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Offshoring and wage inequality in the UK, 1992-2004

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Executive summary

This paper considers whether offshoring has been a contributing factor to the increase in the wage gap between lower and higher skilled workers. It shows that offshoring was not a driver of the increasing skills premium in the United Kingdom between 1992 and 2004. On the contrary, the wage gap would actually have been bigger in the absence of offshoring. Offshoring reduced the wage gap between the most skilled and the least skilled workers in the UK relative to what it would otherwise have been.

Aims and methodology

This paper explores whether off-shoring has contributed to the increasing skills premium in the United Kingdom between 1992 and 2004. It uses an accounting decomposition to isolate the labour market impact of offshoring-biased technological change, which is analogous, in some sense, to the economic growth decomposition used in the productivity literature.

It is based on a methodology the author has previously used to explore the impact of offshoring on the US labour market through structurally estimating a general equilibrium model for the US economy (see Canals 2006). The author applies this methodology to the UK to isolate the impact of offshoring-biased technological change between 1992 and 2004.

The main two sources for the data set used in this paper are EU KLEMS and the Input-Output tables for the United Kingdom. The final data set comprises 30 industries over the period 1992 to 2004; of these 13 are manufactures, 15 services, and 2 agriculture and mining. In order to compute some of the preliminary results, a further industry disaggregation is used (a total of 119 industries).

There are two main steps to the methodology using the EU KLEMS and the Input-Output tables for the United Kingdom:

- Industry cost functions are developed and the technological changes biased towards offshoring are isolated.
- A factor price equation is constructed that relates the change in factor usage or technology with the change in commodity (or industry) prices and the change in factor prices. The price equation includes six production factors - three types of labour, high, medium and low skilled; two types of intermediate inputs, domestic and imported (off-shoring); and capital.

Once these equations are established and assuming perfectly competitive markets, it is possible to calculate the change in factor prices that will result from an offshoring-biased technological shock.

Background

Advances in transportation and information and communication technologies have enhanced the scope for offshoring of intermediate inputs and extended its scope to services.

However, this expansion has raised issues about the impact of offshoring on the labour market. In particular, the advance of offshoring has coincided with an increasing gap between the wages of lower and high skilled workers.

The wages of high skilled workers were 2.7 times greater than the average of low skilled wages in 1992. This premium increased to 2.8 by 2004. Similarly, the premium between wages of medium skilled relative to the low skilled increased from 1.4 to 1.5 between 1992 and 2004. However, the wage premium for high skilled relative to medium skilled workers has decreased, so that while medium skilled workers are catching up, those with the lowest skill level have fallen further behind.

Main findings

The report's main findings are as follows:

- The share of 'offshoring' in UK firms' inputs has fallen slightly between 1992 and 2004. However, the mix has changed. There has been an increase in the offshoring of services and a decrease in the offshoring of goods.
- The increase in wage inequality between higher and low skilled workers over this period was not due to off-shoring. The difference between higher and lower skill wages would actually have been greater in the absence of offshoring. Offshoring is estimated to have reduced the *increase* in the wage gap between high and low skilled workers by almost two-fifths (37 per cent) and the *increase* in the gap between medium and low skilled workers by four-fifths (82 per cent).
- However, despite an overall decrease in the actual wage gap between medium and high skilled workers between 1992 and 2004, this decrease would have been even greater in the absence of offshoring. Offshoring is estimated to have increased the high-medium *change* in the wage gap by around 45 per cent.
- These trends may reflect the change in mix between the offshoring of goods and services. In particular, the offshoring of goods is most likely to impact on the wages of the low-skilled, while the offshoring of services will have had a bigger impact on more skilled workers. In the UK it appears to have had the greatest impact on the wages of the medium-skilled, decreasing their wage gap with the low-skilled but increasing it with the high-skilled.
- Overall, offshoring has tended to offset the impact of other factors on the various skill premiums. This paper does not explore alternative explanations for the actual increase in skill premiums and the slower growth of wages for low-skilled workers. However, it suggests skill-biased technological change as a plausible hypothesis. Technological change may have increased the relative demand for high skill workers and so pushed up their wages.

About this project

This research was prepared for a Department for Business, Enterprise and Regulatory Reform (BERR) research conference on 'Globalisation and the Labour Market', held in London in December 2007. It was carried out as part of the department's employment relations research programme.

1. Introduction

The offshoring phenomenon and its effect on the labour market has been for some time now at the centre of a heated debate. Offshoring in services, often exemplified by the expansion of call centres in Bangalore, India, has been increasingly perceived as a threat to white collar jobs that not long ago seemed immune to the pressures stemming from globalization.

For example, the decision taken by Reuters in 2007 to cover Wall Street news with Indian financial journalists from Bangalore can be described as the beginning of a new era in the offshoring trend.³ Offshoring has also become a politically sensitive issue. During the 2004 US presidential campaign, for instance, Gregory Mankiw, then chairman of the White House Council of Economic Advisers for President Bush, was widely criticized for his comments characterizing offshoring as 'the latest manifestation of the gains from trade that economists have talked about at least since Adam Smith ... more things are tradable than were tradable in the past, and that's a good thing.' The then presidential candidate John Kerry emphasized instead the much more popular view that offshoring was 'taking away jobs from Americans'. Although not everyone seems to agree on its effects, there is no doubt that offshoring has taken place increasingly over the last few decades. A recent report by the consulting firm Deloitte highlights, for instance, the importance of offshoring in the UK financial sector.⁴

Offshoring has become possible thanks to technological changes, namely advances in transportation and communication technologies. Arndt and Kierzkowski (2001) explain that fragmentation, which consists of breaking up a production process into physically separable phases, and outsourcing, understood as the purchase of intermediate inputs in domestic markets, has taken place since the beginning of the Industrial Revolution, or even before it. Offshoring goes beyond this as it implies outsourcing to other countries. The development of international transactions of some services that are intermediate inputs is also a relatively recent innovation, as this type of transaction was traditionally limited to manufactures.

Before going on, it will be useful to clarify some definitions. This article follows Feenstra and Hanson (1999)'s approach and defines offshoring as those intermediate goods and services that are imported.⁵ Using this definition, the paper attempts to estimate the impact of what is termed offshoring-biased technological change or technological change biased towards offshoring on the wages of workers of different skill levels. The concept of technology linked to offshoring is broad as it encompasses the improvement in information and communication technologies (ICT) but also the improved enforcement of property rights, among others.⁶

³ See *BBC News*, 2 February 2007, 'Here is the US news from Bangalore.'

⁴ See Deloitte (2007) and *BBC News*, 22 June 2007, 'Offshore boost for finance sector.'

⁵ Note that both R. C. Feenstra and G. H. Hanson have done some of the best work so far on offshoring and its labour market impact.

⁶ See Bartel et al. (2005), Grossman and Helpman (2004) and Branstetter et al (2006) for examples on ICT and legal environment improvements affecting offshoring.

The wages of workers in the UK have evolved differently by skill level. In particular, between 1992 and 2004, the period analysed in this paper, there has been a decline in the wages for the lowest skilled workers relative to the more skilled ones. However, the relative wage for high skilled relative to medium has decreased, so while medium skilled workers are catching up, those with the lowest skill level are falling further behind.

Many authors have sought to explain the evolution of relative wages by changes in international relative prices or trade, improvements in technology, changes in education levels, immigration, or an increase in the level of offshoring, among other factors. For instance, Haskel and Slaughter (2001) assess the impact of the sector bias of skill-biased technological change in explaining the evolution of the UK wage gap during the seventies and the eighties. They find that this is an important factor in explaining the early decrease and the later increase in the wage gap. Desjonquieres et al. (1999) along with other studies have shown that changes in the prices for low-technology goods have not been the leading cause for changes in the wage gap. A shortcoming of much of this literature, however, is that it tended to consider different possible explanations in isolation.⁷ To remedy this, Canals (2006) attempted to structurally estimate a general equilibrium model for the US economy to isolate the impact of offshoring-biased technological change. The approach taken is an accounting decomposition analogous, in some sense, to the growth decomposition used in the productivity literature⁸.

This paper applies this methodology for the UK during 1992-2004 and concludes that offshoring is not the driver of the increase in the wage gap between high-low and medium-low skilled workers. In addition, offshoring cannot explain the decrease in the high-medium wage gap. On the contrary, the analysis implies that if only offshoring-biased technological change had occurred, the wage gap for both the high-low and medium-low skill pairs would have declined, while an increase in the high-medium skilled wage gap would have taken place. As a corollary, the main drivers of relative wages have been shocks other than offshoring-biased technological change.

⁷ Blum (2007) is an exception.

⁸ Another novelty in the approach is the introduction of services on top of manufactures.

2. Offshoring examples

This section presents some real world examples of offshoring to illustrate the breadth of this phenomenon. While some examples are anecdotal, most describe the typical behaviour of most multinationals.

A classic example of fragmentation and offshoring is the production of the Barbie doll first described by Tempest (1996). The toy is designed in the US; the plastic and hair come from Taiwan and Japan; assembly takes place in Indonesia, Malaysia or China; China also supplies the cotton clothing; the moulds and paint come from the US. It is certainly a global doll.

The World Trade Organization (1998) provides an interesting breakdown of a typical production process of an 'American' car. Thirty per cent of the value is generated in Korea, where the assembly is done; while, technology and component production in Japan adds nearly 18 per cent. Germany, where design takes place, accounts for about 7½ per cent; Taiwan and Singapore produce some of the components, adding some 4 per cent; and the UK provides marketing and advertising services, accounting for 2.5 per cent of value added. Ireland and Barbados do some data processing that adds about 1.5 per cent and; the US, where the remainder of the tasks are located, accounts for about 37 percent of value added. This example helps to show the growing importance of offshoring in services, exemplified in this particular case by the UK, Ireland and Barbados.

The case of radiologists caused a great stir in the US because it had been relatively uncommon for white collar jobs to be offshored. Pollack (2003) explains how some American hospitals send X-rays to India for diagnosis. Despite the huge controversy generated, this is an anecdotal case, as the percentage of X-rays analyzed abroad is very small. Nonetheless, it is an example of how ICT advances facilitate new types of offshoring, mostly in services.⁹

A recent example also concerns the offshoring of some knowledge-based activities, in this case tutoring. TutorVista is an Indian company that provides an unlimited number of 45-minute remote tutoring sessions through the internet for a monthly fee of \$99.¹⁰ A few years ago, before ICT advances, this type of consumer service could only be provided in the same location as the consumer but not anymore.

⁹ Most of the examples presented here are summarized as well in Canals (2006b).

¹⁰ *New York Times*, 31 October 2007, 'Hello, India? I Need Help With My Math.'

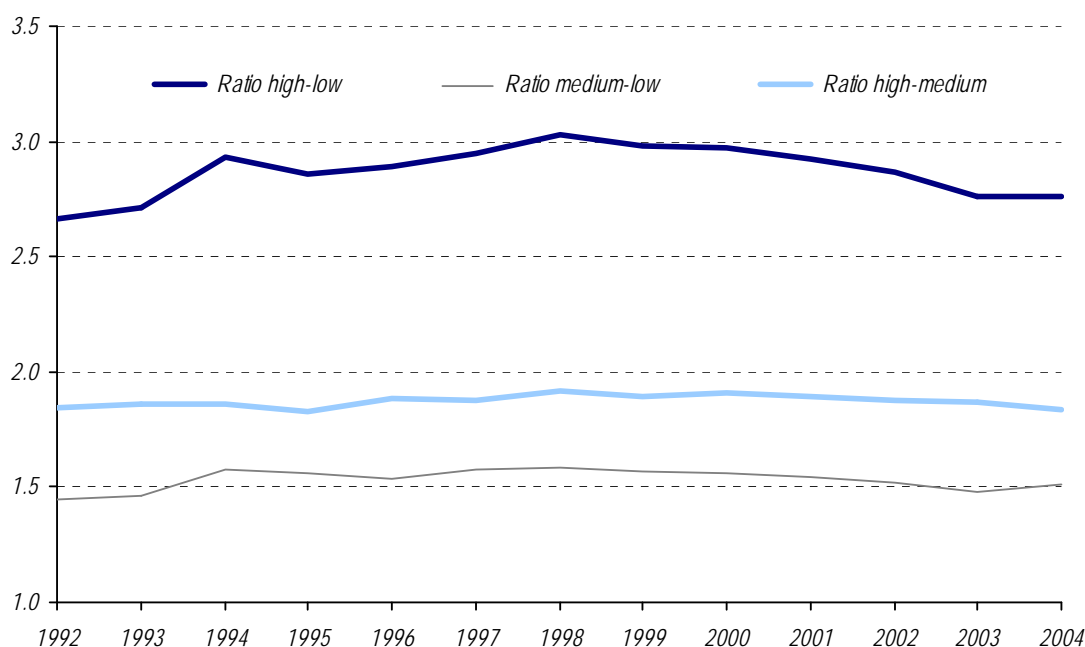
3. Recent trends

This section describes the evolution of the wage gap and offshoring, which are the two key phenomena studied in this paper. In addition, it shows some other variables of interest such as cost-shares, factor prices, and the proportion of high, medium and low skilled workers in the total workforce.

3.1 Recent trends in wage gaps

Chart 1 shows the evolution of the ‘wage gap’ for each skill group in the UK for the period 1992 to 2004.¹¹ Wages for high skilled workers increased by 50.5 per cent over this period; wages for the medium skilled rose slightly more at 51.2 per cent; and wages for low skilled workers expanded by a lower 45.2 per cent.

Chart 1. Change in average wage ratios over time in the UK*



Source: EU KLEMS and own calculations as specified in Annex A.

* Ratio of average hourly wages for each skill group. This is drawn from EU KELMS data on wages for each industry and skill level. The average hourly wage for each skill level is computed using these number of industry employees as weights.

Note: Skill groups are defined in line with the EU KLEMS dataset. That is:

High skilled: university degree (group 1 in their classification)

Medium: HND, HNC, BTEC, teaching qualification, nursing qualification, A level or equivalent, trade apprenticeship, O level or equivalent, BTEC, BEC, TEC GENERAL, City & guilds (groups 2 + 3 + 4) Low Skilled: No qualifications (group 5)

For more information see http://www.euklems.net/data/EUKLEMS_Growth_and_Productivity_Accounts_Part_II_Sources.pdf

Therefore, there has been an increase in the wage gap both between high and low skilled workers (equal to 5.4 per cent or 0.3 per cent annually), and between medium and low skilled workers (equal to 6 per cent or 0.4 per cent annually). However, the wage gap between high and medium skilled workers has slightly

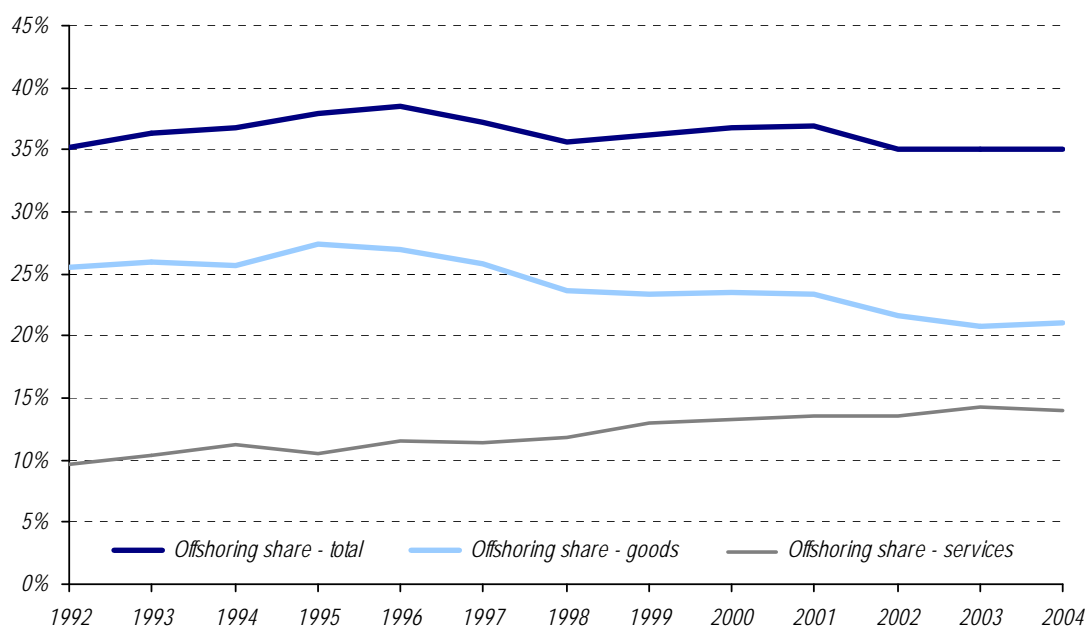
¹¹ The wage gap is calculated as the ratio between the average hourly wages of the different skill groups. However, in this paper the change in the wage gap, also referred as change in wage inequality, is defined as the difference between the growth rate of the wages of the different skill groups.

decreased at a rate of 0.04 per cent per annum or equivalent to 0.7 per cent over the period.

3.2 Recent trends in offshoring

Chart 2 shows trends in the offshoring share of total intermediate inputs, constructed following Feenstra and Hanson's (1999) approach (also see the first column of Table 1 in Annex B). The share of imported intermediate inputs over total intermediates (imports plus domestic production) is computed for each industry i at each point in time t , controlling for the fact that some domestic intermediates might be using imported intermediates, as in Hummels et al. (2001). Then, for each year a weighted average of this offshoring share measure, with weights equal to the value added of each industry, is taken.¹² In addition, the offshoring share is decomposed between services and goods, where the former accounts for the share of imported intermediate services over total intermediates, and similarly for the latter (see second and third column of Table 1 in Annex B.)¹³

Chart 2. Offshoring share of total intermediate inputs in the UK*



Source: Input-Output (IO) tables for UK from National Statistics and own calculations as specified in Annex A.
* Imported intermediaries as a proportion of total intermediate inputs.

The most striking features are first, the quite high level of offshoring in the UK, accounting for more than one-third of total intermediate inputs. Second, against expectations there has been a modest decline in the overall share of offshoring in the UK since the mid-1990s. This was driven by a decline in the level of

¹² A total of 119 industries are used to compute the offshoring share. Metal ores, gas and oil extraction, and petroleum bulk stations and terminals are not included following Feenstra and Hanson (1999).

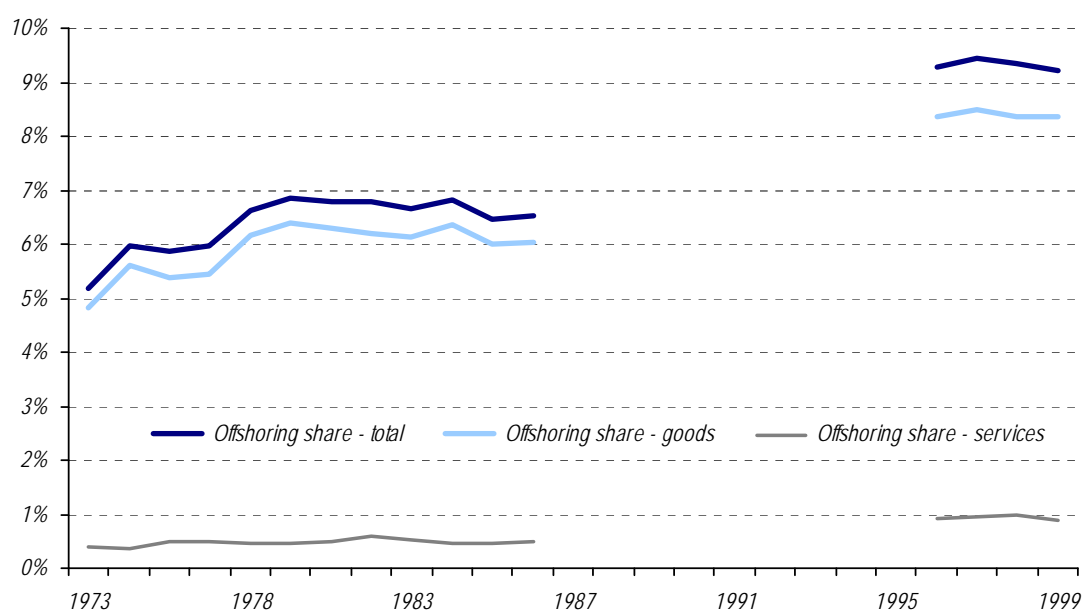
¹³ The offshoring of goods include the agriculture and mining sectors.

offshoring of goods as a percentage of total intermediate inputs over this period, largely offset by an increase in the contribution from offshoring of services.¹⁴

The UK contrasts with the experience in the United States, where the offshoring of both goods and services has increased over time (see Chart 3 and Table 2 in Annex B). However, estimates for the US only cover the period through to the late 1990s; in the last few years the data starts to show a change in the trend for the offshoring of goods that is more in line with the UK case.

Finally, another important difference between the US and the UK is that offshoring is much more prevalent in the latter, particularly for services. Possible reasons are that the UK has a smaller domestic market and is more trade-exposed, especially its large financial and business services sector.

Chart 3. Trends in the offshoring share in the United States*



Source: IO tables for US from National Statistics and own calculations as specified in Annex A. Note: data unavailable from 1987 to 1985.

* Imported intermediaries as a proportion of total intermediate inputs.

It is worth noting that the high-low and medium-low skill gaps follows a trend that is broadly similar to the evolution of the offshoring of goods share. That is, it increases through the nineties and decreases afterwards (although the turning point appears to occur earlier for the offshoring measure).

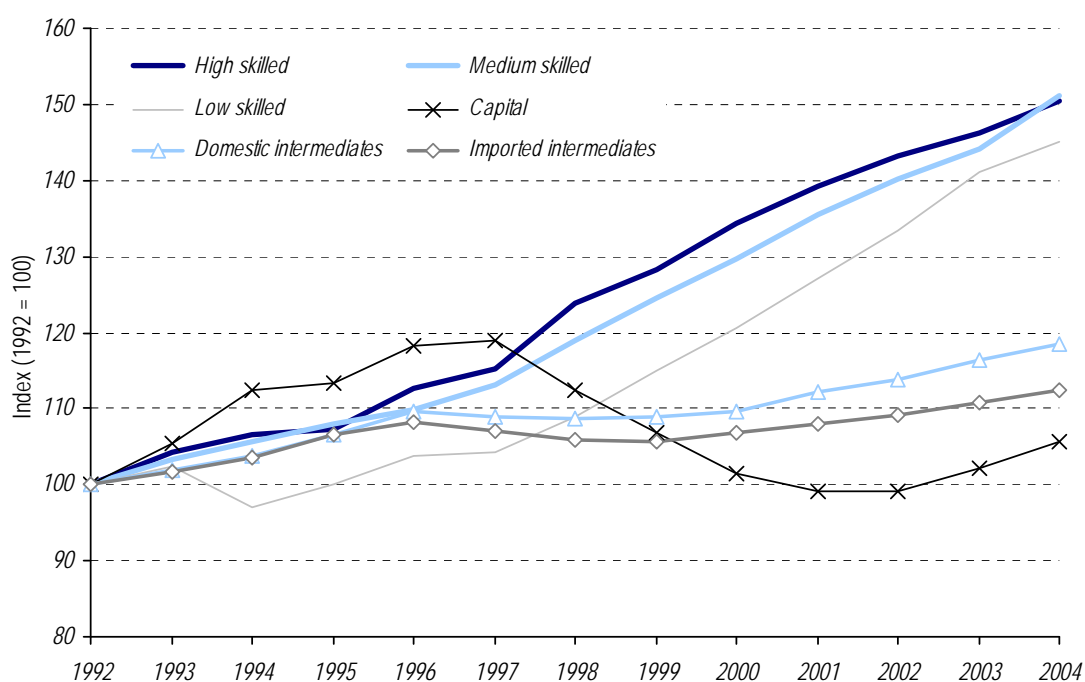
¹⁴ This does not necessarily mean there has been a decline in the *rate* of offshoring of intermediate goods. The expansion of service industries has seen a fall in goods as a proportion both of total production and expenditure.

3.3 Recent trends in factor prices and cost shares

Other variables of interest for the analysis are factor prices, cost-shares and the proportion of the different types of employees. Chart 4 shows that:

- Average hourly wage rates for high and medium-skilled workers increased by more than those for the low skilled.
- The price for domestic intermediate inputs and for offshoring (or imported intermediate inputs) have evolved similarly, but the price of domestic inputs has increased at a somewhat faster pace.
- The price of capital increased until 1997 but has subsequently fallen, reflecting lower inflation and interest rates.

Chart 4. Trends in factor prices



Source: EU KLEMS, IO tables, several price indices and own calculations as specified in Annex A

Table 1 shows the evolution of the average cost-share for each production factor, where more weight is given to those industries with a larger value added. The cost share for both capital and imported intermediates ('offshoring') has remained relatively steady between 1992 and 2004, while the cost share for domestic intermediates has increased.

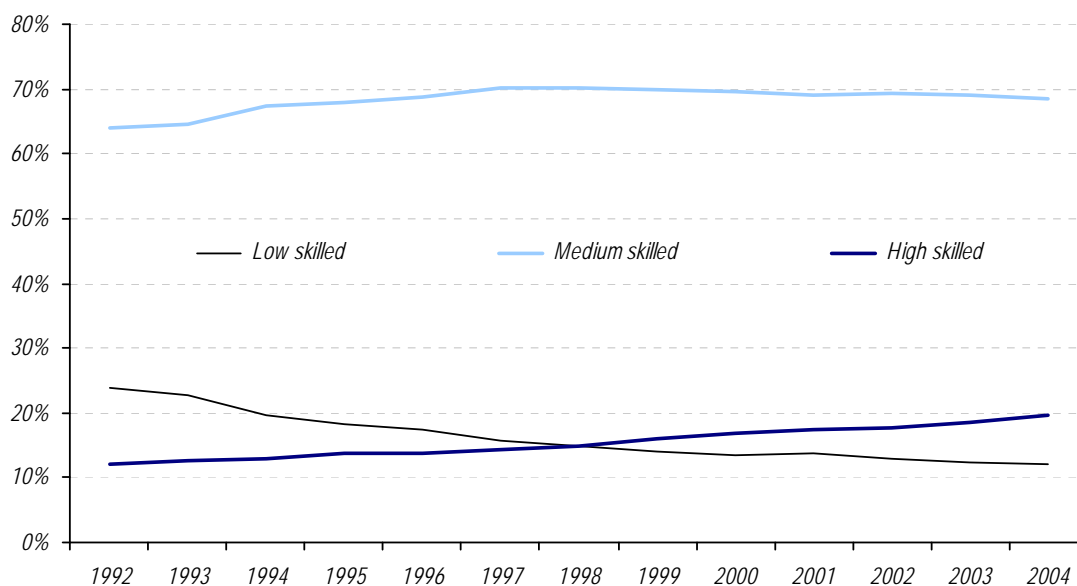
Table 1. The evolution of cost-shares for all inputs

%	Cost share by skill level			Cost share for factor inputs		
	Low skilled	Medium skilled	High skilled	Domestic Interm.	Imported intermediates	Capital
1992	5.12	20.77	7.65	36.06	10.92	19.48
1993	4.62	20.15	7.89	35.75	11.35	20.24
1994	3.60	20.20	7.76	36.63	11.63	20.43
1995	3.28	19.69	7.83	36.46	12.10	20.46
1996	3.04	19.09	7.76	37.03	12.61	21.04
1997	2.65	19.43	8.00	38.03	12.05	20.84
1998	2.52	19.53	8.56	37.74	11.28	20.08
1999	2.44	19.36	9.02	37.14	11.66	19.78
2000	2.37	19.26	9.57	37.16	12.06	19.57
2001	2.43	19.37	9.88	37.20	11.98	19.15
2002	2.27	19.23	10.00	38.06	11.36	19.07
2003	2.23	18.82	10.35	37.86	11.34	19.39
2004	2.12	18.66	10.51	37.66	11.38	19.66

Source: EU KLEMS, IO tables, several price indices and own calculations as specified in Annex A

Note: Each column specifies the percentage of total cost accounted for the different inputs (row add up to 100)

The substantial fall in the cost-share for low skilled workers, from around 5 per cent to 2 per cent, reflects in large part their halving as a proportion of the UK workforce (see Chart 5). The fall in the share of low skilled labour has been offset by a large rise in the proportion of the workforce who are high skilled since 1992, from 12 per cent to almost 20 per cent.

Chart 5. Share of low, medium and high-skilled workers, UK workforce

Source: EU KLEMS. See Table B3 in Annex B

4. Methodology and data

This section builds a two step methodology that is then used to compute the effects of an offshoring-biased technological change on wages in the UK:

- In the first step, each industry cost function is approximated using a second order Taylor polynomial. Then, technological changes biased towards offshoring are isolated.
- In the second step, all industries are assumed to be in perfect competitive markets, so the zero-profit condition must hold. A price equation that relates the change in factor usage or technology with the change in commodity (or industry) prices and the change in factor prices is then derived. Finally, the paper computes the change in factor prices, including for the different labour skill levels, necessary to accommodate and re-establish the zero-profit condition after imputing the offshoring-biased technological shock. That is, it identifies the change in the wage gap due to offshoring.

The methodology assumes that in order to produce one good or service (i) a total of six production factors (f) are necessary. In particular, there are three types of labour, high (h), medium (me) and low skilled (l); two types of intermediate inputs, domestic (d) and imported, also defined as offshoring (o); and capital (k). Moreover, an industry or sector (i) produces only one good or service.

4.1 First step: translog cost function

In order to produce a good or service, an industry incurs some cost that it wishes to minimize. Each industry (i) at each point in time (t) has a cost function ($C_{it}(\cdot)$) which is a function of factor prices (ω_{fit}), production or output (y_{it}), and technology:

$$C_{it}(\omega_{fit}, y_{it}, t) = \sum_f v_{fit}(\omega_{fit}, y_{it}, t) \cdot \omega_{fit} \quad (1)$$

Where v_{fit} stands for the quantity of factor f necessary to produce good i at time t ; t stands for time, and where an argument in the $v(\cdot)$ function represents technological progress changing the cost function over time.¹⁵

The translog functional form (a second order Taylor polynomial approximation) is used to approximate the cost function since it has been proved to have a good fit with the data in a number of empirical papers, see, for example Berndt and Wood (1975). The paper assumes homotheticity and homogeneity of a constant degree with output, as well as homogeneity of degree one with factor prices. In addition, some symmetry restrictions are imposed on the elasticities.¹⁶

¹⁵ Jorgenson (1984, 1987) and Harrigan (2000) use this time argument to account for technology affecting the translog revenue function. We do similarly for the translog cost function.

¹⁶ See Canals (2006) for further details in the methodology and the assumptions taken.

$$\begin{aligned} \ln C_{it} = & \alpha_{0i} + \sum_f \alpha_{fi} \ln \omega_{fit} + \frac{1}{2} \sum_f \sum_{f'} \gamma_{ff'} \ln \omega_{fit} \ln \omega_{f'it} + \\ & + t \sum_f \beta_{fi} \ln \omega_{fit} + \alpha_{\pi} t + \frac{1}{2} \pi_{\pi} t^2 + \alpha_{y_i} \ln y_{it} + \eta_{ly_i} t \ln y_{it} \end{aligned} \quad (2)$$

Logarithmical differentiation with respect to factor prices (ω_{fit}) and Shepard's lemma are employed in order to minimize the cost function. The result is a system of six cost-share equations, one for each production factor (f). However, only five out of the six equations are linearly independent. Thus, to handle the independence problem an arbitrary equation is dropped – the capital cost-share equation in this case.¹⁷

$$\begin{aligned} \theta_{lit} &= \alpha_{li} + \beta_{li} t + \sum_{f'} \gamma_{f'l} \ln \left(\frac{\omega_{f'it}}{\omega_{kit}} \right) \\ \theta_{meit} &= \alpha_{mei} + \beta_{mei} t + \sum_{f'} \gamma_{f'me} \ln \left(\frac{\omega_{f'it}}{\omega_{kit}} \right) \\ \theta_{hit} &= \alpha_{hi} + \beta_{hi} t + \sum_{f'} \gamma_{f'h} \ln \left(\frac{\omega_{f'it}}{\omega_{kit}} \right) \\ \theta_{dit} &= \alpha_{di} + \beta_{di} t + \sum_{f'} \gamma_{f'd} \ln \left(\frac{\omega_{f'it}}{\omega_{kit}} \right) \\ \theta_{oit} &= \alpha_{oi} + \beta_{oi} t + \sum_{f'} \gamma_{f'o} \ln \left(\frac{\omega_{f'it}}{\omega_{kit}} \right) \end{aligned} \quad (3)$$

In the system of equations above θ_{fit} is the cost-share of factor f in industry i at time t ;¹⁸ and the time trend in each cost-share equation can be seen as the *reduced-form effect of technological progress* on cost-shares (see Harrigan (2000)). In other words, β_{fi} is the technological change biased towards factor f that changes the cost-share of production factor f in industry i . For instance, β_{oi} can be understood as an advance in information technologies or on law enforcement which impacts on the offshoring cost-share or, in other words, as offshoring-biased technological change.

4.2 Second step: price equation

The model assumes an economy where each industry i is in a perfectly competitive market, such that the zero-profit condition must hold at each point in time t .

$$p_{it} = \sum_f a_{fit} \omega_{fit} \quad \forall i, t \quad (4)$$

¹⁷ A maximum likelihood procedure is used (Zellner's seemingly unrelated procedure) to avoid variability depending on the equation dropped. See Berndt (1991) for more details.

¹⁸ Notice that the coefficient $\gamma_{ff'}$ is assumed to be equal across industries, that is, equal cross elasticities in all industries.

Where a_{fit} is known as the usage or production technique element, that is, the units of factor f needed to produce one unit of good or service i . The next step consists on differentiating the above zero-profit condition following Leamer (1997) and then applying a Feenstra (2003) correction for dealing with infinitesimal changes when data is used to test the theory. Thus, the above identity can be expressed as:

$$\sum_f \hat{a}_{fit} \frac{1}{2} (\theta_{fit-1} + \theta_{fit}) = \hat{p}_{it} - \sum_f \frac{1}{2} (\theta_{fit-1} + \theta_{fit}) \hat{\omega}_{fit} \quad (5)$$

Where $\hat{x} = dx/x$ stands for the percentage change. The above price equation relates the change in product prices, \hat{p}_{it} , with the change in factor prices, $\hat{\omega}_{fit}$, and the change in factor usage or technology, given by the term in the left hand side of the equation.

4.3 Relate the first and the second step

This paper aims to isolate the effect of offshoring-biased technological change on factor prices, in particular, on the wages for high, medium and low skilled workers. In other words, the paper answers the following counterfactual question: 'if only offshoring had occurred, what would have happened to the UK skill premium between high and low, medium and low, and high and medium skilled workers?'

As explained in section 4.1, β_{oi} in the system of equations (3) captures the technological change biased towards offshoring. Hence, the next equation, (6), identifies the change in the offshoring cost-share that is only due to offshoring-biased technological progress.

$$\Delta \tilde{\theta}_{oit} = \beta_{oi} \Delta t \quad (6)$$

The methodology assumes this is the only shock taking place in the economy. However, it would be incorrect to assume that this is the only cost-share to change, since the cost-shares are inter-related and must sum to one. To correct for this, an extra assumption is made to ensure that the cost-shares do add up to one.¹⁹

Assuming commodity prices are not moving, a relationship between the production techniques elements, a_{fit} , and the cost-shares, θ_{fit} , can be established such that:

$$\hat{\tilde{\theta}}_{fit} = \hat{a}_{fit} \quad (7)$$

Where tilde ($\tilde{}$) stands for the value coming from a change in offshoring-biased technological change only, in opposition to the total or actual change; and hat ($\hat{}$) stands for the percentage change.

Finally, the price equation given by (5) can be rewritten as follows to compute the counterfactual.

¹⁹ See Canals (2006) for further details in the methodology.

$$\sum_f \frac{1}{2} \frac{(\Delta \tilde{\theta}_{fit})^2}{\theta_{fit-1}} = -\sum_f \frac{1}{2} (2\theta_{fit-1} + \Delta \tilde{\theta}_{fit}) \delta_{fit} + \varepsilon_{fit} \quad (8)$$

Where δ_{fit} is the coefficient that needs to be estimated to give the mean or average percentage price change of factor f due to offshoring-biased technological change; and ε_{fit} is an error term that captures the difference between the factor price change for each industry and the mean percentage change at each point in time, plus the percentage change in international commodity prices.

The value given by $(\delta_{ht} - \delta_{lt})$, which indicates the wage gap between high and low skilled workers driven by offshoring-biased technological change, is then compared with the actual wage gap, $(\hat{\omega}_{ht} - \hat{\omega}_{lt})$ to highlight the relative importance of the effect of offshoring on wages. The same approach is taken for the other pairs of skilled workers.

The above equation, (8), is estimated using weighted ordinary least squares (OLS) for the final 30 industries and for the 1992-2004 period, where more weight is given to those industries with larger value added.

4.4 Data sources

The main two sources for the data set used in this paper are EU KLEMS and the Input-Output tables for the United Kingdom.²⁰ The final data set comprises 30 industries over the period 1992-2004; of these 13 are manufactures, 15 services, and 2 agriculture and mining (see Table 2 for the complete list of industries). In order to compute some of the recent trends above, a further industry disaggregation is used (a total of 119 industries). A detailed explanation of the construction of the data set is in Annex A.

²⁰ See Timmer et al. (2007) and United Kingdom Input-Output Analyses (2006) for an overview of the EU KLEMS dataset and the Input-Output tables respectively.

Table 2. Sector disaggregation

	Agriculture and Mining
1	Agriculture, hunting, fishing
2	Mining and quarrying
	Manufacturing
3	Food, beverages and tobacco
4	Textiles, textile, leather and footwear
5	Wood and of wood and cork
6	Pulp, paper, printing and publishing
7	Coke, refined petroleum and nuclear fuel
8	Chemicals and chemical
9	Rubber and plastics
10	Other non-metallic mineral
11	Basic metals and fabricated metal
12	Machinery, nec
13	Electrical and optical equipment
14	Transport equipment
15	Manufacturing nec; recycling
	Services
16	Electricity, gas and water supply
17	Construction
18	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel
19	Wholesale trade and commission trade, except of motor vehicles and motorcycles
20	Retail trade, except of motor vehicles and motorcycles; repair of household goods
21	Hotels and restaurants
22	Transport and storage
23	Post and telecommunications
24	Financial intermediation
25	Real estate activities
26	Renting of machinery and equipment and other business activities
27	Public administration and defence; compulsory social security
28	Education
29	Health and social work
30	Other community, social and personal services

Source: Industries based on EU KLEMS

5. Results

This sections presents the results for the estimated impact of offshoring-biased technological change on the evolution of wages for high, medium, and low skilled workers ($\delta_h, \delta_{me}, \delta_l$, respectively). In other words, it summarises the implications of this analysis for wage ‘gaps’ if only an offshoring-biased technological change had occurred. These estimates are later compared with the actual wage ‘gaps’ during 1992-2004.

Table 3 shows the coefficient estimates for running equation (8), while Table 4 summarizes the wage gaps implied by these estimates (in column 2) and compares them with the actual evolution of the wage gaps (in column 1). For example, the figure in the first row and first column is the actual percentage change for the wage of low skilled workers (45.2 per cent), while the second column shows the percentage change for the wage of low skilled workers if only offshoring had taken place (56.9 per cent). Similarly with the second row, which shows that the actual percentage wage increase for medium skilled was 51.2 per cent. However, if only offshoring had occurred their wage would have decreased by 25.5 per cent. For the high skilled (third row), wages increased by 50.5 per cent, but offshoring only accounted for an estimated 20 per cent (not significant).

The last three rows of Table 4 report the actual, as well as the estimated, change in the wage premium. The results imply that the effects of technological change biased towards offshoring on both, high-low and medium-low wage gap pairs have worked in the opposite direction to the total actual change in the wage gap. That is, offshoring would have reduced the gap in both cases, by 37 per cent for the high-low pair and by up to 82 per cent for the medium-low pair (see fourth and fifth rows in Table 4.) In a similar fashion, while the data shows a small drop in the wage gap between high and medium skilled workers, the methodology shows offshoring is not the phenomena driving down this gap. On the contrary, offshoring would have increased the high-medium wage gap by 45.5 per cent (see last row in Table 4).

These results may reflect differences in the evolution of the offshoring share of services and goods in the UK described in sub-section 3.2. In particular, the increase in offshoring in the UK has only occurred for services, while the offshoring of goods decreased between 1992 and 2004. If, as often stated, the offshoring of goods is a closer substitute for low skilled workers and offshoring of services is a closer substitute for a more skilled type of worker, then we would expect to see the observed pattern in the wage gaps. The decrease in the offshoring good share should have enhanced low skilled wages, while the increase in the services offshoring share should have had a negative impact on the wage of the more skilled. More precisely, it appears that the workers most negatively affected by the increase in offshoring of services in the UK are not the high skilled, but the medium skilled workers.

Therefore, offshoring has been a factor driving down the wage gap between high and low skilled workers due to the relative improvement in the wages for the latter. It has reduced the gap between medium and low skilled workers because, while the decrease in offshoring of goods improves the wages of the low skilled, the wages of medium-skilled workers are reduced by the increase in offshoring of

services. Finally, the wage gap between high and medium has increased due to offshoring because of its downward impact on the wages of medium workers.

Table 3. Regression results. Effect of offshoring on the wage gap for 1992 – 2004

Percentage change in:	Coefficient estimate
Low skilled wage	0.57 (0.30)*
Medium skilled wage	-0.26 (0.14)*
High skilled wage	0.20 (0.20)
Price of domestic intermediates	0.12 (0.06)**
Price of off-shored intermediates	-0.24 (0.004)***
Price of capital	-0.11 (0.08)
<i>Observations</i>	30
<i>R²</i>	0.70

Source: EU KLEMS, IO tables, National Statistics and own calculations as specified in Annex A

Note: Standard errors are reported in parenthesis. *, **, and *** denote significance at the 10%, 5% and 1% levels.

The table shows the results for running the weighted regression given by equation (8) for the 1992-2004 period, where more weight is given to sectors with larger value added.

Wages for each skill group is the average wage per hour. This is drawn from EU KLEMS data on wages for each industry and skill level. The average hourly wage for each skill level is computed using these number of industry employees as weights.

Table 4. Counterfactual results. Effect of offshoring on the wage gap for 1992 – 2004

	Actual (1)	Estimated(2)
Low skilled wage (percentage change)	45.16	56.89*
Medium skilled wage (percentage change)	51.15	-25.52*
High skilled wage (percentage change)	50.49	20.01
Change in Wage gap: high-low skilled	5.35	-36.88*
Change in Wage gap: medium – low skilled	5.98	-82.41**
Change in Wage gap: high-medium skilled	-0.66	45.53*

Source EU KLEMS, IO tables, National Statistics and own calculations as specified in Annex A

Note: *, **, and *** denote significance at the 10%, 5% and 1% levels.

(^) stands for percentage change.

First three rows in the table compare actual percentage wage changes with estimated percentage wage changes, based on the results from the table above. The last three rows compare actual with estimated changes in inequality or the wage gap. That is the difference between the growth rate (or percentage change) of the wages of the different skill groups.

6. Concluding remarks

The skilled-unskilled wage gap in the UK increased between 1992 and 2004. Has this been a consequence of increased offshoring? According to the analysis in this paper, the answer is no - offshoring has not been behind the increase in the skill premium in recent years. In fact, offshoring has tended to offset the impact of other factors on the various skill premiums. While the actual wage gap between high and low and medium and low skills increased, they would have been larger in the absence of offshoring. The actual wage gap between medium and high skilled workers decreased over the period but offshoring was actually putting upward pressure on this wage gap.

In contrast with the experience in the United States, the UK witnessed an increase in the share of services offshoring and a decrease in the share of goods offshoring between 1992 and 2004. These trends may have pushed up the relative wages of low-skilled blue collar workers while decreasing the relative wage of medium skilled workers, more likely to be affected by services offshoring.

Therefore, factors other than offshoring must be explaining the increasing wage gap for low skilled workers. One possibility is an increase in the relative supply of unskilled workers, perhaps driven by immigration. There may be some degree of substitution between firms use of migrant workers and offshoring, so immigration could also reduce the use of offshoring. More plausible, however, is the hypothesis that skill-biased technological change may have increased the relative demand of the high skill workers, which, in turn, has pushed up their wages.

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Annex A: Data sources

The two main data sources are EU KLEMS and Input-Output (IO) tables for the United Kingdom. For the latter, see Office for National Statistics (2006).

Gross Output and Value Added are extracted directly from EU KLEMS. See <http://www.euklems.net> See Timmer, et al (2007) for an overview of the EU KLEMS data and methodology.

Labour cost-shares and prices

From EU KLEMS:²¹

$COMP_{it}$: compensation of employees (millions of pounds)

$EMPE_{it}$: number of employees

H_EMPE_{it} : total hours worked by employees

$LABHS_{it}$: share in total labour compensation to high-skilled

$LABMS_{it}$: share in total labour compensation to medium-skilled

$LABLS_{it}$: share in total labour compensation to low-skilled

H_HS_{it} : share in total hours worked by high-skilled

H_MS_{it} : share in total hours worked by medium-skilled

H_LS_{it} : share in total hours worked by low-skilled

Then, the following variables are computed:

$CE_{hit} = COMP_{it} \cdot LABHS_{it}$ compensation to high-skilled

$CE_{meit} = COMP_{it} \cdot LABMS_{it}$ compensation to medium-skilled

$CE_{lit} = COMP_{it} \cdot LABLS_{it}$ compensation to low-skilled

$H_{hit} = H_EMPE_{it} \cdot H_HS_{it}$ total hours worked by high-skilled

$H_{meit} = H_EMPE_{it} \cdot H_MS_{it}$ total hours worked by medium-skilled

$H_{lit} = H_EMPE_{it} \cdot H_LS_{it}$ total hours worked by low-skilled

Compensation to each skill group is the average wage per hour. This is drawn from EU KLEMS data on wages for each industry and skill level. The average hourly wage for each skill level is computed using these number of industry employees as weights.

The labour cost-shares are computed as follows:

²¹ <http://www.euklems.net/>.

See http://www.euklems.net/data/eu_klems_productivity_report_overview.pdf, page 17 and 18, for more information on the definition of these variables.

$$\theta_{fit} = CE_{fit} / GO_{it} \quad \forall f = h, me, l$$

The price for high, medium and low skilled workers (wages) are computed as follows:

$$\omega_{fit} = CE_{fit} / H_{fit} \quad \forall f = h, me, l$$

Intermediate inputs cost-shares

From EU KLEMS:

II_{it} : total expenditure on intermediates

From IO tables (superscript t is understood):

$$B^{TOT} = \begin{pmatrix} b_{11}^{TOT} & b_{12}^{TOT} & \dots \\ b_{21}^{TOT} & b_{22}^{TOT} & \dots \\ \vdots & \vdots & \vdots \end{pmatrix}$$

where b_{ij}^{TOT} gives the quantity of good belonging to industry i needed to produce the total output of industry j . This matrix is known as the total intermediate matrix.

Following OECD STAN and Feenstra and Hanson (1999) the imported intermediate matrix (B^O) and the domestic intermediate matrix (B^D) are obtained, such that each element is analogous to the one from the total intermediate matrix but for imported (or offshoring) and domestic intermediates, respectively.

When using two different data sets, a scaling factor is needed in order to make both data sets compatible. In this case:

$$\kappa_{it} = \frac{\sum_j b_{jit}^{TOT}}{II_{it}}$$

Then, each element on B^{TOT} , B^O , B^D are scaled using κ_{it} .

The cost-shares for imported and domestic intermediates are obtained by adding up each element for each column in B^O and B^D respectively.²²

Capital cost-share

One minus the cost-share for the rest of production factors (3 types of labour, domestic intermediates and offshoring) gives the capital cost-share.

Price for intermediates

The Producer Price Index (MM22) and the Services Producer Price Index (SPPI), formerly known as Corporate Service Price Index, are used in order to compute a series of prices for the majority of goods and services used as intermediate inputs. Moreover, some other price index are needed, in particular, the

²² For further details on the industry correspondence send and email to the author.

Agriculture Price Index, and from the Department of Business Enterprise and Regulatory Reform the retail price for Gas and Electricity.

Then, following Bartelsman and Gray (1996)'s procedure, a price for domestic intermediates and a price for offshoring is computed for each industry and year such that:

$$\omega_{dit} = \sum_j \frac{b^D_{jit}}{\sum_j b^D_{jit}} \cdot p_{jt}$$

$$\omega_{oit} = \sum_j \frac{b^O_{jit}}{\sum_j b^O_{jit}} \cdot p_{jt}$$

where p_{jt} is the price of goods and services computed using MM2 and SPPI and the rest of price index.

Price of capital (aka the rental price of capital)

From EU KLEMS:

GOS_{it} : gross operating surplus

CAP_QI_{it} : capital services (volume indices 1995 = 100)

Then the rental price of capital in 95 terms can be computed as:

$$\omega_{kit} = \frac{GOS_{it}}{CAP_QI_{it} \cdot GOS_{195}}$$

Annex B: Supplementary tables

Table B1. Trends in the offshoring share, United Kingdom 1992-2004*

%	Total offshoring share	Offshoring share of goods	Offshoring share of services
1992	35.24	25.59	9.65
1993	36.35	25.92	10.43
1994	36.84	25.64	11.20
1995	37.96	27.39	10.56
1996	38.46	26.90	11.56
1997	37.22	25.76	11.46
1998	35.61	23.72	11.89
1999	36.25	23.32	12.93
2000	36.85	25.54	13.31
2001	36.89	23.37	13.52
2002	35.11	21.57	13.54
2003	35.06	20.80	14.26
2004	35.11	21.05	14.05
Average annual growth rate	-0.03	-1.49	2.93

Source: Input-Output tables for UK from National Statistics and own calculations as specified in Annex A.

* Imported intermediaries as a proportion of total intermediate inputs.

Table B2. Trends in the share of offshoring, United States*

%	Total offshoring share	Offshoring share of goods	Offshoring share of services
1973	5.19	4.81	0.38
1974	5.97	5.60	0.37
1975	5.86	5.38	0.48
1976	5.96	5.45	0.51
1978	6.63	6.18	0.45
1979	6.86	6.40	0.47
1980	6.78	6.30	0.48
1981	6.79	6.19	0.60
1983	6.67	6.14	0.53
1984	6.82	6.37	0.44
1985	6.47	6.01	0.46
1986	6.52	6.02	0.50
1996	9.27	8.35	0.92
1997	9.44	8.50	0.94
1998	9.36	8.36	1.00
1999	9.22	8.35	0.87
Average annual growth rate			
1973-1986	1.77	1.73	2.07
1996-1999	2.70	2.55	4.42

Source: IO tables for US from National Statistics and own calculations as specified in Annex A. *Note: data unavailable from 1987 to 1985.

* Imported intermediaries as a proportion of total intermediate inputs.

Table B3. Share of low, medium and high-skilled workers in total UK workforce

%	Low skilled	Medium skilled	High skilled
1992	23.9	64.0	12.1
1993	22.7	64.5	12.8
1994	19.7	67.3	13.0
1995	18.3	68.0	13.7
1996	17.5	68.7	13.8
1997	15.6	70.1	14.3
1998	14.8	70.2	15.0
1999	14.2	69.9	15.9
2000	13.6	69.6	16.8
2001	13.6	69.1	17.3
2002	12.8	69.4	17.8
2003	12.4	69.0	18.6
2004	12.1	68.4	19.5

Source: EU KLEMS and own calculations as specified in Annex A

Note: Each column specifies the percentage of workers for each skill level in the total workforce.