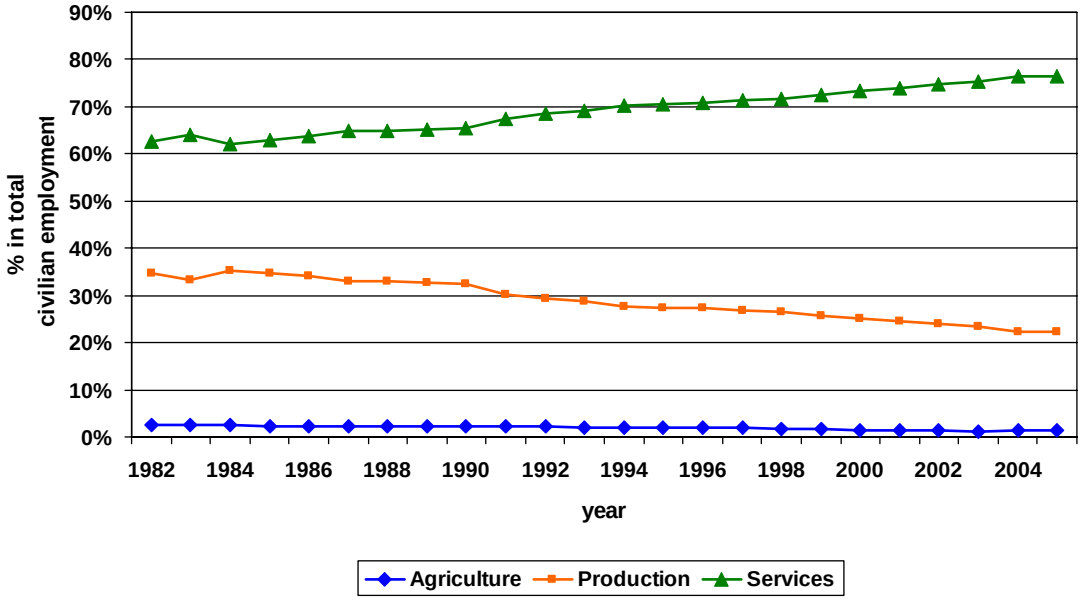
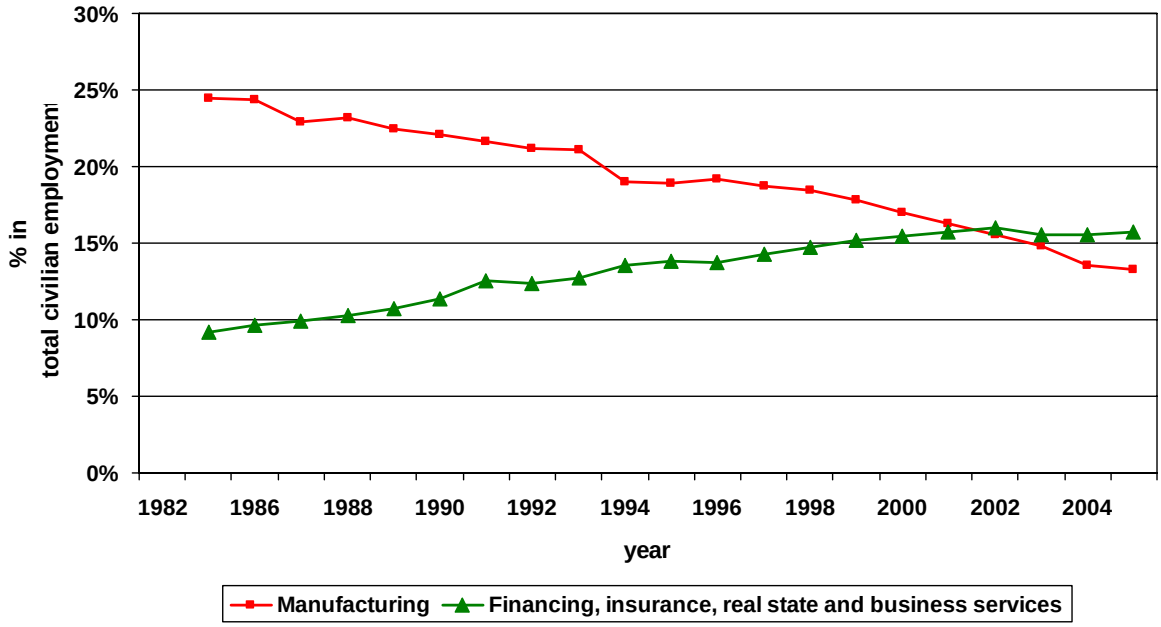
8 Figures

Figure 1: Share in total British civilian employment, by sector



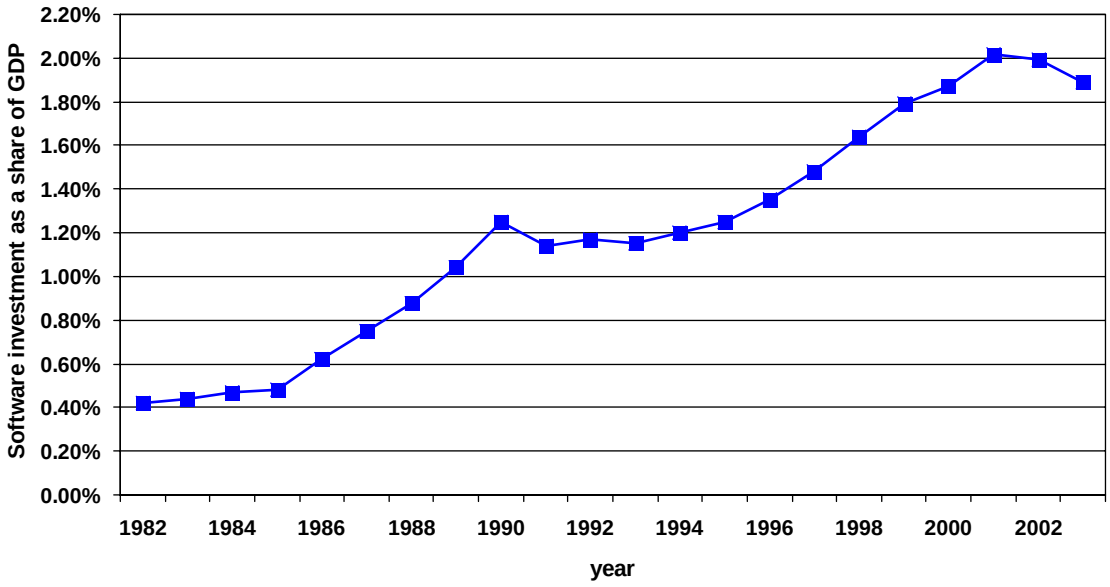
Source: Labor Statistics, OECD, edition 2006.

Figure 2: Share in total British civilian employment, by activity



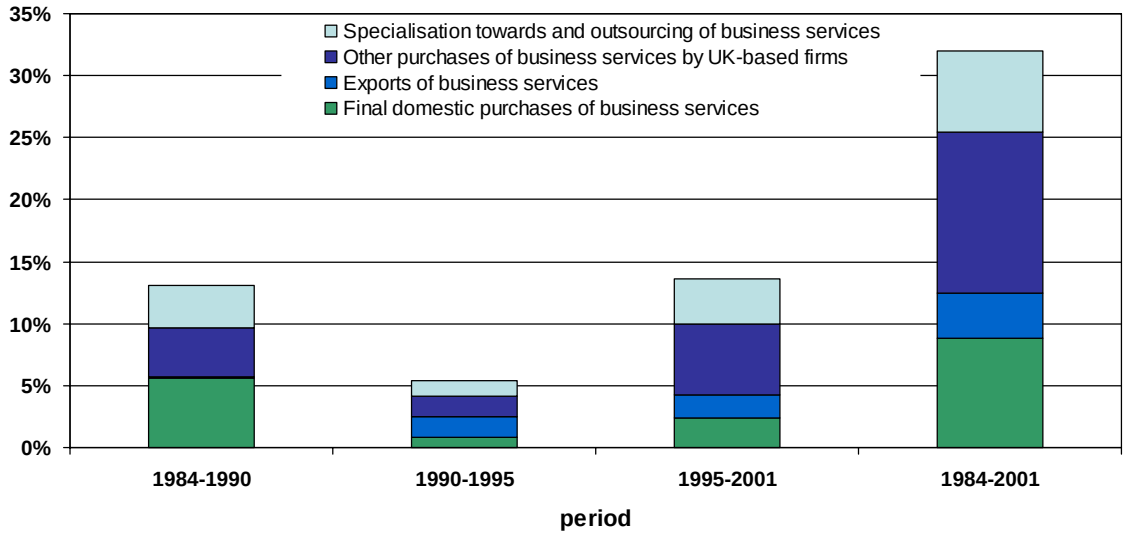
Source: Labor Statistics, OECD, edition 2006.

Figure 3: Software investment as a percentage of UK GDP



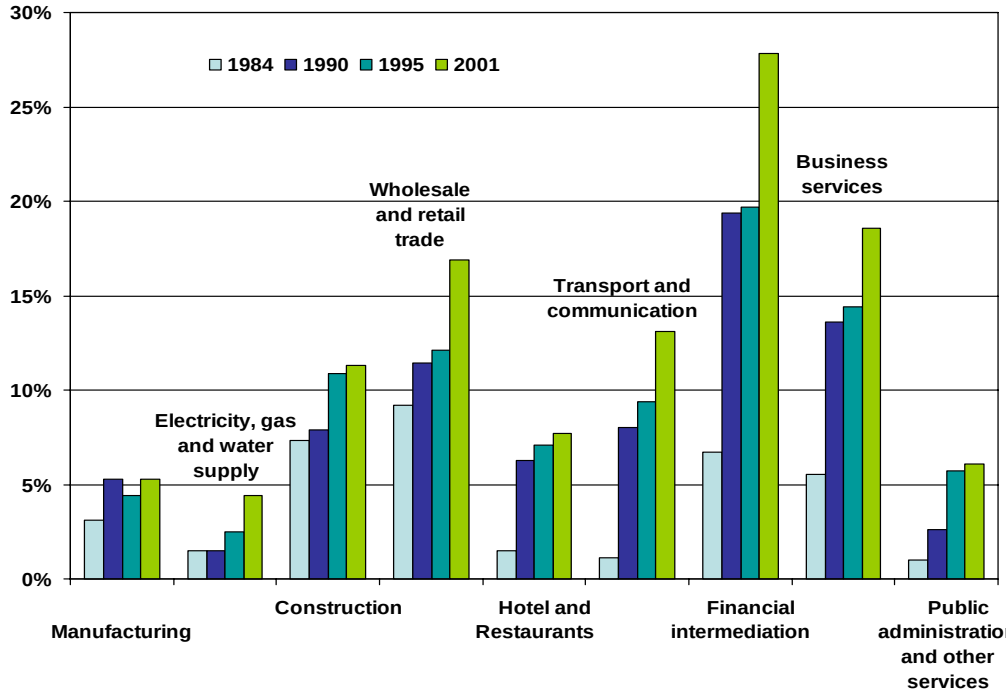
Source: Software investment comprises purchased software and own account software and the figures come from "Survey based measures of software investment in the UK", ONS February 2006; and GDP series is YBHA series from ONS Blue Book.

Figure 4: Business Services output growth as a share of UK total gross output growth, 1984-2001



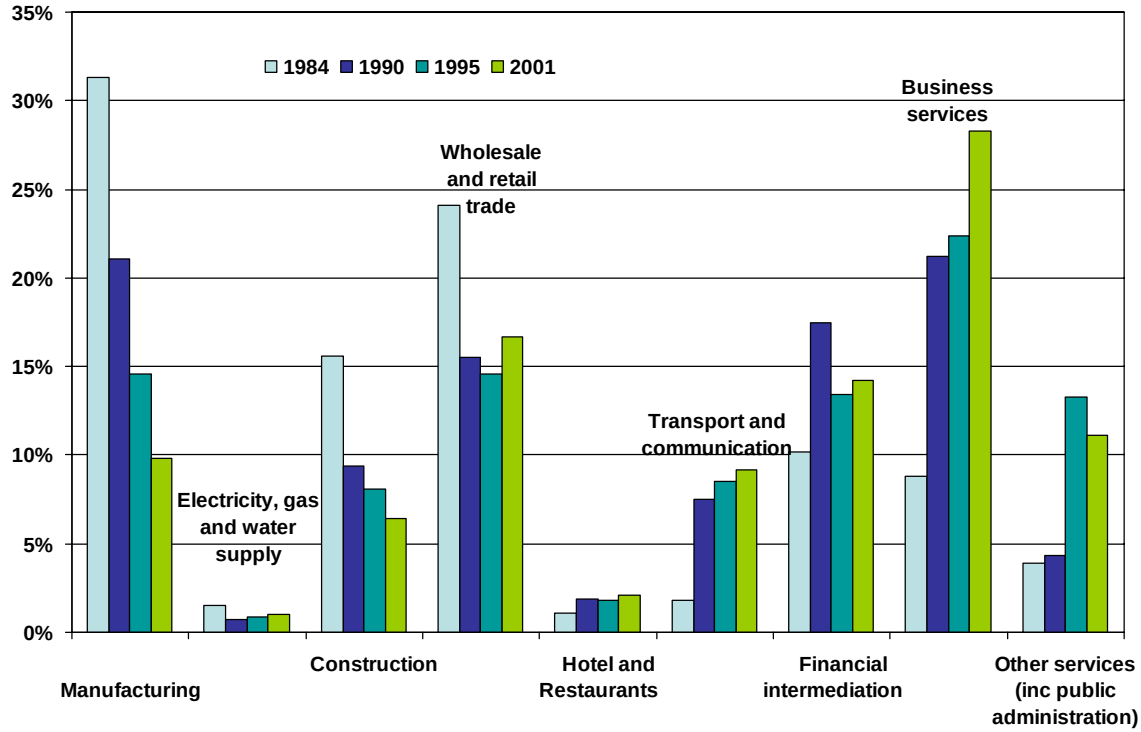
Source: Input Output tables 1984, 1990, 1995 and 2001; Abramovsky, Griffith and Sako (2004)

Figure 5: Share of intermediate purchases of business services in sector' gross output



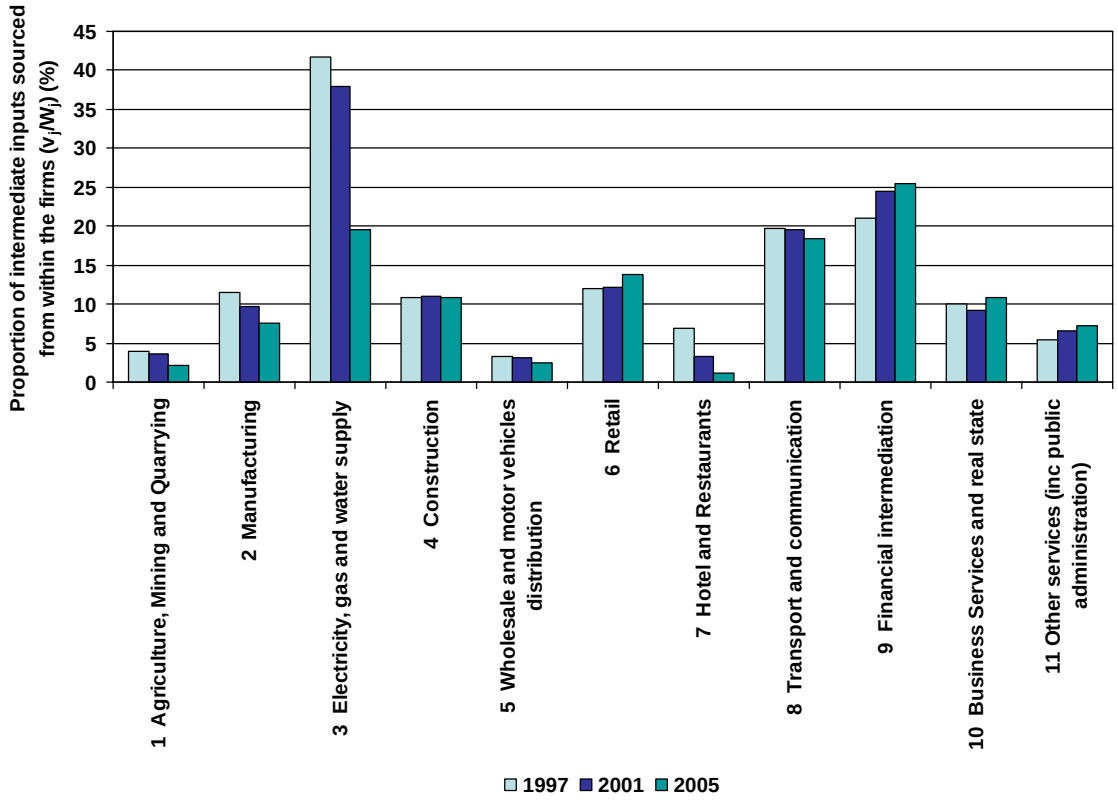
Source: Input Output tables 1984, 1990, 1995 and 2001; Abramovsky, Griffith and Sako (2004)

Figure 6: Purchasers of UK business services (% of intermediate sales of business services)



Source: Input Output tables 1984, 1990, 1995 and 2001; Abramovsky, Griffith and Sako (2004)

Figure 7: Proportion of intermediate inputs sourced from within the firm (vj/Wj)



Source: Authors' calculations using BSD for 1997, 2001 and 2005 (ONS) and the Input Output tables 2001.

9 Tables

Table 1: Business Services share of UK output growth, 1984-2001

		Share of total growth in UK–produced output			
		1984-2001	1984-1990	1990-1995	1995-2001
	Contribution to the period's absolute change in gross output				
(1)	Domestic intermediate purchases of business services (by UK-based firms), of which:	19.5%	27.3%	10.1%	20.7%
(2)	*specialisation and outsourcing*	*6.5%*	*12.7%*	*4.2%*	*8.0%*
(3)	*other intermediate purchases of business services*	*13.0%*	*14.5%*	*5.9%*	*12.7%*
(4)	Final domestic purchases of business services	8.8%	20.8%	2.8%	5.4%
(5)	Exports of business services	3.7%	0.2%	5.9%	4.3%
(6)	Total purchases of business services = (1)+(3)+(4)	32.0%	48.3%	18.9%	30.4%
(7)	Growth in business services sector's output as a share in total output growth over 1984-2001	32.0%	13.0%	5.4%	13.5%
(8)	Total growth (across all sectors) in sub-period as a share of growth in whole period 1984-2001	100%	27.0%	28.4%	44.5%

Notes:

(1) Share of the total increase in UK output that was accounted for by increased purchases of business services by other businesses in the UK, including capital goods. The increase in purchases could be because the purchasing firms have grown in size, and so now need more business services, or because they now use these specialised business services more intensively than before. This is in terms of equation (1): $\sum_j \Delta DID_{j\ bu\sin ess\ services\ t} / \sum_k \Delta Y_{kt}$

(2) is part of (1). It is the increase in firms' purchases of business services that is driven by an increased intensity of usage of business services produced in specialised plants or offices, in order to produce the same amount of output that they were producing in 1984. This is in terms of equation (2): $\sum_j Y_{jt-1} \Delta S_{j\ bu\sin ess\ services\ t} / \sum_k \Delta Y_{kt}$

(4) Share of the total increase in UK output that was accounted for by changes in purchases of business services by domestic consumers and government. This is in terms of equation (1): $\Delta DFD_{bu\sin ess\ services\ t} / \sum_k \Delta Y_{kt}$

(5) Share of the total increase in UK output that was accounted for by an increase in purchases of business services by foreign-based firms; that is an increase in exports of business services. This is in terms of equation (1): $\Delta X_{bu\sin ess\ services\ t} / \sum_k \Delta Y_{kt}$

(6) Total is the sum of rows (1), (3) and (4). It is the share of the total increase in UK output accounted for by Business Services, or $\Delta Y_{bu\sin essservices\ t} \Big/ \sum_k \Delta Y_{kt}$

(7): This is $\Delta Y_{bu\sin essservices\ t} \Big/ \sum_k (Y_{k2001} - Y_{k1984})$

(8): This is $\sum_k \Delta Y_{kt} / \sum_k (Y_{k2001} - Y_{k1984})$

Source: Input Output tables 1984, 1990, 1995 and 2001; Abramovsky, Griffith and Sako (2004).

Table 2: Share of UK output growth due to outsourcing of and specialisation towards business services, 1984-2001

Producing sector	Share of total growth in UK–produced output			
	1984-2001	1984-1990	1990-1995	1995-2001
Agriculture, Mining and Quarrying	0.4%	0.4%	0.6%	0.0%
Production				
Manufacturing	0.9%	3.3%	-1.4%	0.9%
Electricity, gas and water supply	0.1%	0.0%	0.2%	0.2%
Construction	0.3%	0.2%	1.4%	0.1%
Services				
Wholesale and retail trade	0.8%	0.9%	0.4%	1.7%
Hotel and Restaurants	0.2%	0.5%	0.1%	0.1%
Transport and communication	0.8%	1.8%	0.5%	1.0%
Financial intermediation	1.3%	2.9%	0.1%	1.7%
Business Services and real estate	0.8%	1.9%	0.5%	2.0%
Other services	0.8%	1.0%	2.0%	0.3%
Purchases of business services by UK-based firms due to specialisation and outsourcing as a share of total growth in UK–produced output , row (2) in table 1	6.5%	12.7%	4.2%	8.0%

Note: in terms of equation (2), this is for each j: $Y_{jt-1}\Delta S_{j\ bu\sin ess\ services\ t} / \sum_k \Delta Y_{kt}$

Source: Input Output tables 1984, 1990, 1995 and 2001; Abramovsky, Griffith and Sako (2004).

Table 3: Intermediate purchases of business services, by producing sector, 1984-2001

Producing sector	Share of intermediate purchases of business services in producing sector's gross output			
	1984	1990	1995	2001
Agriculture, Mining and Quarrying	0.9%	2.3%	5.5%	5.4%
Production				
Manufacturing	3.1%	5.3%	4.4%	5.3%
Electricity, gas and water supply	1.5%	1.5%	2.5%	4.4%
Construction	7.3%	7.9%	10.9%	11.3%
Services				
Wholesale and retail trade	9.2%	11.4%	12.1%	16.9%
Hotel and Restaurants	1.5%	6.3%	7.1%	7.7%
Transport and communication	1.1%	8.0%	9.4%	13.1%
Financial intermediation	6.7%	19.4%	19.7%	27.8%
Business Services and real estate	5.5%	13.6%	14.4%	18.6%
Other services	1.0%	2.6%	5.7%	6.1%
Total intermediate sales of business services	3.7%	7.8%	8.5%	11.5%

Note: in terms of equation (2), this is for each j: $S_{j\ bu\sin ess\ services\ t}$

Source: Input Output tables 1984, 1990, 1995 and 2001.

Table 4: Purchasers of UK business services, 1984-2001

Producing sector	1984	1990	1995	2001
Agriculture, Mining and Quarrying	1.8%	1.1%	2.4%	1.3%
Production	48.4%	31.2%	23.6%	17.2%
Manufacturing	31.3%	21.1%	14.6%	9.8%
Electricity, gas and water supply	1.5%	0.7%	0.9%	1.0%
Construction	15.6%	9.4%	8.1%	6.4%
Services	49.9%	67.9%	74.0%	81.6%
Wholesale and retail trade	24.1%	15.5%	14.6%	16.7%
Hotel and Restaurants	1.1%	1.9%	1.8%	2.1%
Transport and communication	1.8%	7.5%	8.5%	9.2%
Financial intermediation	10.2%	17.5%	13.4%	14.2%
Business Services and real estate	8.8%	21.2%	22.4%	28.3%
Other services	3.9%	4.3%	13.3%	11.1%
Total intermediate sales of business services	100%	100%	100%	100%

Note: this is, for each j, $DID_{j\ business\ services\ t} / \sum_j DID_{j\ business\ services\ t}$

Source: Input Output tables 1984, 1990, 1995 and 2001.

Table 5: Firm demographics: number of enterprises, 2005

Producing sector	Active enterprises at 5-digit level	Active, private enterprises at IO table industry level[1]		
	Number	Number	Of which Group	% group
1 Agriculture, Mining and Quarrying	139,205	138,157	1,462	1.06%
2 Manufacturing	158,158	154,265	15,052	9.76%
3 Electricity, gas and water supply	498	405	114	28.15%
4 Construction	222,459	220,703	4,419	2.00%
5 Wholesale and motor vehicles distribution	183,493	178,096	11,966	6.72%
6 Retail	209,220	207,392	11,183	5.39%
7 Hotel and Restaurants	142,702	136,005	4,088	3.01%
8 Transport and communication	84,323	82,467	4,336	5.26%
9 Financial intermediation	30,613	21,760	3,345	15.37%
10 Business Services and real state	580,573	563,529	24,378	4.33%
11 Other services (inc public administration)	383,586	317,869	19,868	6.25%
Total	2,134,830	2,020,648	100,211	4.96%

Source: Authors' calculations using the BSD for year 2005 (ONS)
1: Excludes those with missing and zero employment. It also excludes those operating in 2-digit sic code 75 or sic code 99,less than 10 observations of the total live private enterprises with employment. There are no observations with missing employment.
In 2004 there are over 10,000 observations that have missing sic code and no employment, etc. and 18000 that still have no employment after dropping the missing sic codes

Table 6: Firm demographics: number of employees, 2005

Producing sector	Active enterprises at 5-digit level	Active, private sector, with positive employment		
	Total employment	Total employment	Employment in Groups	Share of employment in groups
1 Agriculture, Mining and Quarrying	465,086	456,465	84,988	18.62%
2 Manufacturing	3,341,245	3,294,819	2,193,629	66.58%
3 Electricity, gas and water supply	99,614	88,992	86,096	96.75%
4 Construction	1,243,227	1,237,448	484,035	39.12%
5 Wholesale and motor vehicles distribution	1,700,855	1,696,658	917,596	54.08%
6 Retail	2,941,059	2,929,522	2,248,015	76.74%
7 Hotel and Restaurants	1,709,646	1,662,506	910,486	54.77%
8 Transport and communication	1,456,803	1,207,692	877,474	72.66%
9 Financial intermediation	1,091,797	1,077,393	978,906	90.86%
10 Business Services and real state	4,068,855	3,964,872	2,052,093	51.76%
11 Other services (inc public administration)	8,853,736	2,588,306	1,164,829	45.00%
Total	26,971,923	20,204,673	11,998,147	59.38%

Source: Authors' calculations using the BSD for year 2005 (ONS).
The 5-digit industry 66020 has zero employment and turnover equals zero. This represents almost half the observations with no employment in sector 9.
In 2004 there are over 10000 observations that have missing sic code and no employment, etc. and 18000 that still have no employment after dropping the missing sic codes

Table 7: Changes in demographics, number of firms.

	t+1:2005 ; t:2004		t+1:1998 ; t:1997	
Demographic event	Number of enterprises	% total in 2005	Number of enterprises	% total in 1998
Exit	*270,282*	*13.22%*	*223,352*	*11.71%*
Does not exist in t+1, Stand alone in t	258,882	12.66%	209,826	11.00%
Does not exist in t+1, Group in t	11,400	0.56%	13,526	0.71%
Entry	*310,907*	*15,20%*	*292,497*	*15.34%*
Stand alone t+1, Didn't exist in t	304,453	14.88%	288,067	15.10%
Group in t+1, Didn't exist in t	6,454	0.32%	4,430	0.23%
Stand alone t+1, Stand alone t	*1,608,463*	*78.64%*	*1,501,827*	*78.74%*
same ownership, same industry	1,531,991	74.90%	1,349,774	70.77%
same ownership, different industry	63,194	3.09%	143,761	7.54%
different ownership, same industry	12,298	0.60%	6,776	0.36%
different ownership, different industry	980	0.05%	1,516	0.08%
Stand alone t+1, Group t	*7,521*	*0.37%*	*6,644*	*0.35%*
same ownership, same industry	3,600	0.18%	1,851	0.10%
same ownership, different industry	519	0.03%	612	0.03%
different ownership, same industry	3,149	0.15%	3,207	0.17%
different ownership, different industry	253	0.01%	974	0.05%
Group t+1, Stand alone t	*16,444*	*0.80%*	*7,500*	*0.39%*
same ownership, same industry	1,736	0.08%	764	0.04%
same ownership, different industry	203	0.01%	179	0.01%
different ownership, same industry	12,493	0.61%	4,302	0.23%
different ownership, different industry	2,012	0.10%	2,255	0.12%
Group t+1, Group t	*102,045*	*4.99%*	*98,805*	*5.18%*
same ownership, same industry	88,140	4.31%	79,381	4.16%
same ownership, different industry	3,971	0.19%	16,072	0.84%
different ownership, same industry	9,309	0.46%	2,536	0.13%
different ownership, different industry	625	0.03%	816	0.04%
Total in t+1	*2,045,380*		*1,907,273*	

Note: Industry refers to 5-digit industry level. Source: Authors' calculations using the BSD for years 1997, 1998, 2004 and 2005 (ONS)

Table 8: These are 10 with strongest vertical linkages in 2005 (highest vj/Wj)

Rank 1997	Rank 2005	Producing industry	Number of firms 2005	Input Output table 2001			2005		1997	
				Number of supplying industries	W_j (%)	W_j imports (%)	v_j (%)	v_j/W_j (%)	v_j (%)	v_j/W_j (%)
2	1	99 Telecommunications	4,620	112	61.45	17.65	22.4	36.45	28.72	46.74
6	2	87 Water supply	110	70	66.8	5.09	22.84	34.2	19.88	29.76
7	3	96 Air transport	927	111	74.36	21.5	25.3	34.02	22	29.59
11	4	100 Banking and finance	6,836	106	69.51	6.5	22.6	32.51	16.96	24.4
89	5	93 Railway transport	97	111	72	2.18	20.36	28.28	3.31	4.6
4	6	80 Aircraft and spacecraft	546	80	70.46	31.2	18.86	26.77	21.8	30.94
20	7	101 Insurance and pension funds	1,088	106	80.97	1.94	18.84	23.27	14.84	18.32
5	8	95 Water transport	1,253	108	69	25.24	15.66	22.69	21.21	30.74
3	9	85 Electricity production and distribution	228	73	90.16	5.21	18.87	20.93	32.82	36.4
18	10	97 Ancillary transport services	16,690	111	67.01	2.28	13.77	20.55	12.64	18.87

Note: W_j is the share of intermediate (imported and domestic) inputs in costs, from the Input Output table 2001. W_j is the share of imported inputs in costs and this figure comes from the Input Output table 1995 (detail table). Source: Authors' calculations using BSD for 2005 (ONS) and the Input Output Tables.

Table 9: These are the 10 with weakest vertical linkages in 2005 (lowest vj/Wj)

Rank 1997	Rank 2005	Producing industry	Number of firms 2005	Input Output table 2001			2005		1997	
				Number of supplying industries	Wj (%)	Wj imports (%)	vj (%)	vj/Wj (%)	vj (%)	vj/Wj (%)
75	1	27 Knitted goods	534	74	57.74	15.1	0.14	0.24	7.15	12.39
12	2	120 Membership organisations nec	6,045	112	37.53	2.47	0.16	0.41	1.01	2.69
3	3	1 Agriculture	130,633	118	77.51	9.01	0.39	0.5	0.82	1.06
34	4	83 Sports goods and toys	1,380	73	67.75	15.76	0.44	0.65	3.8	5.6
2	5	109 Legal activities	26,273	103	49	2.57	0.32	0.66	0.29	0.59
4	6	3 Fishing	3,667	91	90.92	10.22	0.7	0.77	1.18	1.3
9	7	84 Miscellaneous manufacturing	8,587	78	76.49	19.47	0.73	0.95	1.61	2.1
22	8	69 Office machinery & computers	1,928	74	85.21	41.71	0.98	1.15	3.41	4.01
40	9	92 Hotels, catering, pubs etc	136,005	113	59.04	7.1	0.69	1.17	4.03	6.83
10	10	122 Other service activities	84,883	109	72.08	16.38	0.96	1.34	1.87	2.59

Note: Wj is the share of intermediate (imported and domestic) inputs in costs, from the Input Output table 2001. Wj is the share of imported inputs in costs and this figure comes from the Input Output table 1995 (detail table). Source: Authors' calculations using BSD for 2005 (ONS) and the Input Output Tables.

Table 10: These are 10 with strongest vertical linkages in 1997 (highest vj/Wj)

Rank 1997	Rank 2005	Producing industry	Number of firms 1997	Input Output table 2001			2005		1997	
				Number of supplying industries	W_j (%)	W_j imports (%)	v_j (%)	v_j/W_j (%)	v_j (%)	v_j/W_j (%)
1	91	86 Gas distribution	51	65	84.65	13.2	1.95	2.3	51.51	60.85
2	1	99 Telecommunications	4,384	112	61.45	17.65	22.4	36.45	28.72	46.74
3	9	85 Electricity production and distribution	131	73	90.16	5.21	18.87	20.93	32.82	36.4
4	6	80 Aircraft and spacecraft	1,174	80	70.46	31.2	18.86	26.77	21.8	30.94
5	8	95 Water transport	1,183	108	69	25.24	15.66	22.69	21.21	30.74
6	2	87 Water supply	90	70	66.8	5.09	22.84	34.2	19.88	29.76
7	3	96 Air transport	1,072	111	74.36	21.5	25.3	34.02	22	29.59
8	61	54 Iron and steel	1,191	73	78.85	18.68	3.81	4.84	20.64	26.18
9	21	55 Non.ferrous metals	918	73	80.42	29.01	10.03	12.47	20.51	25.51
10	15	7 Other mining and quarrying	1,141	68	71.67	15.8	10.97	15.3	17.65	24.63

Note: W_j is the share of intermediate (imported and domestic) inputs in costs, from the Input Output table 2001. W_j is the share of imported inputs in costs and this figure comes from the Input Output table 1995 (detail table). Source: Authors' calculations using BSD for 2005 (ONS) and the Input Output tables 2001.

Table 11: These are the 10 with weakest vertical linkages in 1997 (lowest vj/Wj)

Rank 1997	Rank 2005	Producing industry	Number of firms 1997	Input Output table 2001			2005		1997	
				Number of supplying industries	W_j (%)	W_j imports (%)	v_j (%)	v_j/W_j (%)	v_j/W_j (%)	v_j/W_j (%)
1	79	118 Social work activities	16,925	92	51.68	4.15	4.54	8.78	0.18	0.34
2	5	109 Legal activities	23,292	103	49	2.57	0.32	0.66	0.29	0.59
3	3	1 Agriculture	160,097	118	77.51	9.01	0.39	0.5	0.82	1.06
4	6	3 Fishing	4,345	91	90.92	10.22	0.7	0.77	1.18	1.3
5	14	110 Accountancy services	25,094	105	44.02	4.4	0.79	1.79	0.58	1.32
6	17	23 Textile finishing	776	70	59.61	17.66	1.09	1.83	0.82	1.37
7	52	41 Pesticides	68	70	74.39	36.95	3.47	4.66	1.31	1.76
8	39	116 Education	11,226	113	29.6	4.17	0.9	3.06	0.58	1.96
9	7	84 Miscellaneous manufacturing..	8,920	78	76.49	19.47	0.73	0.95	1.61	2.1
10	10	122 Other service activities	85,051	109	72.08	16.38	0.96	1.34	1.87	2.59

Note: W_j is the share of intermediate (imported and domestic) inputs in costs, from the Input Output table 2001. W_j is the share of imported inputs in costs and this figure comes from the Input Output table 1995 (detail table). Source: Authors' calculations using BSD for 2005 (ONS) and the Input Output Tables.

Table 12: Average vertical linkages by sector

		1997		2001		2005	
Producing sector	W_i (%)	v_i (%)	v_j/W_j (%)	v_i (%)	v_j/W_j (%)	v_i (%)	v_j/W_j (%)
1 Agriculture, Mining and Quarrying	77.28	2.96	3.94	2.74	3.59	1.67	2.21
2 Manufacturing	66.57	7.79	11.46	6.63	9.68	5.07	7.51
3 Electricity, gas and water supply	84.38	34.97	41.69	30.6	37.98	16.04	19.57
4 Construction	74.37	8.09	10.88	8.2	11.03	8.04	10.81
5 Wholesale and motor vehicles distribution	62.07	2.03	3.27	1.93	3.13	1.5	2.43
6 Retail	58.99	7.11	12.06	7.2	12.21	8.16	13.84
7 Hotel and Restaurants	59.04	4.03	6.83	1.98	3.35	0.69	1.17
8 Transport and communication	62.65	12.54	19.64	12.6	19.61	11.93	18.34
9 Financial intermediation	71.07	15.04	21.07	17.64	24.41	18.08	25.39
10 Business Services and real state	55.18	5.74	9.97	5.22	9.13	6.15	10.76
11 Other services (inc public administration)	60.02	3.39	5.4	4.04	6.5	4.47	7.29

Source: Authors' calculations using BSD for 2005 (ONS) and the Input Output table 2001.
Note: The figures are employment-weighted averages across 2/3 digit producing within each broad producing sector.

Table 13: Proportion of firms purchasing the different services, by producing sector (weighted by employment)

Producing industry	payments for hiring /leasing/renting	purchases of computer services	Sample size
2 Manufacturing	95.27%	93.66%	10,729
3 Electricity, gas and water supply	77.75%	99.73%	80
4 Construction	95.54%	89.63%	4,174
5 Wholesale and motor vehicles distribution	91.40%	93.94%	7,865
6 Retail	94.03%	84.42%	5,955
7 Hotel and Restaurants	89.77%	92.81%	2,767
8 Transport and communication	96.38%	97.52%	2,478
10 Business Services and real state	80.62%	90.03%	9,250
Total	91.07%	91.19%	43,298

Source: Authors' calculations using the ARD for the year 2003 (ONS).

Table 14: Average different services purchased as a share of the establishments' total cost, by producing sector (weighted employment)

Producing industry	payments for hiring /leasing/renting			purchases of computer services			Sample size
	Mean	Standard deviation	Mean IO table	Mean	Standard deviation	Mean IO table	
2 Manufacturing	0.78%	0.95%	0.77%	0.60%	1.07%	0.68%	10,729
3 Electricity, gas and water supply	0.72%	1.00%	0.81%	2.35%	2.22%	1.32%	80
4 Construction	3.98%	4.43%	3.86%	0.23%	0.40%	0.79%	4,174
5 Wholesale and motor vehicles distribution	0.66%	1.03%	0.93%	0.44%	0.64%	2.90%	7,865
6 Retail	0.37%	0.70%	0.19%	0.39%	0.46%	2.79%	5,955
7 Hotel and Restaurants	0.68%	1.13%	0.07%	0.44%	0.43%	2.10%	2,767
8 Transport and communication	3.84%	6.67%	2.55%	1.31%	1.41%	4.95%	2,478
10 Business Services and real state	1.10%	2.71%	0.90%	1.67%	3.46%	3.50%	9,250
Total	1.20%	2.98%	0.93%	0.83%	1.86%	1.33%	43,298

Source: Authors' calculations using the ARD, for the year 2003 (ONS).

Table 15: Proportion of firms that are vertically integrated into these services, by producing sector (weighted employment)

Producing industry	payments for hiring /leasing/renting	purchases of computer services	Sample size
2 Manufacturing	2.74%	3.17%	10,729
3 Electricity, gas and water supply	n/a	n/a	80
4 Construction	3.03%	5.59%	4,174
5 Wholesale and motor vehicles distribution	2.68%	1.92%	7,865
6 Retail	0.23%	n/a	5,955
7 Hotel and Restaurants	3.26%	n/a	2,767
8 Transport and communication	n/a	14.72%	2,478
10 Business Services and real state	5.46%	14.39%	9,250
Total	2.54%	5.75%	43,298

Source: Authors' calculations using the ARD, for the year 2003 (ONS).

10 Appendix A: Literature on vertical integration and outsourcing

This section provides a discussion of some of the literature on vertical integration in order to guide our discussion of the descriptive statistics presented below. It does not aim to be comprehensive. We draw heavily on Joskow (2003), who provides a good summary of the literature on this topic.

The early theoretical literature on vertical integration emphasised the existence of market imperfections and saw markets as complements to firms' activities rather than substitutes. They considered vertical integration as costless. They emphasised free-riding which provides a disincentive to investment in certain activities and leads to forward VI (see, for example, Tesler, 1960; and Mathewson and Winter, 1986). Another reason for vertical integration was to exploit economies of scope (emphasised in Bain 1956, 1959), or economies of scale and the size of the market (emphasised in Stigler, 1951). Some models focused on market power and the ability to foreclosure (see, for example, Aghion and Bolton, 1987; Ordover, Salop and Saloner, 1990; Hart and Tirole, 1990), while others focused on uncertainty in demand for inputs that leads to backwards VI (Carlton, 1979).

The two current dominant theories of vertical integration are *Transaction Cost Economics* (TCE), where the main papers are by Coase (1937 1972) and Williamson (1983) and the literature on *Property Rights* (PR), where the main papers are Grossman and Hart (1986), Hart and Moore (1990) and Hart (1995). Both consider vertical integration to be costly.

TCE relies on the interaction between *incomplete contracts* (IC) and *asset specificity (AS)* which generates opportunistic behaviour. There are two problems that arise: first, ex-ante incentives that affect level of investment and the potential aggregate level of production, and second, ex-post inefficiencies (given level of investment) due to bargaining and production decisions that lower the aggregate production level. TCE focuses more on ex-post inefficiencies. In this framework, market and vertical integration are substitutes and there can be hybrids types of organisational form. In principle, TCE also allows for the traditional market imperfections mentioned above (though this has not been developed formally).

The PR literature is based on TCE. It focuses on ex-ante inefficiencies, in particular on which is the distribution of residual rights or bargaining power that gives the most efficient ex-ante investment incentives or maximises the total value of the transaction ex-post. PR assumes that there are no inefficiencies in the trading ex-post, once an agreement is reached. The emphasis in this literature has been on physical, intangible and human assets. PR assumes that

organisational form is determined to provide the optimal distribution of bargaining power, but does not consider differences between market and internal transactions (cost of information, monitoring, etc.).

Asset specificity, combined with incomplete contracts, plays a crucial role in both theories. It creates bilateral dependency since the alternative use of investment yields lower returns.

	Market	Firm
Advantages	Rapid adaptation Repeated contracting: increase incentives to review decisions Price: better information	Informal solution of conflicts Mitigates opportunistic behaviour
Disadvantages	Transactions costs (writing, monitoring given the opportunistic behaviour due to AS and IC)	Shirking / agency problems? Management overload

What empirical evidence is there on TCE and PR? The empirical literature has focused more on the cost of the market rather than the cost of internal organization; and it has often used measures of asset specificity rather than proxies for ex-post adaptation costs (off the equilibrium path). In general it does not distinguish between PR and TCE. Overall there has been little effort to test PR theory directly.

Mastern, Mehan and Snyder (1991) provide a general empirical model to look at the determinants of firms' choice between market contracting (m) and internal organization (o). Here we summarise its main features. Let C_o denote the cost of organising transactions inside the firm (VI) and C_m, the cost of organising transactions through a market contracting mechanism. The vectors X and Z represent attributes of the transactions that affect each organising choice respectively, which may have elements in common. Then, C_o and C_m can be modelled as a function of X and Z as follows:

$$C_o = \alpha X + e$$
$$C_m = \beta Z + u$$

where α and β are the coefficients that measure the marginal governance cost associated with each relevant transactional attribute for internal and market governance structures respectively; and e and u are random disturbance terms, which may or may not be correlated with one another. Then, the probability of choosing VI depends on the cost of VI being lower than the cost of market transactions:

Prob. of choosing internal organisation = $\Pr(C_o < C_m) = \Pr(e - u < \beta Z - \alpha X)$

Usually there are not good measures of the attributes and it is not possible to observe the cost of each structural organisation form directly. What is usually done is to rely on observations of a zero-one limited dependent variable or a measure of intensity of vertical integration and on various proxies for variations in transaction related variables that are elements of X and/or Z such as asset specificity, complexity, uncertainty and frequency of transactions or repeated interactions. If Z and X share common variables, for example asset specificity, then what can be tested is whether the difference $\beta_k - \alpha_k > 0$, but not the sign and significance of each individual coefficient. The importance of this restriction depends on whether there are common variables in Z and X at all (for instance, asset specificity does not affect the C_o at all); whether Z and X are orthogonal; and e and u are uncorrelated.

We now summarised briefly some papers that have developed models to understand the determinants of vertical integration in the context of TCE and PR frameworks.

Baker and Hubbard (2002) present a model that explains the determinants of asset ownership in trucking, based on the existence of both incomplete contracts and job design and measurement issues. They test their model by examining how the adoption of different classes of on-board computers (OBCs) between 1987 and 1997 influenced whether shippers use their own trucks for hauls or contract with for-hire carriers. They find that OBCs' incentive-improving features pushed hauls toward private carriage, but their resource-allocation-improving features pushed them toward for-hire carriage. Their main conclusion is that ownership patterns in trucking reflect the importance of both incomplete contracts (Grossman and Hart, 1986) and of job design and measurement issues (Holmstrom and Milgrom, 1994).

Grossman and Helpman (2002) develop an equilibrium model of industrial structure in which the organization of firms is endogenous. Differentiated consumer products can be produced either by vertically integrated firms or by pairs of specialized companies. Production of each variety of the consumer good requires a specialized component. Vertically integrated firms can manufacture the components they need, but they face a relatively high cost of governance. Specialized firms can produce at a lower cost, but search for partners is costly, and input suppliers face a potential holdup problem. They study the determinants of the equilibrium mode of organization when inputs are fully or partially specialized.

Grossman and Helpman (2003) develop a model in which the heterogeneous firms in an industry choose their modes of organization and the location of their subsidiaries or suppliers. They assume that the principals of a firm are constrained in the nature of the contracts they

can write with suppliers or employees. Their main result concerns the sorting of firms with different productivity levels into different organizational forms. They use the model to examine the implications of falling trade costs for the relevant prevalence of outsourcing and foreign direct investment.

Grossman and Helpman (2005) study the determinants of the location of subcontracted activity in a general equilibrium model of outsourcing and trade. They model outsourcing as an activity that requires search for a partner and relationship-specific investment that are governed by incomplete contracts. The extent of international outsourcing depends *inter alia* on the thickness of the domestic and foreign market for input suppliers, the relative cost of searching in each market, the relative cost of customizing inputs and the nature of the contracting environment in each country.

Acemoglu, Aghion and Zilibotti (2003) develop a model based on managerial overload and technological frontier, in an imperfect contracts framework. The model states that the benefits of vertically integrated firms come from keeping all rents at the expense of investing in certain activities, especially the innovation-related ones. If the economy is closer to the technological frontier, innovation becomes more important and hence outsourcing is the way to incentive innovation-related investment, by sharing ex-post rents and increasing returns to specialisation. The decision in this model is whether intermediate good producers remain vertically integrated or outsource the production or the innovation activity and this depends on the economy's distance to the world technological frontier and the level of competition in the intermediate goods market. Outsourcing yields faster productivity growth equilibrium than vertically integrated economies and always converges towards the world technology frontier. Vertically integrated economies that are far from frontier may never converge (trap) and this depends on level of competition (if too low, rents are too high and cost of hold-ups from outsourcing increase).

Acemoglu, Aghion, Griffith and Zilibotti (2005) similarly develop a model in the context of imperfect contracts (property rights theory) and relationship-specific investments, where backward vertical integration incentive ex-ante producer's investments and reduces supplier's ex post bargaining power and investment incentives, contrary to forward vertical integration. Whether producer or supplier's investments are more important determines which organization form yields greater efficiency (non-integration gives similar incentives to both parties). Technology intensity differences between supplier and producers give a proxy to relative importance of investments. Vertical integration responses to technology intensity, of

both producer and supplier, increase with the supplier's input share in the producer's costs. They found that vertical integration is more common when the producer is more technology intensive than the supplier and when the supplier account for a greater share in costs (if relative margin is backward integration). Also, the effect of technology intensity is reinforced with greater share of costs. The role of competition in downstream and upstream activities is also important in determining whether to outsource. The greater the outside option for the supplier is –greater number of producers- the more likely outsourcing is compared to backward vertical integration. The greater the number of suppliers is, the lower outside option for them, the more likely they are to be vertical integrated.

Bartel, Lach and Sicherman (2005) argue that an important driver of the recent increase in outsourcing is the computer and information technology revolution, characterized by increased rates of technological change. They develop a model to explain the decision to outsource services (associated with labour outsourcing) to provide tasks that were previously carried out in-house or new tasks. The model, where firms make organizational choice to minimize costs, is based on economies of scale in the production of these services combined with adjustment costs of outsourcing: economies of scale in the production of services incentive outsourcing (and specialization) and adjustment costs of outsourcing these services give the opposite incentive. Since these costs are heterogeneous across firms, only some firms outsource. The main idea is that these adjustment costs have decreased in the last decade because the services have become more IT-intensive involving more general and portable skills that reduce the (adjustment) cost of outsourcing them, compared to the cost of producing them in-house. Their model shows that an increase in the pace of technological change increases outsourcing because it allows firms to use services based on leading edge technologies without incurring in the sunk costs of adopting these new technologies. In addition, firms using more IT-intensive technologies face lower outsourcing costs of IT-based services. This generates a positive correlation between the IT level of the user and its outsourcing share of IT-based services, implication that is verified in the data.

Finally, we refer to an empirical descriptive paper that looks at the importance of business-oriented services as a growth engine in the US. Goodman and Steadman (2002) analyse employment growth in the services sectors between 1988 and 2000, using the US labour survey. They find that most of the job gains are in service sector. Also that business-oriented service sectors grew proportionally more in that period. They use the Input Output tables to define business and consumer oriented goods and services. They attribute the growth in

business-oriented services partly to the increase in outsourcing and changes in contractual arrangements. They consider that changes in contractual arrangement (outsourcing) are especially important for the growth of the personnel-supply industry, although it affects other business-oriented services as well, such as computer services and management consulting. They suggest that the motivations for outsourcing of labour might be to increase flexibility and generate potentially cost efficiency of training the workers. This should not impact the level of aggregate employment if it is just a displacement across industries. However, if employment costs decrease, there may be a potential increase in the demand for labour. Also changing technology motivates outsourcing (especially for the computer services and the management consultancy services). They comment that low growth in jobs in accounting, auditing and bookkeeping might be due to technology advances that reduce the time needed for those tasks.

As mentioned in the beginning, recent theories on vertical integration emphasise the existence of imperfect contracts and asset specificity (i.e. holdup problems) as the determinants of vertical integration. There are some industry characteristics that can affect the extent to which holdup problems exist, such as technology intensity (asset specificity) and competition in the upstream and downstream industries. Some of the empirical work looking at the importance of such industry characteristics in determining vertical integration have looked at vertical linkages within manufacturing industries, but have not looked at services or over time.

11 Appendix B: Data

B.1 BSD

This project uses the enterprise level ONS Business Structure Database (BSD) within the ONS data laboratory to look at vertical linkages. The main information used is the 5-digit industry code; ownership information and employment. The data currently available in the BSD covers the years 1997 to 2005.

We use the data at the enterprise group-industry level, using the 2/3 digit industry level from the Input-Output Table. The impact this has on the number of observations in the data is summarised in Tables 1 and 2.

In order to use the BSD data for this research we do the follows:

- drop all establishments in Northern Ireland.

- use only plants that are designated as “active”

- drop all plants with zero employment

- drop all plants classified as public companies, central government bodies and local authorities

- drop enterprises in the sector “public administration and defence; compulsory social security” (sic code 75)

We only kept privately owned enterprises on the basis that public sector enterprises are unlikely to have vertical linkages on the same basis as private sector plants.

We then differentiate between foreign-owned and domestic-owned plants using information from the BSD. At the moment, we are not using this since we need to be able to distinguish UK multinationals firms as well (see section on AFDI below).

We categorise plants as “stand-alone” if there are no other plants within the same enterprise group in the BSD.

We then collapse the data at the enterprise group-industry level, using the industry classification of the Input Output tables, which includes 121 industries (excluding industry 123 which corresponds to private households with employed persons and industry 115 which corresponds to Public administration).

These industries ‘6 Metal ores extraction’, ‘15 Sugar’, ‘20 Tobacco products’ and ‘104 Letting of dwellings’ have less than 10 observations (stand alone and part of a group). Because by looking at the input output table they are quite unique industries we now omit them from the analysis (the same happens in 2004).

We also create a broader classification of 11 sectors. To do the descriptive statistics we assign each of the 121 industries to one of the 11 sectors (see spreadsheet “correspondences”).

There is one 5-digit industry (66020) that has zero aggregate employment. (In 2004 this does not happen but there are 10,000 observations with missing sic code instead).

Finally, the industry code information in the BSD is not on a consistent basis over time. Data prior to 2003 is coded on a Standard Industrial Classification (SIC) 1992 basis and data from 2003 onwards on a SIC 2003 basis. The changes between these two sets of codes are not substantial and do not affect the analysis at the IO industry level. However, for the analysis of

demographic changes over time between 1997 and 2005, we will convert the SIC 2003 codes into SIC 1992, so that the codes are consistent over time.

B.2 ARD

We use the ONS Annual Respondents Database to look at establishment level purchases of services. This is available for a random stratified sample of establishments in manufacturing and service industries (except financial services) from 1999 onwards, available up to 2003. There is a breakdown of the purchases of several input services, of which we focus on the ones that we can compare easily to the Input Output Table breakdown:

- payments for hiring, leasing or renting plant, machinery and vehicles

- purchases of computer and related services

We only consider producing sectors 2 to 8 and 10 (the financial and public sectors are not well covered by the ARD).

B.3 Input Output Tables

The Input Output tables are a central part of the UK national accounts. The Input Output Annual Supply and Use Tables show the supply and demand for products in terms of 123 industries and 123 products. Industries are defined using the Standard Industrial Classification and businesses are classified to industries according to whatever product accounts for the greatest part of their output. In this project we use the Use Tables. For each industry, the Use Table shows the cost incurred in the production process as intermediate consumption along with the costs of labour and capital and taxes on production. For each product, the Use Table shows intermediate demand and final demand and is valued at the prices that purchasers pay. Estimates of consumption (both intermediate and final demand) include goods and services both domestically produced and imported. The Input Output Annual Supply and Use Tables are based on a wide range of sources. They are mainly based on returns from ONS statistical surveys such as the Annual Business Inquiry (ABI), PRODucts of the European COMmunity (PRODCOM), International Trade in Services survey (ITIS), Financial Industry inquiries and the EFS and other government data.[17] The ABI forms the single largest ONS-based source

[17] For a more detailed description of the sources and methods underlying the Input Output Annual Supply and Use Tables see Mahajan (2006) and Office for National Statistics (1997).

used to populate the Input Output Annual Supply and Use Tables; and under the umbrella of the ABI, forms are sent to businesses across the whole economy collecting a detailed breakdown of purchases of goods and services used as intermediate consumptions. In 2005/06, detailed questionnaires on intermediate purchases were sent to a selected ABI sub-sample of 13,000 businesses (Mahajan, 2006). Hence, the data underlying the Input Output tables are micro-level data on the transactions between establishments, either owned by the same firm or unrelated establishments. Transactions between establishments owned by the same firm are captured as long as an actual sale takes place; however if an internal transfer is made, then this would be probably not captured.

The Input Output Annual Supply and Use Tables are also the basis for the Input Output Analytical Tables. These tables provide a separate analysis of the uses of domestically produced and imported goods and services. The latest Input Output Analytical Tables produced for the UK were produced for the year 1995. These tables are symmetric (product by product or industry by industry) and the valuation is at basic prices (the amount received by producers for their output).

Below we detail how we use the Input Output tables to do each of the two analyses carried out in this report.

B.3.1 Aggregate analysis: the role of specialisation and outsourcing

We use the Input Output Analytical Tables for the years 1984, 1990 and 1995 combined with the Input Output Annual Supply and Use Tables for 2001. We use the Domestic Use Table at basic prices. In order to do this we have to transform the Combined Use Table from the Input Output Annual Supply and Use Tables for year 2001 to a Domestic Use Table at basic prices. We do so by using information from the Input Output Analytical Table for 1995. We convert all nominal figures in terms of 2001 prices using the GDP deflator.

The Standard Industrial Classification of industries change across years as well as the I-O industry classification. The table below show the definition of each sector in terms of the 2-digit Standard Industrial Classification. In recent years, often the financial intermediation sector has been defined as including the activities Financial Intermediation, Except Insurance and Pension Funding (SIC code65), Insurance and Pension Funding, Except Compulsory Social Security (SIC code 66) and Activities Auxiliary to Financial Intermediation (SIC code 67). Also, the business services sector comprises a broad range of services activities including Research and Development services (SIC code 73). This is different in the Input Output

Analystical Table for 1984 and hence we define the sectors to make comparisons between years consistent.

Sector	Standard Industrial Classification codes (1992)
Agriculture, Mining and Quarrying	01-14
Manufacturing	15–37
Electricity, gas and water	40–41
Construction	45
Wholesale and retail	50–52
Hotels and restaurants	55
Transport and communications	60-64
Financial intermediation	65, 66
Business services	67, 70, 71, 72, 74
Other services	73, 75-99

B.3.2 Micro analysis: vertical integration

We use the combined use matrix from the Input Output Supply and Use Tables, 2001 (Edition 2003). This provides information about a purchasing industry *j* demand of different products *k* to use as inputs. In doing so, we are assuming that if a firm owns a plant in producing industry j and supplying industry k in the UK, it can provide itself from its plant in k in the UK –even if the industry imports a high proportion of input k. We are also assuming that each industry *j* produces only one main product; in fact, on average, 90% of an industry j's domestic output is made up of product *j* (see Table 1: Domestic output at basic prices, column 3, of the Input-Output Supply and Use Tables, 2001 (Edition 2003)). So in our analysis we refer indistinctively to industry and product. As we mentioned above, the Input Output Use Table has information available at the 2/3-digit industry level. We have 122 (producing and supplying) industries that can be vertically linked, which gives us a total of 14,884 pairs of producing-supplying industries.[18] Of these, 10,071 (or almost 70%) have a positive trade flow according to the Input Output Use Table. See the spreadsheet "Correspondences" for a classification of industries into sectors used in this analysis.

[18] We are omitting the producing industry 124 "Financial intermediation services indirectly measured (FISIM)" registered in the Input Output Table as a separate producing industry and the producing industry 123 "Private households with employed persons". The producing industry 6 "Metal ores Extraction" has all values set to zero or missing in the Input Output Table (and this is also the case for previous years).

B.4 AFDI

The use of the ONS Annual Inquiry into Foreign Direct Investment (AFDI) allows us to identify UK-owned multinational firms within the BSD. To date, we have been unable to link the BSD with the AFDI. This is because the ONS have re-issued the AFDI data but it still does not have the linking reference code needed to link it to other micro level datasets within the ONS, and this was not available until the 31st January 2007. Moreover we have been advised that linking to the BSD may be problematic due to differences in identifier codes. This means that a separate analysis of the vertical integration patterns of (UK and foreign-owned) multinationals has not been feasible within the time frame of the project.

12 Appendix C: Demographics by industry

Table C1: Demographics by sector, 2004-2005

Demographic event	Producing industry							
	1 Agriculture, Mining and Quarrying		2 Manufacturing		3 Electricity, gas and water supply		4 Construction	
	Number	% industry	Number	% industry	Number	% industry	Number	% industry
Stand alone 2005, Didn't exist in 2004	7,609	5.49%	14,814	9.44%	108	23.08%	34,754	15.65%
Group in 2005, Didn't exist in 2004	65	0.05%	472	0.30%	37	7.91%	246	0.11%
Stand alone 2005, Stand alone 2004	*128,983*	*93.10%*	*123,259*	*78.57%*	*181*	*38.68%*	*181,130*	*81.54%*
same industry	126,906	91.61%	117,014	74.59%	153	32.69%	173,399	78.06%
different industry	2,077	1.50%	6,245	3.98%	28	5.98%	7,731	3.48%
Stand alone 2005, Group 2004	*103*	*0.07%*	*1,140*	*0.73%*	n/a	n/a	*400*	*0.18%*
same industry	93	0.07%	1,017	0.65%	n/a	n/a	344	0.15%
different industry	10	0.01%	123	0.08%	n/a	n/a	56	0.03%
Group 2005, Stand alone 2004	*181*	*0.13%*	*2055*	*1.31%*	n/a	n/a	*933*	*0.42%*
same industry	160	0.12%	1,782	1.14%	23	4.91%	785	0.35%
different industry	21	0.02%	273	0.17%	n/a	n/a	148	0.07%
Group 2005, Group 2004	*1,595*	*1.15%*	*15,128*	*9.64%*	*111*	*23.72%*	*4,660*	*2.10%*
same industry	1,523	1.10%	14,433	9.20%	100	21.37%	4,266	1.92%
different industry	72	0.05%	695	0.44%	11	2.35%	394	0.18%
Total in 2005	138,536	100.00%	156,868	100.00%	468	100.00%	222,123	100.00%

Source: Authors' calculations using the BSD for year 2005 and 2004 (ONS)
Industry refers to 5-digit industry level.

Table C1: Demographics by sector, 2004-2005 *continued*

Demographic event	Producing industry							
	5 Wholesale and motor vehicles distribution		6 Retail		7 Hotel and Restaurants		8 Transport and communication	
	Number	% industry	Number	% industry	Number	% industry	Number	% industry
Stand alone 2005, Didn't exist in 2004	18,684	10.31%	27,491	13.20%	28,314	20.67%	13,121	15.70%
Group in 2005, Didn't exist in 2004	353	0.19%	231	0.11%	195	0.14%	236	0.28%
Stand alone 2005, Stand alone 2004	146,455	80.81%	168,108	80.73%	103,221	75.35%	64,679	77.41%
same industry	140,861	77.73%	161,178	77.40%	99,497	72.63%	62,905	75.28%
different industry	5,594	3.09%	6,930	3.33%	3,724	2.72%	1,774	2.12%
Stand alone 2005, Group 2004	991	0.55%	610	0.29%	382	0.28%	331	0.40%
same industry	887	0.49%	547	0.26%	344	0.25%	299	0.36%
different industry	104	0.06%	63	0.03%	38	0.03%	32	0.04%
Group 2005, Stand alone 2004	1772	0.98%	1023	0.49%	751	0.55%	742	0.89%
same industry	1,566	0.86%	811	0.39%	638	0.47%	660	0.79%
different industry	206	0.11%	212	0.10%	113	0.08%	82	0.10%
Group 2005, Group 2004	12,971	7.16%	10,765	5.17%	4,122	3.01%	4,447	5.32%
same industry	12,387	6.84%	10,369	4.98%	3,943	2.88%	4,288	5.13%
different industry	584	0.32%	396	0.19%	179	0.13%	159	0.19%
Total	181,226	100.00%	208,228	100.00%	136,985	100.00%	83,556	100.00%

Source: Authors' calculations using the BSD for year 2005 and 2004 (ONS)
Industry refers to 5-digit industry level.

Table C1: Demographics by sector, 2004-2005 *continued*

Demographic event	Producing industry					
	9 Financial intermediation		10 Business Services and real state		11 Other services (inc public administration)	
	Number	% industry	Number	% industry	Number	% industry
Stand alone 2005, Didn't exist in 2004	2,624	11.18%	111,332	19.56%	45,602	14.04%
Group in 2005, Didn't exist in 2004	393	1.68%	2,379	0.42%	1,847	0.57%
Stand alone 2005, Stand alone 2004	15,558	66.31%	425,960	74.85%	250,929	77.24%
same industry	14,922	63.60%	403,866	70.97%	243,588	74.98%
different industry	636	2.71%	22,094	3.88%	7,341	2.26%
Stand alone 2005, Group 2004	233	0.99%	1,859	0.33%	1,470	0.45%
same industry	208	0.89%	1,679	0.30%	1,329	0.41%
different industry	25	0.11%	180	0.03%	141	0.04%
Group 2005, Stand alone 2004	590	2.51%	4640	0.82%	3728	1.15%
same industry	503	2.14%	4,052	0.71%	3,249	1.00%
different industry	87	0.37%	588	0.10%	479	0.15%
Group 2005, Group 2004	4,064	17.32%	22,902	4.02%	21,280	6.55%
same industry	3,852	16.42%	21,819	3.83%	20,469	6.30%
different industry	212	0.90%	1,083	0.19%	811	0.25%
Total	23,462	100.00%	569,072	100.00%	324,856	100.00%

Source: Authors' calculations using the BSD for year 2005 and 2004 (ONS)
Industry refers to 5-digit industry level.

Table C2: Demographics by sector, 1997-1998

Demographic event	Producing industry							
	1 Agriculture, Mining and Quarrying		2 Manufacturing		3 Electricity, gas and water supply		4 Construction	
	Number	% industry	Number	% industry	Number	% industry	Number	% industry
Stand alone 1998, Didn't exist in 1997	7,586	4.53%	21,679	11.86%	97	27.02%	38,840	19.41%
Group in 1998, Didn't exist in 1997	48	0.03%	558	0.31%	24	6.69%	195	0.10%
Stand alone 1998, Stand alone 1997	158,304	94.48%	140,896	77.06%	130	36.21%	155,643	77.76%
same industry	153,652	91.70%	120,911	66.13%	113	31.48%	151,941	75.91%
different industry	4,652	2.78%	19,985	10.93%	17	4.74%	3,702	1.85%
Stand alone 1998, Group 1997	128	0.08%	1354	0.74%	n/a	n/a	441	0.22%
same industry	106	0.06%	1,015	0.56%	n/a	n/a	351	0.18%
different industry	22	0.01%	339	0.19%	n/a	n/a	90	0.04%
Group 1998, Stand alone 1997	97	0.06%	1389	0.76%	10	2.79%	400	0.20%
same industry	76	0.05%	1,013	0.55%	n/a	n/a	323	0.16%
different industry	21	0.01%	376	0.21%	n/a	n/a	77	0.04%
Group 1998, Group 1997	1395	0.83%	16955	9.27%	92	25.63%	4628	2.31%
same industry	1,280	0.76%	14,167	7.75%	82	22.84%	4,166	2.08%
different industry	115	0.07%	2,788	1.52%	10	2.79%	462	0.23%
Total in 1998	167,558	100.00%	182,831	100.00%	359	100.00%	200,147	100.00%

Source: Authors' calculations using the BSD for year 2005 and 2004 (ONS)
Industry refers to 5-digit industry level.

Table C2: Demographics by sector, 1997-1998 *continued*

Demographic event	Producing industry							
	5 Wholesale and motor vehicles distribution		6 Retail		7 Hotel and Restaurants		8 Transport and communication	
	Number	% industry	Number	% industry	Number	% industry	Number	% industry
Stand alone 1998, Didn't exist in 1997	22,109	11.17%	29,745	12.53%	26,387	21.03%	12,478	18.63%
Group in 1998, Didn't exist in 1997	547	0.28%	195	0.08%	123	0.10%	187	0.28%
Stand alone 1998, Stand alone 1997	159,247	80.49%	191,381	80.65%	94,214	75.08%	63,827	95.31%
same industry	144,082	72.83%	160,445	67.61%	91,199	72.68%	59,592	88.99%
different industry	15,165	7.67%	30,936	13.04%	3,015	2.40%	4,235	6.32%
Stand alone 1998, Group 1997	961	0.49%	754	0.32%	439	0.35%	270	0.40%
same industry	734	0.37%	495	0.21%	375	0.30%	222	0.33%
different industry	227	0.11%	259	0.11%	64	0.05%	48	0.07%
Group 1998, Stand alone 1997	966	0.49%	424	0.18%	253	0.20%	332	0.50%
same industry	727	0.37%	241	0.10%	182	0.15%	251	0.37%
different industry	239	0.12%	183	0.08%	71	0.06%	81	0.12%
Group 1998, Group 1997	14015	7.08%	14812	6.24%	4068	3.24%	4251	6.35%
same industry	11,968	6.05%	11,573	4.88%	3,705	2.95%	3,719	5.55%
different industry	2,047	1.03%	3,239	1.36%	363	0.29%	532	0.79%
Total in 1998	197,845	100.00%	237,311	100.00%	125,484	100.00%	66,965	100.00%

Source: Authors' calculations using the BSD for year 1998 and 1997 (ONS)
Industry refers to 5-digit industry level.

Table C2: Demographics by sector, 1997-1998 *continued*

Demographic event	Producing industry					
	9 Financial intermediation		10 Business Services and real state		11 Other services (inc public administration)	
	Number	% industry	Number	% industry	Number	% industry
Stand alone 1998, Didn't exist in 1997	2,810	13.45%	86,050	27.59%	40,286	17.22%
Group in 1998, Didn't exist in 1997	332	1.59%	1,221	0.39%	1,000	0.43%
Stand alone 1998, Stand alone 1997	17,479	83.67%	301,227	96.58%	219,479	93.81%
same industry	14,671	70.23%	279,093	89.48%	180,851	77.30%
different industry	2,808	13.44%	22,134	7.10%	38,628	16.51%
Stand alone 1998, Group 1997	182	0.87%	1074	0.34%	1035	0.44%
same industry	122	0.58%	861	0.28%	773	0.33%
different industry	60	0.29%	213	0.07%	262	0.11%
Group 1998, Stand alone 1997	378	1.81%	1972	0.63%	1279	0.55%
same industry	271	1.30%	1,165	0.37%	808	0.35%
different industry	107	0.51%	807	0.26%	471	0.20%
Group 1998, Group 1997	4113	19.69%	17441	5.59%	17035	7.28%
same industry	3,130	14.98%	13,806	4.43%	14,321	6.12%
different industry	983	4.71%	3,635	1.17%	2,714	1.16%
Total	20,891	100.00%	311,891	100.00%	233,966	100.00%

Source: Authors' calculations using the BSD for year 1998 and 1997 (ONS)
Industry refers to 5-digit industry level.

13 Appendix D: Vertical linkages by broad supplying sector

Table D1 shows how vertical linkages vary across different broad supplying sectors in 1997.

We first construct for each producing sector *p* the weighted average across producing industries j of intermediate purchases from supplying sector *s* as a share of industry j's total costs, that is:

$$w_{ps} = \frac{1}{E_p} \sum_{j \in p} e_j \sum_{k \in s} w_{jk}$$

Then, we define the producing industry *j* level of vertical integration with a broad supplying sector *s*, that is the total amount of inputs used by producers in that industry that they can provide from within the firm from supplying sector *s*, which can be written as follows,

$$v_{js} = \frac{1}{E_j} \sum_{i} e_{ij} \sum_{k \in s} d_{ijk} w_{jk}$$

And we calculate the weighted average of these across the different broad producing sectors *p*, that is:

$$v_{ps} = \frac{1}{E_p} \sum_{j \in p} e_j v_{js}$$

Finally we construct our measure of vertical integration, which can be written as follows:

$$\frac{v_{ps}}{W_p} = \frac{1}{E_p} \sum_{j \in p} e_j \frac{v_{js}}{W_j}$$

Table D2 and table D3 show the same statistics in 2001 and 2005 respectively. Consider table D3 for example, the "manufacturing" broad producing sector, table 11 says that on average manufacturing industries purchase 47.20% of inputs (as a share of their costs) from manufacturing industries; on average 4% of their total costs are made up of manufacturing inputs purchased from within the firm; and the percentage of intermediate costs that are supplied by vertically integrated manufacturing suppliers is on average 6%. Industries in the "business services" broad producing sector also exhibit on average a significant proportion of their costs made up from inputs sourced from industries within the sector (37.7%) and a relatively high average percentage of intermediate costs supplied by vertically integrated business services suppliers (10.3%). Industries in the "financial intermediation" broad producing sector source a higher proportion of their inputs from "business services" industries

(26.9%); 11.3% being the percentage of intermediate costs supplied by vertically integrated business services suppliers.

Table D1: Average vertical linkages by broad producing sector and broad supplying sector, 1997

		Supplying broad sector									
Producing broad sector	Statistics	1 Agriculture, Mining and Quarrying	2 Manufacturing	3 Electricity, gas and water supply	4 Construction	5 Wholesale and motor vehicles distribution	7 Hotel and Restaurants	8 Transport and communication	9 Financial intermediation	10 Business Services and real state	11 Other services
1 Agriculture, Mining and Quarrying	w_{ps}	12.80%	37.10%	2.60%	1.90%	4.10%	0.30%	3.70%	3.00%	6.80%	4.80%
	v_{ps}	1.30%	0.40%	0.00%	0.20%	0.00%	0.00%	0.30%	0.20%	0.40%	0.10%
	v_{ps}/W_p	1.80%	0.50%	0.00%	0.20%	0.00%	0.00%	0.50%	0.30%	0.50%	0.10%
2 Manufacturing	w_{ps}	2.60%	47.50%	2.10%	0.30%	0.10%	0.20%	3.60%	2.30%	5.70%	2.00%
	v_{ps}	0.60%	6.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.20%	0.60%	0.20%
	v_{ps}/W_p	0.70%	8.90%	0.00%	0.00%	0.00%	0.00%	0.20%	0.40%	1.00%	0.30%
3 Electricity, gas and water supply	w_{ps}	20.60%	9.90%	34.20%	3.40%	0.30%	0.30%	1.40%	1.70%	8.60%	2.50%
	v_{ps}	11.00%	0.50%	17.00%	1.60%	0.00%	0.00%	0.10%	0.50%	3.40%	0.90%
	v_{ps}/W_p	12.90%	0.70%	19.20%	2.20%	0.00%	0.00%	0.10%	0.60%	4.70%	1.20%
4 Construction	w_{ps}	3.00%	21.10%	0.20%	33.20%	0.20%	0.40%	1.20%	0.50%	10.60%	4.10%
	v_{ps}	0.00%	0.30%	0.00%	6.60%	0.00%	0.00%	0.00%	0.00%	0.60%	0.50%
	v_{ps}/W_p	0.10%	0.50%	0.00%	8.90%	0.00%	0.00%	0.00%	0.00%	0.80%	0.70%
5 Wholesale and motor vehicles	w_{ps}	0.30%	18.30%	0.60%	0.60%	1.30%	0.40%	20.20%	1.50%	14.00%	5.00%
	v_{ps}	0.00%	0.40%	0.00%	0.00%	0.10%	0.00%	0.50%	0.10%	0.60%	0.40%
	v_{ps}/W_p	0.00%	0.60%	0.00%	0.00%	0.20%	0.00%	0.80%	0.10%	0.90%	0.60%
6 Retail	w_{ps}	0.50%	13.10%	1.40%	1.20%	0.60%	3.20%	7.20%	1.50%	14.80%	15.30%
	v_{ps}	0.00%	0.10%	0.00%	0.10%	0.00%	0.30%	0.30%	0.30%	0.80%	5.20%
	v_{ps}/W_p	0.00%	0.20%	0.00%	0.10%	0.00%	0.50%	0.50%	0.50%	1.40%	8.80%

Producing broad sector	Statistics	Supplying broad sector: 1 Agriculture, Mining and Quarrying	2 Manufacturing	3 Electricity, gas and water supply	4 Construction	5 Wholesale and motor vehicles distribution	7 Hotel and Restaurants	8 Transport and communication	9 Financial intermediation	10 Business Services and real state	11 Other services (inc public administration)
7 Hotel and restaurants	w_{ps}	2.30%	38.10%	0.70%	0.40%	0.30%	0.70%	4.10%	0.80%	8.30%	3.40%
	v_{ps}	0.10%	2.50%	0.00%	0.00%	0.00%	0.20%	0.20%	0.10%	0.60%	0.30%
	v_{ps}/W_p	0.20%	4.30%	0.00%	0.00%	0.00%	0.30%	0.30%	0.10%	1.10%	0.50%
8 Transport and communication	w_{ps}	0.10%	17.60%	0.60%	1.20%	1.30%	0.70%	21.40%	1.20%	14.70%	4.00%
	v_{ps}	0.00%	1.60%	0.00%	0.30%	0.10%	0.00%	7.50%	0.10%	2.20%	0.60%
	v_{ps}/W_p	0.00%	2.60%	0.00%	0.50%	0.20%	0.00%	11.60%	0.10%	3.60%	1.00%
9 Financial intermediation	w_{ps}	0.00%	6.80%	0.60%	2.20%	0.40%	1.10%	16.90%	8.60%	28.20%	6.80%
	v_{ps}	0.00%	0.30%	0.00%	0.60%	0.00%	0.20%	0.40%	4.80%	6.60%	2.00%
	v_{ps}/W_p	0.00%	0.40%	0.00%	0.80%	0.10%	0.30%	0.60%	6.70%	9.30%	2.80%
10 Business services and real state	w_{ps}	0.00%	4.80%	0.40%	0.50%	0.60%	0.70%	5.10%	1.10%	37.40%	4.50%
	v_{ps}	0.00%	0.00%	0.00%	0.10%	0.00%	0.00%	0.10%	0.00%	5.20%	0.20%
	v_{ps}/W_p	0.00%	0.10%	0.00%	0.10%	0.10%	0.10%	0.30%	0.10%	9.10%	0.30%
11 Other services	w_{ps}	0.10%	9.80%	0.60%	1.60%	0.40%	0.40%	3.50%	1.00%	14.80%	28.30%
	v_{ps}	0.00%	0.00%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	0.70%	2.50%
	v_{ps}/W_p	0.00%	0.10%	0.00%	0.20%	0.00%	0.00%	0.10%	0.10%	1.10%	3.80%

Note: The figures are employment-weighted averages across 2/3 digit producing within each broad producing sector.
Source: Authors' calculations using BSD for 1997 (ONS) and the Input Output Tables.

Table D2: Average vertical linkages by broad producing sector and broad supplying sector, 2001

		Supplying broad sector									
Producing broad sector	Statistics	1 Agriculture, Mining and Quarrying	2 Manufacturing	3 Electricity, gas and water supply	4 Construction	5 Wholesale and motor vehicles distribution	7 Hotel and Restaurants	8 Transport and communication	9 Financial intermediation	10 Business Services and real state	11 Other services
1 Agriculture, Mining and Quarrying	w_{ps}	12.90%	36.70%	2.60%	1.90%	4.10%	0.30%	3.80%	3.00%	7.00%	4.70%
	v_{ps}	1.50%	0.20%	0.00%	0.20%	0.00%	0.00%	0.20%	0.20%	0.30%	0.10%
	v_{ps}/W_p	2.00%	0.30%	0.00%	0.20%	0.00%	0.00%	0.30%	0.30%	0.40%	0.10%
2 Manufacturing	w_{ps}	2.70%	47.60%	2.00%	0.30%	0.10%	0.20%	3.60%	2.30%	5.80%	2.10%
	v_{ps}	0.20%	5.40%	0.00%	0.00%	0.00%	0.00%	0.10%	0.10%	0.50%	0.10%
	v_{ps}/W_p	0.30%	8.00%	0.00%	0.00%	0.00%	0.00%	0.20%	0.20%	0.80%	0.20%
3 Electricity, gas and water supply	w_{ps}	17.40%	10.60%	33.30%	3.90%	0.30%	0.30%	1.50%	1.80%	9.90%	2.70%
	v_{ps}	5.20%	0.40%	16.20%	2.10%	0.00%	0.00%	0.20%	0.20%	5.30%	0.90%
	v_{ps}/W_p	6.10%	0.60%	18.50%	3.10%	0.00%	0.00%	0.30%	0.20%	7.70%	1.30%
4 Construction	w_{ps}	3.00%	21.10%	0.20%	33.20%	0.20%	0.40%	1.20%	0.50%	10.60%	4.10%
	v_{ps}	0.00%	0.20%	0.00%	6.80%	0.00%	0.00%	0.00%	0.00%	0.60%	0.50%
	v_{ps}/W_p	0.00%	0.30%	0.00%	9.10%	0.00%	0.00%	0.00%	0.00%	0.80%	0.70%
5 Wholesale and motor vehicles	w_{ps}	0.30%	18.20%	0.60%	0.60%	1.30%	0.40%	20.30%	1.50%	14.00%	5.00%
	v_{ps}	0.00%	0.40%	0.00%	0.00%	0.10%	0.00%	0.40%	0.00%	0.60%	0.40%
	v_{ps}/W_p	0.00%	0.60%	0.00%	0.00%	0.20%	0.00%	0.60%	0.10%	1.00%	0.60%
6 Retail	w_{ps}	0.50%	13.10%	1.40%	1.20%	0.60%	3.20%	7.20%	1.50%	14.80%	15.30%
	v_{ps}	0.00%	0.10%	0.00%	0.10%	0.00%	0.30%	0.10%	0.10%	1.40%	5.10%
	v_{ps}/W_p	0.00%	0.10%	0.00%	0.10%	0.00%	0.50%	0.20%	0.20%	2.40%	8.60%

Producing broad sector	Statistics	Supplying broad sector: 1 Agriculture, Mining and Quarrying	2 Manufacturing	3 Electricity, gas and water supply	4 Construction	5 Wholesale and motor vehicles distribution	7 Hotel and Restaurants	8 Transport and communication	9 Financial intermediation	10 Business Services and real state	11 Other services (inc public administration)
7 Hotel and restaurants	w_{ps}	2.30%	38.10%	0.70%	0.40%	0.30%	0.70%	4.10%	0.80%	8.30%	3.40%
	v_{ps}	0.00%	1.00%	0.00%	0.00%	0.00%	0.20%	0.10%	0.00%	0.50%	0.20%
	v_{ps}/W_p	0.00%	1.60%	0.00%	0.00%	0.00%	0.30%	0.10%	0.00%	0.90%	0.40%
8 Transport and communication	w_{ps}	0.10%	17.30%	0.60%	1.20%	1.20%	0.70%	21.60%	1.20%	14.80%	4.00%
	v_{ps}	0.00%	1.40%	0.00%	0.30%	0.10%	0.00%	7.80%	0.10%	2.40%	0.50%
	v_{ps}/W_p	0.00%	2.20%	0.00%	0.50%	0.10%	0.00%	12.00%	0.10%	3.90%	0.80%
9 Financial intermediation	w_{ps}	0.00%	6.80%	0.60%	2.10%	0.40%	1.10%	17.20%	9.30%	27.50%	6.50%
	v_{ps}	0.00%	0.50%	0.00%	0.40%	0.10%	0.10%	0.20%	5.70%	7.90%	2.60%
	v_{ps}/W_p	0.00%	0.60%	0.00%	0.60%	0.20%	0.20%	0.30%	7.90%	11.10%	3.60%
10 Business services and real state	w_{ps}	0.00%	4.90%	0.40%	0.50%	0.60%	0.70%	5.00%	1.10%	37.30%	4.40%
	v_{ps}	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.00%	4.90%	0.10%
	v_{ps}/W_p	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	0.10%	0.10%	8.60%	0.10%
11 Other services	w_{ps}	0.10%	9.70%	0.60%	1.50%	0.40%	0.40%	3.50%	1.00%	14.80%	28.20%
	v_{ps}	0.00%	0.10%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	0.60%	3.20%
	v_{ps}/W_p	0.00%	0.10%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	1.00%	5.20%

Note: The figures are employment-weighted averages across 2/3 digit producing within each broad producing sector.
Source: Authors' calculations using BSD for 2001 (ONS) and the Input Output Tables.

Table D3: Average vertical linkages by broad producing sector and broad supplying sector, 2005

Producing broad sector	Statistics	Supplying broad sector: 1 Agriculture, Mining and Quarrying	2 Manufacturing	3 Electricity, gas and water supply	4 Construction	5 Wholesale and motor vehicles distribution	7 Hotel and Restaurants	8 Transport and communication	9 Financial intermediation	10 Business Services and real state	11 Other services
1 Agriculture, Mining and Quarrying	w_{ps}	12.70%	37.60%	2.60%	1.80%	4.20%	0.30%	3.50%	2.90%	6.70%	4.90%
	v_{ps}	1.00%	0.00%	0.00%	0.10%	0.00%	0.00%	0.20%	0.10%	0.20%	0.00%
	v_{ps}/W_p	1.30%	0.10%	0.00%	0.10%	0.00%	0.00%	0.30%	0.10%	0.20%	0.00%
2 Manufacturing	w_{ps}	2.90%	47.20%	2.00%	0.30%	0.10%	0.20%	3.70%	2.20%	5.70%	2.10%
	v_{ps}	0.10%	4.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.10%	0.30%	0.10%
	v_{ps}/W_p	0.20%	6.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.20%	0.40%	0.10%
3 Electricity, gas and water supply	w_{ps}	19.30%	10.10%	38.10%	3.00%	0.30%	0.30%	1.40%	1.70%	7.90%	2.30%
	v_{ps}	0.00%	0.10%	11.10%	1.20%	0.00%	0.00%	0.10%	0.00%	2.30%	0.30%
	v_{ps}/W_p	0.00%	0.20%	12.50%	1.80%	0.00%	0.00%	0.10%	0.00%	3.50%	0.50%
4 Construction	w_{ps}	3.00%	21.10%	0.20%	33.20%	0.20%	0.40%	1.20%	0.50%	10.60%	4.10%
	v_{ps}	0.00%	0.10%	0.00%	6.80%	0.00%	0.00%	0.00%	0.00%	0.40%	0.50%
	v_{ps}/W_p	0.00%	0.20%	0.00%	9.20%	0.00%	0.00%	0.00%	0.00%	0.60%	0.60%
5 Wholesale and motor vehicles	w_{ps}	0.30%	18.20%	0.60%	0.60%	1.30%	0.40%	20.30%	1.50%	14.00%	5.00%
	v_{ps}	0.00%	0.20%	0.00%	0.00%	0.10%	0.00%	0.30%	0.00%	0.40%	0.40%
	v_{ps}/W_p	0.00%	0.40%	0.00%	0.00%	0.20%	0.00%	0.40%	0.00%	0.60%	0.60%
6 Retail	w_{ps}	0.50%	13.10%	1.40%	1.20%	0.60%	3.20%	7.20%	1.50%	14.80%	15.30%
	v_{ps}	0.00%	0.10%	0.00%	0.00%	0.00%	0.10%	0.20%	0.00%	2.30%	5.30%
	v_{ps}/W_p	0.00%	0.10%	0.00%	0.10%	0.00%	0.20%	0.30%	0.00%	3.80%	9.00%

Producing broad sector	Statistics*	Supplying broad sector: 1 Agriculture, Mining and Quarrying	2 Manufacturing	3 Electricity, gas and water supply	4 Construction	5 Wholesale and motor vehicles distribution	7 Hotel and Restaurants	8 Transport and communication	9 Financial intermediation	10 Business Services and real state	11 Other services (inc public administration)
7 Hotel and restaurants	w_{ps}	2.30%	38.10%	0.70%	0.40%	0.30%	0.70%	4.10%	0.80%	8.30%	3.40%
	v_{ps}	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.20%	0.10%
	v_{ps}/W_p	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%	0.20%
8 Transport and communication	w_{ps}	0.10%	16.60%	0.60%	1.20%	1.20%	0.70%	22.20%	1.20%	14.90%	4.00%
	v_{ps}	0.00%	1.10%	0.00%	0.20%	0.00%	0.00%	7.50%	0.00%	2.20%	0.40%
	v_{ps}/W_p	0.00%	1.70%	0.00%	0.30%	0.00%	0.00%	11.40%	0.00%	3.50%	0.60%
9 Financial intermediation	w_{ps}	0.00%	6.80%	0.60%	2.00%	0.40%	1.10%	17.50%	9.60%	26.90%	6.20%
	v_{ps}	0.00%	0.50%	0.00%	0.60%	0.00%	0.30%	1.00%	4.50%	8.10%	2.00%
	v_{ps}/W_p	0.00%	0.70%	0.00%	0.90%	0.00%	0.40%	1.30%	6.30%	11.30%	2.80%
10 Business services and real state	w_{ps}	0.00%	4.80%	0.40%	0.50%	0.60%	0.70%	5.00%	1.10%	37.70%	4.30%
	v_{ps}	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.90%	0.00%
	v_{ps}/W_p	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.00%	10.30%	0.10%
11 Other services	w_{ps}	0.10%	9.60%	0.60%	1.80%	0.40%	0.40%	3.60%	1.00%	15.00%	27.50%
	v_{ps}	0.00%	0.00%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	0.70%	3.50%
	v_{ps}/W_p	0.00%	0.10%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	1.20%	5.60%

Source: Authors' calculations using BSD for 2005 (ONS) and the Input Output Tables.
Note: The figures are employment-weighted averages across 2/3 digit producing within each broad producing sector.