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International Fragmentation and Relative Wages in the UK

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Abstract

While growing wage inequality is of ongoing concern in many developed countries, there still does not exist a consensus on the predominant source of this trend. Some argue that skill-biased technological change is responsible for the shift in the relative demand of skilled workers while others hold increased import competition from low-wage countries reducing employment for the unskilled responsible for the growing income divide within countries. This paper re-examines the trade-based explanation by focussing on international outsourcing. In a recent paper, Feenstra and Hanson (1996) estimate the effect of international outsourcing on wage inequality in the US. This paper extends the FH approach using more detailed definitions of import penetration and outsourcing as well as data for UK manufacturing industries for the period 1982-1996. The econometric results suggest that technical change and import penetration matter for wage inequality (although the effect of the latter depends crucially on whether or not estimations are weighted) while the role of outsourcing cannot be clearly determined.

Outline

Non-Technical Summary

One of the main consequences of the process of globalisation is the increasing international fragmentation of production, that is, the splitting up of production processes into separate components so that they can be produced in different locations. This phenomenon is likely to have important implications for both the composition and the pattern of international trade. International fragmentation of production leads to the establishment of international production networks, which are associated with trade in intermediates.

In this paper fragmentation (or outsourcing) is related to the debate on trade and wages. It is argued that both the sector and the factor bias of fragmentation are likely to affect relative wages. This study focuses on the factor bias by estimating the relative demand for labour derived from a translog cost function. Different measures of outsourcing are constructed on the basis of the import-use matrices of the input-output tables. Labour market data were obtained from the New Earnings Survey; a dataset which allows one to define skill groups on the basis of the Standard Occupational Classification instead of using the crude distinction between manual and non-manual workers used elsewhere in the literature.

The results obtained in the empirical estimations show that there appears to be a positive relationship between capital intensity and skill intensity confirming the idea that capital and skilled labour are complements. Also both expenditure on computers as well expenditure on research and development seem to be appropriate indicators of skill-biased technological change. According to the results, an increase in skill-biased technological change is associated with an increase in wage inequality.

The paper, however, presents mixed results with respect to the role of trade on domestic wage inequality. Unweighted regressions fail to confirm the expected positive relationship between foreign competition and outsourcing. Instead, foreign competition has a significant and negative effect. The impact of foreign competition is even stronger and more negative when it is measured in terms of imports from developing countries. However, when the estimations are weighted in order to account for differences in industry size, thereby emphasising large industries, the results indicate a positive and significant effect of foreign competition on wage inequality.

The empirical estimations provide some weak evidence of a positive relationship between outsourcing and wage inequality. However, the coefficients on outsourcing are not statistically significant. Therefore, it is not possible to comment on the different measures

of outsourcing. It is hoped that more explicit conclusions concerning the role of outsourcing can be drawn when new data on outsourcing become available with the 1995 input-output tables for the UK.

1. Introduction

One of the main consequences of the process of globalisation is the increasing international fragmentation of production.[1] This phenomenon is likely to have important implications for both the composition and the pattern of international trade.

International fragmentation of production leads to the establishment of international production networks, which are associated with trade in intermediates. Some recent studies have provided evidence of the growing importance of trade in intermediates (Campa and Goldberg, 1997; Yeats, 2001). From the data for the UK used in this paper, for example, it appears that the share of intermediate purchases imported from abroad (within the same industry) increased from 34% to 42% over the period 1984-1990.

However, fragmentation does not only affect the composition of international trade but may also change the pattern of trade. In the literature on fragmentation the main driving force behind outsourcing is the existence of differences in factor endowments across national borders. Unskilled labour-intensive stages of production tend to be shifted to usnkilled labour-abundant developing countries, while more technologically advanced stages remain in skilled labour-abundant developed countries. It is asserted therefore that the possibility of fragmentation enhances the integration of developing countries in the world economy. Indeed for the UK the share of imports from developing countries over total imports increased from 18% to 22% over the period 1982-1996 indicating increased competition from low-wage countries.

It is, therefore, worth analysing the impact of fragmentation on labour markets and in particular on the skill structure of demand. Many have expressed the fear in developed countries that outsourcing will tend to reduce the demand for unskilled workers resulting in either falling relative wages or increased unskilled unemployment. However, in the theoretical literature this is not necessarily the case, but the direction of its effect depends on the circumstances. Moreover, it is an empirical question whether outsourcing is a large enough phenomenon in order to account for significant labour market effects.

[1] The term fragmentation was coined by Jones and Kierzkowski (1990). It refers to the splitting up of production processes into separate components so that they can be produced in different locations. There exist many terms that are used to indicate the same phenomenon. These are amongst others, vertical specialisation (Hummels, Ishii and Yi, 2001), intra-product specialisation (Arndt, 1997), delocalization (Leamer, 1998),

This paper relates fragmentation to wage inequality as there still does not exist a consensus on the predominant source of the trend in wage inequality. Some argue that skill-biased technological change is responsible for the shift in the relative demand of skilled workers, others hold increased import competition from low-wage countries reducing employment for the unskilled responsible for the growing income divide within countries. Most empirical work indicated that technological change explains the lion's share of the increased wage inequality, although trade appeared to play a significant role as well.

The purpose of this paper is to re-examine the trade-based explanation by focusing on international outsourcing in UK manufacturing. Outsourcing differs importantly from import penetration in final goods in the sense that it explicitly takes into account the extent to which firms move production activities abroad. Moreover, labour demand is affected not only in import-competing industries, but in all industries that use foreign inputs. Hence, the impact of outsourcing is not limited to changing labour demands between industries, but also affects the relative demand for labour within industries.

In a recent paper, Feenstra and Hanson (1996) estimate the effect of international outsourcing on wage inequality in the US using a partial-equilibrium approach based on a translog cost function. They measure outsourcing (fragmentation) as the share of imported intermediate inputs in total intermediate inputs using input-output data from the Census of Manufactures and trade data from the NBER trade data base. They find that there has been a positive effect of outsourcing on the relative wages of skilled workers in the US over the period 1979-1990.

The present paper aims at extending the Feenstra and Hanson approach using input-output data for manufacturing industries in the UK for the period 1982-1996. Extending the analysis to include the 1990s is thought to be crucial, as the significance of international fragmentation seems to be a phenomenon particularly of the last decade. Also using import-use matrices of the input-output tables instead of intermediate purchases the measure of outsourcing applied in this paper can be deemed more appropriate than the measure used by Feenstra and Hanson. Furthermore, labour market data, obtained from the New Earnings Survey (NES), allow one to define skill groups on the basis of the Standard Occupational

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outsourcing (Feenstra and Hanson), disintegration (Feenstra, 1998). Throughout this review these terms will be used interchangeably.

Classification (SOC) instead of the crude distinction between manual and non-manual workers used elsewhere in the literature.

The paper is structured as follows. Section 2 presents a brief discussion on the impact of fragmentation on relative wages in theory. The emphasis is put on the discussion of sector bias versus factor bias. Section 3 gives a selective survey of the empirical literature. Section 4 presents descriptive data on labour market developments and fragmentation. A first attempt will be made to link the phenomena. Section 5 sets out the methodology employed in the econometric analysis and Section 6 contains the results. Finally, Section 7 concludes.

2. Theory

The two main demand-side explanations of the increase in domestic wage inequality have focussed on the role of skill-biased technological change (SBTC) and international trade.[2] Until recently skill-biased technological change was associated with within industry changes in skill intensity as a result of its effect of relative productivity, whereas international trade was associated with between industry changes based on general equilibrium trade models. Empirically these two explanations were investigated using different methodologies. Relative labour demand regressions were mainly used to estimate the impact of SBTC, whereas trade economists generally favoured product price studies.

Recently, however, it has become increasingly apparent that this is too simple a way of representing reality. First, Haskel and Slaughter (1998) have pointed out that even skill-neutral technological change can account for some of the increase in relative wages emphasising the sector bias of technological change. As long as technical change affects the relative profitability of sectors it has an impact on relative factor prices (Haskel, 2000). Second, Feenstra and Hanson (1995) analyse the impact of outsourcing, that is trade in intermediates, within a one-sector framework emphasising the factor bias of outsourcing.

The theoretical literature on fragmentation or outsourcing generally takes the form of moving unskilled intensive manufacturing processes from a developed country to a developing country. It is argued that fragmentation has a similar effect as technological change. However, the question whether one should emphasise the factor or the sector bias

[2] See Chennels and Van Reenen (1999) for a survey of the former and Slaughter (2000) and Haskel (2000) for surveys of the latter literature.

of outsourcing in order to analyse its impact on domestic wage inequality is open to debate as will become clear from the following discussion.

Feenstra and Hanson (1995) model outsourcing of unskilled-intensive fragments from the US to Mexico in order to explain the empirical finding of increasing wage inequality in *both* the US and Mexico. They do so by analysing outsourcing in a one-sector two-country framework with capital mobility. As a result they emphasise the factor bias of outsourcing and consequently outsourcing has a qualitatively similar effect as SBTC. Kohler (2000) remarks that if technological change at home *and* abroad has a similar effect as technological change in a closed economy as pointed out in Krugman (2000), then this should also hold when outsourcing induces upgrading at home and abroad. As in a closed economy the factor bias of technological change determines what happens to relative factor prices, it is justified to emphasise the factor bias of outsourcing.

In contrast, Arndt (1997) analyses the impact of fragmentation in a small open developed economy in a standard 2x2x2 Heckscher-Ohlin model. As a result Arndt emphasises the sector bias of outsourcing. He concludes that outsourcing of labour-intensive components in the labour-intensive industry actually reduces wage inequality whereas it increases wage inequality in the capital/skill-intensive industry. Jones and Kierzkowski (2000) confirm these possibilities, but also stress that there are many other scenarios one may think of. A priori, therefore, it is very difficult to predict how fragmentation will actually affect relative wages.

The present study approaches outsourcing from a one-sector perspective by estimating the relative demand for labour. As a result outsourcing of labour-intensive components abroad is expected to reinforce wage inequality. If outsourcing turns out insignificant or negative this may be either due to the limited magnitude of the phenomenon or outsourcing may be driven to an important extent by other considerations than low wages.

3. Empirical Literature

The empirical literature analysing the impact of international fragmentation of production on domestic wage inequality is still fairly limited. In this section a brief survey of the literature is given. Besides taking into account studies that explicitly relate labour market developments to outsourcing, the survey also includes some studies from the broader wage inequality debate that are important from a methodological perspective or relate to the specific case of the UK.

Berman, Bound and Griliches (1994) were the first to apply relative labour demand regressions in order to shed light on factors driving the widening wage gap in the US. They devote much attention to the analysis of skill upgrading across and within sectors in the belief that within-industry upgrading results mainly from skill-biased technological change (SBTC), and between-industry upgrading from either international trade or defence procurement. Berman et al. find that within-industry upgrading dominates. Consequently, they focus on within-industry upgrading by employing a translog cost function, the main advantage of which is that one can easily derive the relative demand for labour.

Berman et al. observe that in the US the share of skilled wages in the total wage bill accelerated over time from an annual increase of 0.07 % for the period 1959-1973 to 0.21% for 1973-1979 to 0.47% for 1979-1987. Two indicators of SBTC are included in the labour demand regressions: investment on computers over total investment and expenditure on R&D. Results indicate that together these measures account for around 70% of the variation in the cost share of skilled labour. Therefore, they conclude that defence procurement and international trade are of minor importance in explaining increased wage inequality.

Feenstra and Hanson (1995, 1996) are the first to approach the question of wage inequality from the angle of outsourcing while adopting the methodology advanced by Berman et al. (1994). Feenstra and Hanson measure outsourcing by combining disaggregated data on intermediate purchases obtained from the Census of Manufacturers with trade statistics and add their measure of outsourcing or import penetration to a translog cost function.

Feenstra and Hanson use data for the period 1972-1990. The regression analysis only provides evidence for a positive effect of outsourcing on the relative demand for labour for the 1980s. Over this period outsourcing accounted for about 30% to 50% of the increase in the nonproduction wage share, which is considerably more than the proportion explained by the import penetration variable. They argue that this is because outsourcing directly measures the extent to which industries move production to low-wage countries. A possible explanation for the lack of evidence for the 1970s and the convincing evidence for the 1980s is sought in a change in the pattern of trade as the trade share with developing countries has risen dramatically in recent years.

In Feenstra and Hanson (1999) the measure of outsourcing is refined by distinguishing between narrow and broad outsourcing.[3] The broad definition of international outsourcing captures all imported intermediates within a given industry, that is

$$S_O^B = \frac{\sum_{i=1}^{i} O_{ijt}}{VA_{jt}}$$

The narrow definition of international outsourcing only considers imported intermediates in a given industry from the same industry (which corresponds to diagonal terms of the import-use matrix), i.e.,

$$S_O^N = \frac{O_{i=j,t}}{VA_{jt}}$$

The broad definition (which corresponds to the column totals of the import-use matrix) was used in their earlier work. The narrow definition is preferred by Feenstra and Hanson as it is thought to come closer to the real idea of outsourcing (it excludes packaging or primary inputs such as steel, for example) especially when the level of aggregation is relatively high (2-digit). From the empirical analysis it follows that narrow outsourcing is indeed more important in explaining changes in the cost shares indicating that it is a more precise measure of outsourcing. Outsourcing accounts for 13-23 % of the variation, and technology for about 8-32% depending on the proxy used.[4] They conclude that both outsourcing and SBTC are important.[5]

Machin and Van Reenen (1998) provide evidence on the effect of SBTC and trade on wage inequality in seven OECD countries, including the US and the UK. R&D and capital intensity are generally positively related to upgrading and statistically significant. Surprisingly, comparing results across countries reveals that the impact of R&D and

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[3] Note that the formal representations are based on the use of import-use matrices (not as in Feenstra and Hanson, 1997, 1999).

[4] Feenstra and Hanson (1997, 1999) actually try to integrate the two main explanations by using a general equilibrium approach estimating so-called mandated wage regressions. In order to make their results comparable to previous results they re-run the standard regression with the new data. These are the regressions referred to in the text.

[5] In a related paper Autor, Katz, and Krueger (1998) using similar data find that outsourcing is positive but statistically insignificant in all regressions.

computer expenditure on upgrading is smallest in the UK and the US, i.e. the countries where skill upgrading was most important. In testing for the impact of foreign competition they distinguish between imports from OECD and non-OECD countries, using both a constant-returns-framework and a non-constant-returns framework. Import penetration is included in either levels or changes for total or non-OECD imports. Import penetration is only once statically significant for the UK when using non-OECD changes in import penetration in the non-CRS framework, although its sign is negative in contrast to what is expected. It is argued that as the methodology only allows one to analyse within-industry shifts as a result of factor bias, one cannot necessarily expect a positive relationship between foreign competition and upgrading as trade is a general equilibrium phenomenon.

Anderton and Brenton (1999) claim to analyse the impact of outsourcing on wage inequality in the UK by estimating the impact of total imports on relative wages in the textiles and non-electrical machinery industries for the period 1970-1983. As in Machin and Van Reenen (1998) they distinguish import penetration from developed and from developing countries; however, they do not consider trade in intermediates, which constitutes the essence of outsourcing but focus on total imports. Only foreign competition from developing countries is positive and statistically significant. They argue that import penetration, which they take as a measure of outsourcing accounts for about 40% of the increased wage inequality and one third of the change in the structure of employment in textiles.

It is interesting to see to what extent the impact of outsourcing differs across sectors with different factor intensities. Textiles are considered to be unskilled-intensive, while non-electrical machinery is considered skill-intensive. Both sectors exhibit high levels of outsourcing. It follows that textiles are more sensitive to the impact of outsourcing than non-electrical machinery.[6]

Dell'mour et al. (2000) analyse the impact of outsourcing on labour markets for the case of Austria over the period 1990-1998. They estimate both relative labour demand (partial equilibrium) and mandated wage (general equilibrium) regressions. As wages are assumed to be fairly rigid in Austria the employment share of skilled workers is used as the

[6] Therefore, one might conclude that both sectors are subject to different types of outsourcing. Outsourcing in unskilled-intensive industries generally takes the form of moving the production of unskilled-intensive components abroad, whereas skill-intensive industries also tend to engage in technological sourcing where capital-intensive components are shifted abroad.

dependent variable for the relative labour demand regressions. They include two measures of openness proxied by import penetration and export openness and one measure of outsourcing based on data on trade in intermediates obtained from input-output tables. For their measure of outsourcing they distinguish the origin of imports by multiplying imported intermediates by the share of a region's imports over total imports. They find positive and significant results for export openness and outsourcing and a negative and significant effect for import penetration.

4. Trends in Labour Markets and Fragmentation

In this section the sources of the data for labour markets and fragmentation will be discussed and the trends analysed. A first attempt will be made to link the two developments together before going to the actual regression stage.

4.1 Labour markets (1982-1997)

In most developed countries it is a well-established fact that the demand for skilled labour has gone up relative to that for unskilled labour. As a result in countries with flexible labour markets the wage gap between the unskilled and the skilled has increased significantly over the last few decades. In countries with relatively rigid labour markets the relative change in demand may be reflected in changes in relative employment/unemployment.

Labour market data are obtained from the New Earnings Survey (NES). The NES is based on a series of surveys that cover approximately one percent of the working population. Besides providing data on wages, employment and numerous other factors, it also classifies each employee to the Standard Occupational Classification (SOC), which allows one to construct a more accurate measure of skill than the one based on manual/non-manual workers generally used in the literature. In the NES workers are classified according to 9 Major Groups and 22 Sub-Major Groups.[7] The SOC Major Groups are based on qualifications, training, skills, and experience, while the Sub-Major Groups are determined by the nature of the job. Therefore, distinguishing skill groups on the basis of their Major Group Codes allows one to construct a very accurate measure of skill. For the determination of skill groups the approach taken by Gregory, Zissimos and Greenhalgh (2001) is adopted. Apart from providing a more accurate measure of skill, this approach

[7] For a description of those skill groups see the appendix to this section.

allows to distinguish three skill groups: skilled, intermediate, and unskilled.[8] As a result it is possible to see to what extent wage inequality is a phenomenon of the tails or instead affects the whole labour force. Finally, the present study is limited to male workers.

[Table 1 here]

Table 1 shows the relative wage developments between the different skill groups based on the average hourly wages of each skill group. Generally speaking, the table indicates increased wage inequality in favour of the more skilled. A closer look reveals that relative wages of the semi-skilled to the unskilled have been relatively stable over time. The relative wage of skilled workers to both semi and unskilled workers has risen significantly. Therefore, it seems reasonable to group unskilled and semi-skilled workers together. Thus, in the following skilled indicates skill group 1 and unskilled reflects both semi and unskilled.

Inspection of the data on the employment developments of the different skill groups, which are not reported here, shows that absolute employment dropped importantly in all three categories indicating that services increased in importance relative to manufacturing employment. Total skilled labour fell by 23%, semi-skilled employment by 29%, and unskilled employment by 19%. Relative employment, however, remained fairly constant for all skill groups with only the share of semi-skilled labour to unskilled labour falling somewhat.

Gregory et al. (2001) analyse the changes in the skill structure of labour demand for the whole economy including services. Their analysis is particularly relevant as they use the same labour data and the same criterion to distinguish skill and their findings are, therefore, directly comparable to the results in this paper. They show that the share of skilled labour increased from 25 to 31% over the period 1979-1990, while the share of semi-skilled labour fell slightly from 48 to 47% and unskilled employment dropped from 25 to 21%.

Figure 1a represents the share of the wage bill spent on skilled labour. The figure confirms the widely documented increase in domestic wage inequality during the 1980s and early 1990's. However, the graph also indicates a sharp fall in the skilled cost share of the wage bill from 1993 onwards although this should be interpreted with caution as the 1998 value

[8] Unskilled workers are those classified in Major Groups 1 to 3, semi-skilled workers in Major Groups 4 to 7, and skilled workers in Major Groups in 8 and 9.

not presented shows that the skilled labour cost share is back on its 1993 level.[9] Therefore, instead of observing a reversal of the trend it would be more appropriate to speak of the 'levelling off' of the trend in line with evidence for the US (Autor, Katz and Krueger, 1998).

[Figures 1a and 1b here]

Figure 1b represents the employment share of skilled labour over total manufacturing employment. The figure seems to indicate broadly the same trend as Figure 1a.[10]

4.2 Fragmentation

The increasing international fragmentation of production translates into the rising importance of trade in intermediate products. Recently, several studies have attempted to shed light on the development of trade in intermediates using diverse data sources. Hummels, Ishii and Yi (2001) analyse input-output tables for 10 OECD and four emerging market economies and find that outsourcing accounts, on average, for about 20% of exports from these countries. Yeats (2001) uses SITC Rev.3 trade statistics in combination with outward processing trade data (OPT) and finds that trade in intermediates accounts for approximately 30% of total trade in the US. He does, however, note that this figure may be much higher for developing countries as those countries are more and more the focus of outsourcing from developed countries. Görg (2000), using Eurostat data on inward processing trade (IPT) for EU countries shows that IPT in the 'peripheral' countries of the EU increased from 12 to 24% of imports from the US. Campa and Goldberg (1997) using data derived from input-output tables for four OECD countries observe that the ratio of imported intermediates to sales in UK manufacturing rose from 13% in 1974 to 22% in 1993, while import penetration rose from approximately 20 to 30% over the same period.[11]

Input-output tables are the most appropriate source to analyse simultaneously developments across industries and time. Hence, in this study outsourcing will be measured with the help of input-output tables. There are at least two limitations to the use of these data for the analysis of fragmentation. First, when focusing on trade in intermediates one necessarily

[9] The 1998 observation was omitted due to data limitations for other variables.
[10] However, it should be noted that the share of unskilled employment follows quite a similar path (whereas one would expect the opposite). Both types of labour therefore gain in importance relative to semi-skilled labour.
[11] Campa and Goldberg (1997) note that imported intermediates tend to be high in sectors where import penetration ratios are high leading to the conclusion that outsourcing occurs within the same broad industry.

ignores the possibility of outsourcing of the final production stage such as assembly (Ng and Yeats, 1999). Second, the data do not capture outsourcing when products are not re-imported, but exported to third markets.

For the UK approximately every five years input-output tables are developed that distinguish between imported intermediates and domestically produced intermediates (import-use and domestic-use matrix). The present study uses input-output tables for 1984 and 1990.[12] In addition, from 1992 onwards combined-use matrices are available annually.

In Feenstra and Hanson (1996) outsourcing is defined as the change in the combined-use matrix times the change in the import penetration shares within that industry divided by total intermediate purchases. In other words, outsourcing is the ratio of the change in specialisation at the industry level to that of the whole economy times the increase in imports at the industry level. Hence, outsourcing is driven by specialisation/relative outsourcing and import penetration.

Compared to Feentra and Hanson (1996) using import-use matrices instead of combined-used matrices plus trade data has at least three advantages. First, outsourcing is no longer driven by increased import penetration of all goods. Increased import penetration refers both to trade in intermediates and trade in final goods. A measure of outsourcing defined as trade in intermediates may therefore be biased when final goods are included, i.e. the significance of outsourcing may be underestimated when trade in intermediates grows faster than trade in final goods.

Second, outsourcing no longer depends on its change relative to the change in the economy-wide average, but on the absolute increase in specialisation. Hence, the measure used not only captures the cross-industry variation in outsourcing but also the within-industry variation in outsourcing. Outsourcing defined in relative terms will tend to emphasise the sector bias, whereas outsourcing defined in absolute terms will tend to emphasise the factor bias of outsourcing.

Third, the combined-use matrix includes domestic sourcing. However, assuming that wages within countries are equalised, this must be driven by other factors than labour cost differences. There is no reason to believe that increased specialisation within the economy

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[12] Input-output tables for 1995 should be available from the Office for National Statistics in the not too distant future and will then be used to update the present study.

has important labour market effects. For the purpose of this paper, therefore, it does not matter whether products are produced by one firm or by several firms as long as they are produced within a single country. Hence, the replacement of domestic inputs with intermediates sourced abroad should be included in a measure of outsourcing even though it does not reflect fragmentation in the sense of increased specialisation.

Following Feenstra and Hanson (1997, 1999) both the narrow and broad outsourcing are adopted as both measures are subject to different short-comings. From a theoretical perspective broad outsourcing measuring trade in intermediates by purchasing industry, may be inappropriate for the analysis of fragmentation as it does not focus on intra-product specialisation which is likely to take place within the industry. In addition, the distinction between narrow and broad outsourcing as introduced by Feenstra and Hanson (1999) is very crude as it is purely based on the way industries are classified. From a fragmentation perspective it can well be the case that industries are classified on an unequal level of disaggregation. Compare for example the two following industries: 'motor vehicles and parts' and 'textiles'. Both industries are classical examples where fragmentation occurs. However, 'automobiles and parts' is represented in the input-output tables for the UK as one single industry, whereas textiles are made up of 10 different industries. As a result the narrow measure of outsourcing will not pick up much of the outsourcing in textiles. The broad measure on the other hand will be distorted through the inclusion of raw materials.[13]

One may refine the outsourcing variable to outsourcing to low-wage countries (Anderton and Brenton, 1999; Dell'mour et al, 2000). Developed countries can be defined as those countries that are members of the OECD, and developing countries the rest of the world. The measure of outsourcing is multiplied by the import share of the UK from developing countries over total imports. Thereby emphasis is given to Yeats' (2001) observation that trade in intermediates is especially important in trade with developing countries. Thus for narrow outsourcing this gives:

[13] For this reason an intermediate measure could be used that excludes large supplying industries of raw materials. For the data used in this paper this would imply the exclusion of Iron and Steel (S1), Basic Non-Ferrous Metals (S2), and Timber and Wood Products (S46). This is not done in the present paper.

$$S_O^N = \frac{O_{i=j,t}}{VA_{jt}} * \frac{M_{jldc}}{M_j}$$

As Dellmour' et al. note 'the implicit assumption in the calculation of intermediate imports by country groups is that for each good the country import shares are the same across input purchasing sectors (p. 254)'.[14]

In this paper outsourcing is defined as imported intermediates over value added. Total outsourcing increased from 37.7 to 40.2 % over the period 1984-1990. More revealing of the spectacular recent development is the share of (broad) international outsourcing over total intermediate purchases. In only seven years the share of international outsourcing to total sourcing increased from 36.4 to 43.3%. Within industry (narrow) outsourcing increased from 34.2 to 42.2%. These trends indicate that there is evidence of substantial restructuring in the manufacturing sector, which may have important implications for the pattern of trade and the domestic labour market.

The sectoral analysis of outsourcing shows that there exists substantial variation across industries. Three industries that exhibit very high broad outsourcing are 'basic non-ferrous metals', 'electronic consumer goods, records and tapes', and 'grain milling, starch, and food products'. That it is important to define outsourcing carefully becomes clear when comparing narrow and broad outsourcing. Only 'basic non-ferrous metals' and 'oils and fats' show significant outsourcing under the narrow definition. In this case therefore it seems that the narrow definition is too strict a measure of outsourcing as electronics is one of those industries that inspired the debate on fragmentation.

In order to get an initial impression about the relationship between fragmentation and wage inequality, it is illuminating to relate fragmentation to skill intensity. If there exists a

[14] It may be useful to think of outsourcing in the following way. Outsourcing can be divided into two components: the change in input usage (combined use over value added) and the change intermediate import penetration (similar to Feenstra and Hanson matrix). Thus, for narrow outsourcing this gives the following decomposition: $S_O^N = \Delta O_{i=j,t} / VA_{jt} = \Delta C_{jt} / VA_{jt} \times \Delta O_{i=j,t} / \Delta C_{i=j,t}$. In a closed economy an increase in outsourcing equals the increase in the first RHS-term. This can either point at increasing specialisation through domestic substitution at the industry level (an increase in C) or that the industry is in decline (value added falls). In an open economy with international outsourcing an increase in the first RHS-term may signal in addition to the points above at increasing international specialisation. An increase in C as a result of increasing international specialisation may affect value added in two ways. Firstly, international substitution away affects the domestic supplier industry, which is reflected by a reduction in value added. Secondly, international outsourcing may improve the industry's competitive position or/and be related to the upgrading in the industry both leading to an increase in value-added.

negative relation indicating that fragmentation is driven by factor cost differences, outsourcing may be an important factor in explaining domestic wage inequality. Industries within the same range of skill intensity are grouped together in clusters. Skill intensity is measured as the cost share of skilled labour over the total wage bill.[15] Figure 2 shows broad and narrow outsourcing for 1984 and 1990 across five clusters of skill intensity. Cluster 1 industries spend the smallest share on skilled labour and cluster 5 the largest.[16] Figure 2a seems to suggest a negative relationship between broad outsourcing and skill intensity implying that unskilled-intensive industries may be more prone to outsourcing. Figure 2b in contrast fails to show any relation between narrow outsourcing and skill intensity. Finally, the changes in outsourcing over time do not seem to be related to skill intensity. Hence, this superficial look at the data suggests that broad outsourcing will be likely to be a more effective measure of outsourcing than narrow outsourcing. Broad outsourcing seems to be related to the skill intensity of the industry. However, it should be noted these figures are not appropriate to analyse the impact of outsourcing on skill upgrading as one cannot control for any other exogenous factors that may affect skill intensity. To do so, one needs to estimate a properly specified econometric model.

[Figures 2a and 2b here]

5. Econometric Analysis

In order to estimate the effect of outsourcing, import penetration and technology on relative wages in UK manufacturing we take a translog cost function approach. This methodology, which by now has become standard in the literature, is based on the work of Berman, Bound and Griliches (1994) and Feenstra and Hanson (1996).[17] The translog cost function has the useful property that its first derivatives with respect to factor returns give the factor cost share. Following Berman et al. capital is quasi-fixed so that both output and capital can be treated as fixed in the short-run, while skilled and unskilled labour are the only variable

[15] This is also the dependent variable that will be used in the regression analysis.

[16] See Appendix III for the precise definition of skill intensity clusters and their constituent industries. It should be noted that the composition of each cluster is allowed to change over time as a result of upgrading. Hence, cluster 1 in 1984 does not necessarily contain the same industries as cluster 1 in 1990. However, assigning industries to clusters on the basis of their skill intensity in specific year does not change the general picture.

[17] As pointed out above, this approach is a partial equilibrium approach. An alternative approach would be to investigate general equilibrium effects estimating mandated wage regressions (see Slaughter, 2000). While this is beyond the scope of the present paper it is a topic for further research.

factors of production.[18] In general notation the translog cost function can be represented as follows:

1)
$$\ln C_i = \alpha_o + \sum_{j=1}^{J} \alpha_j \ln w_{ij} + \sum_{k=1}^{K} \beta_k \ln x_{ik} + \frac{1}{2}\sum_{j=1}^{J}\sum_{s=1}^{J} \gamma_{js} \ln w_{ij} \ln w_{is} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \delta_{kl} \ln x_{ik} \ln x_{il} + \sum_{j=1}^{J}\sum_{k=1}^{K} \varphi_{jk} \ln w_{ij} \ln x_{ik}$$

where C_i is the variable cost for industry i=1,…, I, w_{ij} denotes wages of the optimal skill-mix of workers for skill group j=1,…, J, and x_{ik} denotes fixed inputs or outputs k=1,…, K.

Differentiating the translog cost function with respect to wages yields the factor payments to skill group j over the total wage bill.

2)
$$S_{ij} = \alpha_j + \sum_{s=1}^{J} \gamma_{js} \ln w_{ij} + \sum_{k=1}^{K} \varphi_{jk} \ln x_{ik}, j = 1,..,s,.,J$$

Most studies using this approach have estimated this set of equations by pooling data across industries thereby assuming that the same cost function applies across industries (e.g. Berman et al., 1994; Feentra and Hanson, 1996). Berman et al. argue that the cross-industry variation of wages reflects only differences in the quality of workers and thus assume that quality-adjusted wages will be constant across industries. Therefore, the wage terms can be dropped from the right-hand-side of the equation above.[19]

3)
$$S_{ij} = \alpha_j + \sum_{k=1}^{K} \varphi_{jk} \ln x_{ik}, j = 1,...,J$$

Feenstra and Hanson (2001) argue that one should include 'any structural variables that shift the production function and therefore affect costs (p. 21)'. The structural variables include import penetration, outsourcing and technological change.[20] A full set of time dummies is included in order to capture developments in the economy's skill preferences

[18] As pointed out above, semi-skilled and unskilled workers are grouped together. If one were to maintain three variable inputs, one would have to estimate a system of two equations further complicating the translog cost function.
[19] Dropping relative wages also solves the problems of endogeneity and collinearity with the dependent variable.
[20] According to the Stolper-Samuelson theorem relative labour demand is simply determined by relative goods prices. However, Feenstra and Hanson (1996) argue that outsourcing has an impact on unit input requirements which is related to changes in relative commodity prices in a large country. The regressions, therefore, can be seen as a reduced-form relationship between outsourcing and the unit input requirement for skilled labour.

over time. Writing in full and including the structural variables gives the following equation:

4) $$S_{ij} = \varphi_{j0} + \varphi_{j1} \ln K_i + \varphi_{j2} \ln Y_i + \varphi_{j3} T_i + \varphi_{j4} M_i + \varphi_{j5} O_i + \varphi_{j6} D + \varepsilon_i$$

where K denotes capital intensity measured by capital stock in industry i over sales, Y output in industry i, T is a proxy for technological change calculated as either expenditure on R&D over value-added or expenditure on computers over total intermediate purchases, M represents import penetration measured both in total, from developed countries and from developing countries, O reflects either broad or narrow outsourcing and D is a full set of time dummies. Following Dell'mour et al. (2000) the two measures of outsourcing are also included after multiplying outsourcing by the share of developing countries imports over total imports. As it is argued that import penetration and outsourcing measure two essentially different phenomena, they will be included together in the regression.

Most studies take first differences in order to purge industry-specific time-invariant effects. The present study instead applies panel data estimation techniques to estimate equation (4) rather than first differences. There are at least two reasons for doing so. First, panel data estimation techniques, be it either fixed or random effects estimation, are a more efficient and reliable way to estimate panel data taking account of time-invariant effects than first-differencing. Second, first-differencing only allows one to look at the changes in the variables, whereas panel estimation uses levels of the variables. The model is estimated using fixed effects techniques given that the cross-sectional units are a constant set of manufacturing sectors.

6. Results

In order to have a first look at the data, simple OLS is estimated on the pooled data, the results of which are reported in Appendix IV. Although the coefficients are likely to be biased as a result of industry-specific time-invariant effects, the results are generally consistent with those obtained using panel estimation techniques. As pointed out above the fixed-effects model is applied instead of taking first differences in order to solve for those industry-specific time-invariant effects. Table 2 contains the results of the fixed-effects estimations of the cost shares of skilled labour over the total wage bill over the period 1982-1996.

In regressions (1) and (2) the two measures of technology are evaluated together with capital intensity and output. Capital intensity and output are positive and statistically significant in both cases. The positive sign on capital intensity confirms the idea that capital and skill are complements.[21] The two measures of technology are expenditure on computers (T1) and expenditure on R&D (T2). In both cases the regressions indicate that SBTC is an important factor in explaining the change in the relative demand for labour. As T1 is only weakly significant, expenditure on R&D will be used in the other regressions.

[Table 2 here]

Regressions (3)-(5) include three different measures of foreign competition in the regression. M1 reflects total import penetration, M2 import penetration from developing countries and M3 import penetration from developed countries. Anderton and Brenton (1999) argue that foreign competition from developing countries accounts for a larger share of UK wage inequality than total foreign competition, i.e. import penetration from developing countries offers a more precise indication of the extent to which unskilled workers compete with unskilled labour in low-wage countries. Indeed, the share of imports from developing countries over total imports increased from 18% to 22% over the period 1982-1996 indicating an increasing exposure to low-wage competition. One would expect a positive sign on all three trade variables, with M2 explaining more than the other measures. Surprisingly, import penetration seems to be negatively related to wage inequality. M1 is negative in all specifications, although not always significant. M2 is negative and always highly statistically significant. M3 is insignificant in all specifications.

This result however does not stand alone in the literature. Using a similar methodology Machin and Van Reenen (1998) and Dell'mour (2000) also find negative signs on import penetration in at least some cases. For the case of Austria one explanation is that Austria is an importer of relatively skill-intensive goods and therefore imports should actually be expected to reduce wage inequality. However, this explanation cannot explain the results obtained here for the different measures of foreign competition. In this case M1 and M3 should be even more important in explaining reduced wage inequality which is clearly not the case. The only other explanation advanced is that trade impacts on wage inequality

[21] Experiments excluding sales or replacing capital intensity by capital stock did not change results significantly for the variables of interest.

solely though its sector bias, which cannot be picked up with the partial equilibrium methodology employed here.

For outsourcing, however, the factor bias in addition to its sector bias is likely to be important. In regressions (6) and (7) narrow and broad outsourcing are added to the regression. The correlation matrix shows that outsourcing and import penetration are only slightly correlated indicating that the two variables capture two essentially different factors. Therefore, there is no need to replace the trade variables by the outsourcing variables (as in Feenstra and Hanson, 1996) since it appears more appropriate to add outsourcing to the equation (as in Autor, Katz and Krueger, 1998).

The table shows that both broad and narrow outsourcing are positive (NO1 and BO1), but statistically insignificant. Multiplying the share of imports from developing countries over total imports in line with Dell'mour et al. (2000) does not improve the results (not presented in the table). The results though are quite sensitive to the exclusion of certain industries. If some industries are excluded that are associated with poor data on outsourcing results become weakly significant (see Appendix IV, Table A2, Regressions (6)-(9)). With such a low level of significance, however, it is impossible to make conclusive statements about the performance of broad relative to narrow outsourcing in explaining wage inequality.

It has become common practice in the literature to weight regressions in order to account for differences in industry size (see, for example, Baldwin and Cain, 2000). The variables in the regressions reported in Table 3 are, therefore, pre-multiplied by the share of average sector value added over average manufacturing value added. Capital intensity, output and technology whether measured in terms of expenditure on computers or expenditure on R&D are positive and all statistically significant as before. Including outsourcing has the same impact as before. It is positive although statistically insignificant.[22]

However, weighting changes the results in one important and rather unexpected way. The impact of trade on wage inequality is now positive and statistically significant for all three measures of import penetration. It should be noted that weighting emphasises large

[22] It seems that outsourcing has a stronger effect on wage inequality in the smaller industries. There exists no obvious explanation for this. However the following considerations may play a role. Are smaller industries more specialised? Are smaller industries associated with smaller establishment? If the latter were true than smaller industries may be associated with higher skilled labour cost shares reflecting the fixed cost of management.

industries at the expense of the small. The results may, perhaps, indicate that foreign competition in large industries tends to increase wage inequality, whereas it tends to reduce wage inequality in the small industries. This could suggest that industries have to be sufficiently large in order to have an impact on labour markets or, in other words, only for large industries does the positive sign on import competition reflect the general equilibrium effect of trade. There is no obvious explanation for the relationship between foreign competition and wage inequality in the small industries. However, it is clear from the weighted regressions that it is important to account for differences in industry size in one way or another.

[Table 3 here]

Replacing cost shares by the employment shares gives a similar picture as shown by the results presented in Table 4. When regressing employment shares results improve when the relative wage (RWAGE) is included. Output, technology and relative wages are significant and positive. The trade variables are still positive, but insignificant. Outsourcing is insignificant as before.

[Table 4 here]

7. Conclusion

In this paper fragmentation is related to the debate on trade and wages. It is argued that both the sector and the factor bias of outsourcing are likely to affect relative wages. This study focuses on the factor bias by estimating the relative demand for labour derived from the translog cost function. Different measures of outsourcing are constructed on the basis of the import-use matrices of the input-output tables. Labour market data were obtained from the New Earnings Survey (NES). This dataset allows one to define skill groups on the basis of the Standard Occupational Classification (SOC) instead of using the crude distinction between manual and non-manual workers used elsewhere in the literature.

The results obtained in the different specifications are consistent in at least two ways. First, estimations generally indicate a positive relationship between capital intensity and skill intensity confirming the idea that capital and skilled labour are complements. Second, both expenditure on computers as well expenditure on R&D seem to be appropriate indicators of

SBTC. According to the results, an increase in SBTC is associated with an increase in wage inequality.

The present paper presents mixed results with respect to the role of trade on domestic wage inequality. The unweighted regressions fail to confirm the expected positive relationship between foreign competition and outsourcing. Instead, foreign competition has a significant and negative effect. The impact of foreign competition is even stronger and more negative when it is measured in terms of imports from developing countries. Machin and Van Reenen (1998) and Dell'mour et al (2000) find similar results for import penetration and argue that as trade is a general equilibrium phenomenon, its impact cannot be reasonably expected to be picked up by the methodology employed in this paper. However, when the variables are weighted in order to account for differences in industry size, thereby emphasising large industries, the results indicate a positive and significant effect of foreign competition on wage inequality. It is argued, therefore, that industries should be sufficiently large for them to have a significant effect on labour markets. That is, the general equilibrium effects of trade can only be picked up when industries are sufficiently large.

The unweighted regressions provide some weak evidence of a positive relationship between outsourcing and wage inequality. However, the coefficients on outsourcing are not statistically significant. Therefore, it is not possible to comment on the different measures of outsourcing. It is hoped that more explicit conclusions concerning the role of outsourcing can be drawn when new data on outsourcing become available with the 1995 input-output tables for the UK.

Future research will be directed towards improving the understanding of the role of industry size. Foreign competition seems to have two effects. The results indicate that foreign competition has a negative direct effect on wage inequality. The positive effect of foreign competition in the weighted regressions may be considered a second-order effect that only becomes apparent when industries are sufficiently important. The latter effect may reflect the general equilibrium effects of trade. In particular, one would like to analyse the factor bias and sector bias of technology, trade and outsourcing in a common general equilibrium framework. This could be done by employing mandated wage regressions as discussed by Slaughter (2000).

Tables and Figures

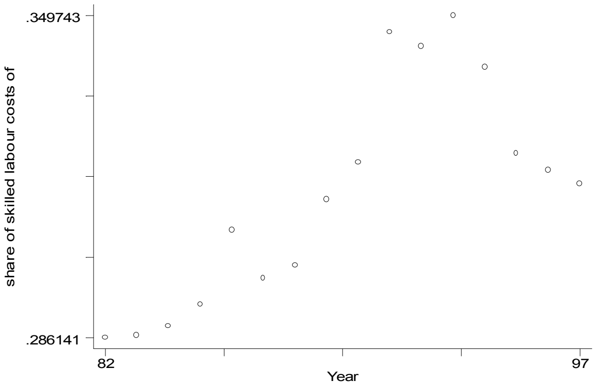
Table 1: Relative Wage Developments UK Manufacturing (1982-1997)

year	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
skilled/ unskilled	1.49	1.49	1.52	1.51	1.60	1.61	1.68	1.68	1.72	1.73	1.77	1.78	1.78	1.69	1.66	1.69
skilled/ semi-skilled	1.38	1.40	1.41	1.40	1.47	1.49	1.50	1.50	1.58	1.58	1.61	1.61	1.63	1.54	1.52	1.53
semi-skilled/ unskilled	1.08	1.06	1.07	1.08	1.09	1.09	1.12	1.12	1.09	1.10	1.10	1.10	1.09	1.10	1.09	1.10

Source: NES, own calculations

Figure 1a:
Cost share of skilled labour

Figure 1b:
Employment share of skilled labour
of skilled labour



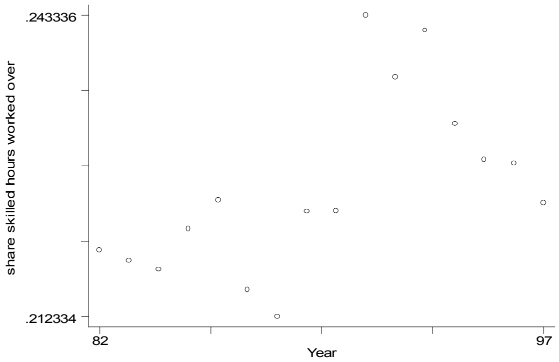


Figure 2: Outsourcing and Skill Intensity (1984-1990)
A) Broad Outsourcing
B) Narrow Outsourcing

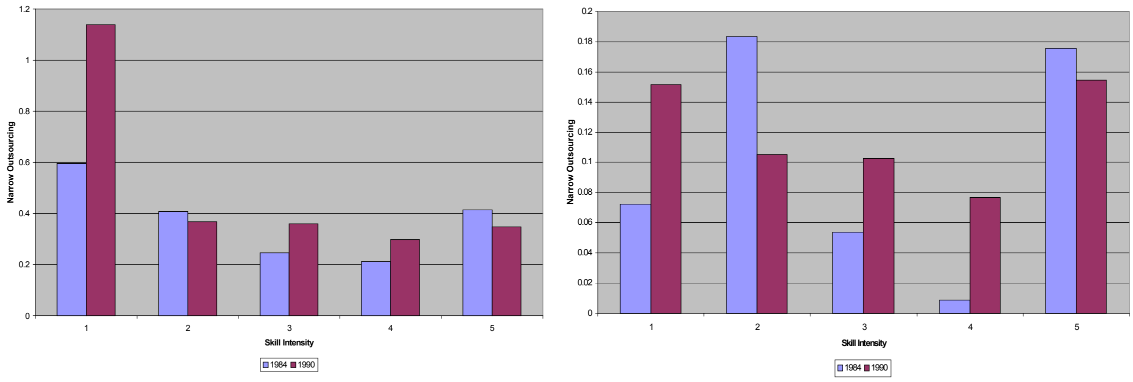


Table 2: Unweighted regressions of skilled cost shares by two-way fixed effects (1982-1996)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(K/Y)	.067 (.033) **	.057 (.033) *	.058 (.033) *	.038 (.033)	.057 (.033) *	.036 (.033)	.038 (.033)
Log(Y)	.075 (.031) **	.073 (.031) **	.051 (.035)	.024 (.036)	.073 (.033) **	.019 (.037)	.023 (.036)
T1	.203 (.118) *						
T2		.029 (.009) ***	.028 (.009) ***	.030 (.009) ***	.029 (.009) ***	.029 (.009) ***	.029 (.009) ***
M1			-.007 (.006)				
M2				-.029 (.011) **		-.032 (.012) ***	-.030 (.012) **
M3					.0002 (.008)		
BO1							.001 (.005)
NO1						.004 (.005)	
Constant	.063 (.104)	.082 (.102)	.179 (.129)	.267 (.126) **	.081 (.118)	.284 (.128) **	.270 (.126) **
R-sq	0.0427	0.0497	0.0560	0.0814	0.0720	0.0822	0.0815
N	682	680	680	680	680	680	680

Notes: Standard error in parentheses. Regressions are unweighted. Sectors 3, 11, 18, 19, 27, and 40 are excluded, as result of data limitations in those sectors. Imports are divided by 1000.

Table 3: Weighted regressions of skilled cost shares by two-way fixed effects (1982-1996)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(K/Y)	.053 (.025) **	.050 (.025) **	.041 (.026)	.048 (.025) *	.041 (.026)	.041 (.026)	.041 (.026)
Log(Y)	.136 (.024) ***	.144 (.024) ***	.159 (.025) ***	.158 (.025) ***	.154 (.024) ***	.154 (.024) ***	.154 (.024) ***
T1	.288 (.139) **						
T2		.070 (.031) **	.077 (.030) ***	.077 (.031) **	.074 (.030) **	.074 (.030) **	.074 (.030) **
M1			.014 (.005) ***				
M2				.027 (.014) *			
M3					.018 (.007) **	.018 (.007) **	.018 (.007) ***
BO1							.0004 (.010)
NO1						.002 (.015)	
Constant	-.005 (.002) **	-.005 (.002) ***	-.007 (.002) ***	-.007 (.002) ***		-.007 (.002) ***	-.007 (.002) ***
R-sq	0.707	0.709	0.707	0.711	0.705	0.705	0.705
n	697	695	695	695	695	695	695

Notes: Regressions are weighted by the proportion of average sector value added of average manufacturing value added. Sectors 11, 18, 19, 27, and 40 are excluded, as result of data limitations is those sectors. Imports are divided by 1000.

Table 4: Weighted regressions of skilled employment shares by two-way fixed effects (1982-1996)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(K/Y)	.024 (.024)	.022 (.024)	.022 (.024)	.023 (.024)	.023 (.024)	.023 (.024)	.023 (.024)
Log(Y)	.047 (.024) **	.052 (.024) **	.052 (.024) **	.054 (.025) **	.050 (.024) **	.050 (.024) **	.050 (.024) **
T1	.273 (.130) **		.270 (.130) **	.262 (.130) **	.273 (.130) **	.273 (.130) **	.274 (.130) **
T2		.041 (.028)					
M1			.004 (.005)				
M2				.013 (.013)			
M3					.004 (.007)	.004 (.007)	.004 (.007)
BO1							-.007 (.010)
NO1						-.00007 (.014)	
RWAGE	.076 (.020) ***	.076 (.020) ***	.073 (.020) ***	.073 (.020) ***	.074 (.020) ***	.074 (.020) ***	.075 (.020) ***
Constant	-.0006 (.002)	-.001 (.002)	-.001 (.002)	-.001 (.002)	-.0009 (.002)	-.0009 (.002)	-.0009 (.002)
R-sq	0.621	0.623	0.619	0.622	0.619	0.619	0.619
n	699	697	697	697	697	697	697

Notes: Regressions are weighted by the proportion of average sector value added of average manufacturing value added. Sectors 11, 18, 19, 27, and 40 are excluded, as result of data limitations is those sectors. Imports are divided by 1000.

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Appendix I: Data

Data on sales, value added and capital expenditure are obtained from the Census of Production. Capital stock data are estimated from capital expenditures using the Perpetual Inventory Method (PIM). At least two difficulties arise when estimating the capital stock. First, economic depreciation consists of two elements: physical deterioration due to usage or ageing, and obsolence, which refers to the reduction of efficiency relative to new assets. Second, it is generally accepted that different types of capital are subject to different rates of depreciation. Oulton and O'Mahony (1994) provide estimates for the total rate of economic depreciation for five different types of capital. In addition, they present estimates of the proportion of capital expenditure on each capital type for various years over the period 1968-1984 for 10 industries. Combining this information it is possible to generate industry-specific depreciation rates. Applying PIM with a pattern of geometric decay gives the following formula:

$$K_{it} = \sum\nolimits_{t-q}^{t} (1 - \sum\nolimits_{1}^{k} S_k \delta_k)^{q-1} I_{i,t-q} + (1 - \sum\nolimits_{1}^{k} S_k \delta_k)^{t-1979} K_{i,1979}$$

The capital stock for industry *i* at time *t* equals the sum of expenditure on asset *k* at time *t-q* depreciated by the asset-specific economic depreciation rate δ_k plus the depreciated benchmark capital stock. Both the proportion of capital expenditure on each asset, S_k, and the depreciation rate are assumed constant over time. This way annual capital stock estimates are generated.

Feenstra and Hanson (2001) use computer expenditure on total investment as a proxy for technological change. Here, office machinery purchases over total intermediate purchases from the combined-use matrix are used. The data is available for 1984, 1990, 1992-1997 from the ONS. The data are extrapolated by using the trend in sales. Sales are used as a proxy for industry output. Trade data are obtained from the OECD Trade Database. The trade data are classified according to SITC Rev. 2 and Rev.3. The industry data on sales, value added and capital are classified according to SIC(80) and SIC(92) respectively. Based on product descriptions and industry size a 'best guess' for each SIC(92) industry was obtained. Consequently, industries were regrouped in order to make the classification compatible to the level of aggregation in the I-O tables. The resulting classification was verified with help of a table provided by the ONS which gives a rough indication of the percentage changes to industry output, based on the National Accounts correlator used during the conversion.[23] The correspondence table thus obtained distinguished 53 SIC manufacturing industries. The table should be fairly reliable in both ways.[24]

For the years where no import-use tables are available the following three-step procedure is applied:

1- Linearly extrapolate share of import-use over combined use. As opposed to Dell'mour et al. here we do not assume 'that the development of the imported intermediate share of each good is the same across sectors (p. 296)'.
2- Apply extrapolated share to combined-use where import-use is not available. In our case this provides a third fixed point for 1997. (The value-added of combined-use tables for intermediate years seems limited since outsourcing and specialisation reflect structural changes in the economy.)
3- Use weighted extrapolation to fill up the gaps. Weights are either total imports or imports from developing countries.

[23] It is worth saying again that this was not a product correlator, and it would be misleading to apply it to products (e.g. the correlator would be useless where domestic production of a certain product is very small and most purchases are imports).

[24] The most detailed mapping publicly made available by the CSO, allows just a maximum of 28 industries. This clearly shows that there is a cost of having a larger sample size (Gregory et al., 2001). The concordance table between SIC80 and SIC92 used here is based on work by Vishal Ragoobur. For the trade data a correspondence between SITC Rev.3 and SIC80 was obtained from Blanes and Elliot and a correspondence between SITC Rev.2 and SIC80 was obtained from Vishal Ragoobur.

Appendix II: Standard Occupational Classification

Major Groups	Sub-Major Groups
1 Managers and Administrators	1 Corporate Managers and Administrators
	2 Managers/Proprietors in Agriculture and Services
2 Professional Occupations	3 Science and Engineering Professionals
	4 Health Professionals
	5 Teaching Professionals
	6 Other Professional Occupations
3 Associate Professional and Technical Occupations	7 Science and Engineering Associate Professionals
	8 Health Associate Professionals
	9 Other Associate Professional Occupations
4 Clerical and Secretarial Occupations	10 Clerical Occupations
	11 Secretarial Occupations
5 Craft and Related Occupations	12 Skilled Construction Trades
	13 Skilled Engineering Trades
	14 Other Skilled Trades
6 Personal and Protective Service Occupations	15 Protective Service Occupations
	16 Personal Service Occupations
7 Sales Occupations	17 Buyers, Brokers and Sales Reps.
	18 Other Sales Occupations
8 Plant and Machine Occupations	19 Industrial Plants and Machine Operators, Assemblers
	20 Drivers and Mobile Machine Operators
9 Other Occupations	21 Other Occupations in Agriculture, Forestry and Fishing
	22 Other Elementary Occupations

Appendix III: Skill intensity

For cost share of skilled labour of wage bill the following rule was used:
0-0.15 =1, 0.15-0.30=2, 0.30-0.45=3, 0.45-0.6=4, 0.6-1=5

'From simple to high-tech':

Description	Cluster	Description	Cluster
Carpets and rugs	1	Cement, lime and plaster - Concrete asbestos, abrasive prod	2
Agricultural machinery and tractors	1	Motor vehicles and parts	2
Grain milling, starch, and food products	1	Industrial gases, paints, dyes, printing ink etc and other chemical products nes	2
Structural clay products	1	Fertilizers	2
Tobacco	1	Rubber products	3
Other textiles	1	Electronic consumer goods, records and tapes	3
Processing of plastics	1	Office machinery and computer equipment	3
Metal casting and goods etc - Other vehicles	1	Glass	3
Paper and board products	1	Telecommunication etc equipment, electronic capital goods, instrument engineering	3
Other manufacturing	1	Industrial plant and steelwork, and other machinery	3
Preparation, spinning and weaving of textiles	1	Alcoholic drinks	3
Refractory and ceramic goods	2	Milk and milk products	3
Confectionery	2	Printing and publishing	4
Animal feeding stuffs	2	Insulated wire and cable	4
Synthetic resins etc	2	Made-up textiles articles, except apparel	4
Organic chemicals	2	Bread, biscuits and flour confectionery	4
Iron and steel	2	Ordnance, small arms and ammunition	4
Soap and toilet preparations	2	Knitted and crocheted fabrics and articles	5
Timber and wood products	2	Man-made fibres	5
Domestic electric appliances	2	Pharmaceutical products	5
Textile finishing	2	Electronic components and sub-assemblies	5
Slaughtering, meat processing, leather, leather goods, clothing and furs	2	Shipbuilding and repairing	5
Oils and fats	2	Furniture	5
Fruit, vegetables, fish processing, soft drinks	2	Inorganic chemicals	5
Basic non-ferrous metals	2	Pulp, paper, and board	5
Footwear	2	Aerospace equipment manufacturing and repairing	5
Other electrical equipment	2		

Appendix IV: Additional Regressions

Table A1: Estimation in levels by pooled OLS (1982-1996)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(K/Y)	.0306217	.0244978	.0313091	.0236706	.0172784	.0242728	.0255177	.0253902
	(.016093)	(.015931)	(.0163688)	(.016283)	(.01610)	(01657)	(.01596)	(.01591)
	*		*					
Log(Y)	.0190612	.0165936	.0203297	.0252021	.02268	.0266392	.0162652	.0173534
	(.009281)	(.009476)	(.0091574)	(.009329)	(.009529)	(.00910)	(.009483)	(.00947)
	**	*	**	***	**	***	*	*
T1	5.342616	5.373058	5.373905				5.409187	5.381734
	(1.02994)	(1.02895)	(1.031021)				(1.0297)	(1.02726)
	***	***	***				***	***
T2				.0338607	0345263	.0339524		
				(.01259)	(.012569)	(.01261)		
				***	***	***		
M1	-.006592			-0068056				
	(.004073)			(.004136)				
				*				
M2		-.0204402			-0213267		-0255053	-0291819
		(.010702)			(.010860)		(.01191)	(.011769)
		*			**		**	**
M3			-0064882			-0066154		
			(.005343)			(.005429)		
BO								.0119858
								(.006769)
								*
NO							.0068469	
							(.00707)	
Constant	.3959704	.4350801	.4569356	.3285893	.3948509	.4164432	.4429272	.432285
	(.084797)	(.090276)	(.0967413)	(.085197)	(.091193)	(.097847)	(.09064)	(.090141)
	***	***	***	***	***	***	***	***
Adj R^2	0.0635	0.0641	0.0609	0.0353	0.0358	0.0322	0.0640	0.0671
n	665	664	664	665	664	664	664	664

Notes: Standard errors in parentheses. Regressions are unweighted. Imports are divided by 1000.

Table A2: Estimation skilled cost shares in levels by two-way fixed effects (1982-1996)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log(K/Y)	0597492	.0515523	.0581046	.0343119	.0624634	.0316339	.0348001	.0333637	.0351879
	(.032729)	(.0327)	(.0327)	(.03301)	(.03368)	(.03306)	(.033)	(.03297)	.0329967
			*						1.066
	*				*				
Log(Y)	.0670984	.065614	.0254834	.0024932	.0565725	-.0052264	-0031766	-.0065234	-.0038893
	(.03136)	(.0314)	(.0354)	(.0364)	(.03299)	(.0369)	(.0366)	(.03679)	.0367171
		***			*				-0.106
	**								
T1	.1526802								
	(.13837)								
T2		.0299038	.0280454	.0298258	.028504	.02977	.0294339	.0297151	.0293298
		(.00886)	(.0089)	(.00878)	(.00892)	(.008776)	(.0088)	(.0088)	(.00878)
			***	***				***	***
		***			***	***	***		
M1			-.0144547						
			(.0060)						
			**						
M2				-.0414994		-.0482787	-.0490157	-.0506298	-.0502958
				(.01215)		(.013)	(.0132)	(.01339)	(.01387)
				***		***	***	***	***
M3					-.0085732				
					(.0083)				
BO1							.0075843		
							(.0053)		
BO2									.0137352
									(.0105)
NO1						.0067539			
						(.00539)			
NO2								.015573	
								(.0096)	
Constant	.0959686	.1174966	.3028029	.364559	.1724467	.3619117	.354583	.3700096	
	(.10834)	(.10666)	(.131)	(.1286)	(.1206)	(.1318)	(.13059)	(.13166)	
			**	***		***			
							***	***	
R^2	0.0388	0.0476	0.0539	0.0498	0.0496	0.0459	0.0485	0.0462	0.0478
N	667	665	665	664	664	664	664	664	664

<u>Notes:</u> Standard errors in parentheses. Regressions are unweighted. Sectors 3, 19, 22, 41, 45, 47, and 53 are excluded, as result of data limitations in those sectors. Imports are divided by 1000.

Table A3: Estimation skilled cost shares in levels by two-way fixed effects (1982-1996)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(K/Y)	.033 (.024)	.037 (.024)	.030 (.024)	.036 (.024)	.030 (.025)	.030 (.025)	.030 (.025)
Log(Y)	.121 (.023) ***	.116 (.023) ***	.126 (.024) ***	.122 (.024) ***	.124 (.023) ***	.126 (.024) ***	.126 (.024) ***
T1		.278 (.137) **	.281 (.137) **	.277 (.134) **	.288 (.137) **	.281 (.137) **	.281 (.137) **
T2	.042 (.023) *						
M1			.011 (.005) **			.011 (.005) **	.011 (.005) **
M2				.018 (.014)			
M3					.014 (.007) **		
BO1							.002 (.010)
NO1						.0004 (.015)	
Constant	-.183 (.097) *	-.138 (.099)	-.209 (.102) **	-.157 (.107)	-.185 (.107) *	-.223 (.102) **	-.208 (.102) **
R-sq	0.695	0.694	.0694	0.696	0.692	0.694	0.694
N	769	771	763	762	762	762	762

Notes: Standard error in parentheses. Regressions are weighted by value-added. Industry 40 has been dropped as a result of data limitations. Imports are divided by 1000.