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Measuring and interpreting trends in the division of labour in the Netherlands*

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Abstract

This paper introduces indicators about the division of labour to measure and interpret recent trends in employment in the Netherlands. We show that changes in the division of labour occur at three different levels: the level of the individual worker, the level of the industry and the spatial level. At each level the current organisation of work is determined by an equilibrium of forces that glue tasks together and unbundled tasks. Communication costs are the main force for clustering or gluing together tasks; comparative advantage stimulates unbundling and specialisation. Our results show that on average the Netherlands has witnessed unbundling in the period 1996-2005. So, on average the advantages of specialisation have increased. These developments can explain to a considerable extent changes in the structure of employment. Especially at the spatial level our approach explains a substantial part of the increase in offshoring during this period.

JEL: F16, J23, J24
Key Words: offshoring, tasks, technology, trade, labour market

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1. Introduction

The division of labour has changed over the past fifteen years. Revolutionary progress in information and communication technologies (ICT) has enabled a break-up of the production process, which has had implications for the structure of employment (e.g., Bresnahan, 1999, Autor et al., 2006, Blinder, 2006 and Baldwin, 2010). ICT has changed the way individual tasks can be carried out and it has created new possibilities for communication between workers. ICT has also substantially lowered coordination costs (e.g., Varian, 2010). Since firms take advantage of these new opportunities by organising the production process differently, this has changed the task composition of occupations across workers (e.g., Borghans and Ter Weel, 2006). The same development also created new opportunities to outsource substantial parts of the production to other firms. This changes the organisation of work across industries as well (e.g., Bloom et al., 2009). Finally, production increasingly takes place in global supply chains in which the tasks required to manufacture goods and services are performed in several locations all over the world. This changes the composition of occupations across countries as well (e.g., Antràs et al., 2006). These rapid and complex to comprehend developments have triggered concerns that in the end more and more tasks currently performed by Dutch workers can and most likely will be carried out abroad. This modern way of organising work demands a framework for analysing what the consequences are for labour-market outcomes.

The aim of this paper is to document trends in the division of labour in the Netherlands in the most recent period and to shed light on what type of tasks are most likely to be affected by these new technological possibilities to organise production differently. We introduce a set of empirical indicators to measure the possibilities and benefits of separating tasks at the worker, industry and spatial level. These indicators are based on a theoretical framework that defines economic activities as a set of tasks. There are forces stimulating bundling of tasks across occupations, industries and space and forces stimulating the separation of tasks across these three dimensions. We relate these indicators to changes in employment across occupations in the Netherlands to investigate to what extent changes in the optimal division of labour can account for recent employment trends in the Dutch labour market.

Our approach builds on the notion that occupations are bundles of tasks. The organisation of these tasks is determined by different forces. It depends on the trade-off between coordination and production costs whether tasks are separated into different occupations or not. When coordination becomes easier it might be beneficial to separate tasks into different occupations. When tasks can be separated from occupations, they could also be

leaving the firm (be outsourced). Whether or not this happens depends on the make-or-buy trade-off. Carrying out tasks in-house has a coordination advantage, whereas outsourcing tasks could have a cost advantage. Finally, if tasks leave the firm they could also leave the country (be offshored). Whether or not this happens depends on proximity vs. cost advantages. In our framework we introduce indicators to measure these forces of bundling and unbundling of tasks. We introduce measures of connectivity and comparative advantage at the level of the worker, industry and across space. Differences in how tasks are connected determine to what extent tasks belong together and differences in task prices in the labour market measure comparative advantage and show to what extent there is a potential for separating tasks from each other.

Measuring what has been going on in terms of the changes in how work is organised is important to understand employment changes. There has been a lot of speculation about the effects of offshoring on employment in Western economies and the subject has been on the international policy agenda for a while now. But, so far, there is hardly any framework suitable for examining some of the basic mechanisms and facts. Recent work by Antràs et al. (2006), Grossman and Rossi-Hansberg (2008) and Baldwin and Robert-Nicoud (2010) provides models to think about the labour-market effects of offshoring, but these models are not easily brought to the data. In addition, the literature has been hampered by the difficulty of finding good proxies for the division of labour at different levels of aggregation and offshoring. Indeed, to measure the effect of offshoring on employment we require a model of differences in offshoring costs across tasks. Our framework and empirical work is among the first attempts to do so.[1]

In our empirical work we focus on the Netherlands in the period 1996-2005. This is a period of rapid change in terms of ICT diffusion. The Internet and modern communication technologies have affected coordination costs especially in this period. In addition, the Dutch economy is a small open economy that should go with the worldwide trends of economic and technological developments to remain competitive (e.g., Ter Weel et al., 2010). Finally, there is no previous work on how recent developments in technology and trade have affected employment in the Netherlands.[2] Earlier work by Borghans and Ter Weel (2006) presents

[1] A recent paper by Criscuolo and Garicano (2010) utilises a measure of offshorability by investigating the legal licensing requirements to execute some tasks. Legal requirements are a burden to offshore tasks that would have been offshored otherwise. Their findings suggest that jobs that are "stuck" at home benefit from complementarities with the offshored inputs.

[2] CPB (2008) presents a sound analysis of wage inequality in the Netherlands relative to the United States in the period 1979-2005 but does not address the underlying changes in the division of labour. Earlier work on wage inequality in the Netherlands, summarised in Ter Weel (2003), looks at earlier periods and focuses mainly on

estimates of the division of labour in Dutch firms, but does not look at the individual and spatial dimensions. The only recent estimate for the effects of offshoring on Dutch employment is one from Goos et al. (2009). They present evidence of polarisation in the labour market in terms of employment in a number of OECD countries, including the Netherlands. However, their analysis neither addresses the division of labour nor is it able to present a picture at a sufficiently detailed level to understand the underlying mechanisms of changes in the structure of employment.

Our main findings are that the Netherlands has indeed witnessed a period of unbundling of tasks in the past decade. We are able to identify specific tasks and occupations that have been most vulnerable to these developments. Possibilities for unbundling at the individual level are to a large extent comparable to such possibilities at the industry level. These trends are able to explain a large part of the changes in the structure of employment over this period and especially the development at the spatial level can account for the trend in offshoring of activities

An important policy conclusion is that although unbundling at the individual and industrial level is not favourable for the employment of relatively low-educated workers, the employment risks for this group are not larger than for others. The reason for this is that the link between the tasks performed by relatively low-skilled workers and local demand are stronger than for tasks carried out by higher skilled workers. Thinking in terms of clusters of activities provides an interesting tool for policy makers to reduce the vulnerability to offshoring of regions in the Netherlands.

Our work is related to the research focussing on explaining changes in the structure of employment and wage inequality (see Acemoglu and Autor, 2010, for an overview of this literature). Particularly the recent body of work by Autor et al. (2006), Goos and Manning (2007), Goos et al. (2009), Criscuolo and Garicano (2010) and Firpo et al. (2009) shows that certain types of occupations seem to be disappearing in terms of employment and/or seem to be paying lower wages over time. The latter paper shows that offshoring and technological change account for about half of the changes in the US wage distribution between the early 1980s and 2002. Second, from a firm's organisational perspective Osterman (1994), Caroli and Van Reenen (2001) and Bresnahan et al. (2002) suggest both independent and complementary effects of organisational change and computer technology adoption on the

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institutional factors in explaining differences in wages across groups in the Dutch labour market. Gorter et al. (2005) analyse the effects of offshoring for the Dutch economy. They do however not pay attention to employment.

demand for labour in Britain, France and the United States. These studies focus on decentralisation of authority within firms. The changes in the assignment of workers to tasks we focus on are related to papers by Borghans and Ter Weel (2004, 2006), Autor et al. (2003), Garicano and Rossi-Hansberg (2006), Spitz-Oener (2006) and Green (2009). Third, trade economists have began to recognise that most trade is in intermediate products. Feenstra and Hanson (1996, 1999) show that outsourcing has contributed to an increase in the relative demand for skilled workers in the United States. The fragmentation of production into intermediate products suggests that changing the internal composition of sectoral production is a potential channel through which trade affects the demand for labour. However, this literature neglects the division of labour. Trade economists have recently begun to study how technology has facilitated the breaking up of occupations into tasks and how falling costs of offshoring affect factor prices. Most prominently the theoretical work by Grossman and Rossi-Hansberg (2008) combines the work by labour economists on the importance of tasks and the work by trade economists on the breaking up of the supply chain to study the effects on wages. They point to the role of improvements in communication and transportation technology in explaining the unbundling of the production process.[3] As technologies improve, it becomes more beneficial to fragment the production process to take advantage of cross-country differences in the cost of performing the tasks, or producing the (intermediate) goods. Empirically, Crino's (2010) estimates suggest that service offshoring from the United States has led to increases in high-skilled US service occupations since the late 1990s.

This paper proceeds as follows. The next section presents the theoretical background of the paper. Section 3 explains how we constructed the database for the empirical analysis. In Section 4 we present the empirical strategy and compose the several measures used in the empirical analysis. Section 5 and 6 present the results. In Section 7 we discuss the implications and conclusions.

2. The division of labour

Discussions about the division of labour enter the economics literature via Adam Smith' *Wealth of Nations* in which he puts forward the example of the pin factory that benefits from specialisation. It became practical in Henry Ford's production model of the T-Ford and was criticised by Charlie Chaplin in the movie Modern Times. Essentially the idea of the division

[3] Ellison et al. (2010) examine decisions of firms to co-locate to explain co-agglomeration patterns in the United States. Proximity of consumers, thick labour markets, face-to-face interactions to exchange ideas and natural advantages all play a role in the firm's decision making. It turns out that input-output linkages are still important in US manufacturing.

of labour and the gains from specialisation was already present in Plato's piece *The Republic* in which he argues: "Quantity and quality are more easily produced when a man specialises appropriately on a single job for which he is naturally fitted, and neglects all others."

2.1. Modern times

Originally Adam Smith related the division of labour to the extent of the market. Now, more than two centuries later, when markets have become very large, we know that many people within one market perform the same tasks without further specialisation (e.g., Baumgardner, 1988).

Smith already noticed that communication costs are crucial in determining the division of labour, although the word communication still referred to transport at that time: "Were there no other communication between those two places, therefore, but by land-carriage, as no goods could be transported from the one to the other, except such whose price was very considerable in proportion to their weight, they could carry on but a small part of that commerce which at present subsists between them, and consequently could give but a small part of that encouragement which they at present mutually afford to each other's industry." (Smith, 1776). Since the time of Smith transport costs have fallen substantially, leading to the notion of a global village. However, it did not lead to a degree of specialisation far beyond what people have been expecting, because more subtle communication costs have led to new limitations to specialisation.

Since the 1990s, the division of labour has been heavily influenced by the computerisation of work. The adoption and rapid diffusion of the bundle of new information and communication technologies has been the most radical technological change of the last century, and its development will continue for a number of decades to come. The ICT revolution has caused the costs of many kinds of interactions to drop by making a great many processes operate more efficiently, and it has allowed for the opportunity to engage in new interactions that have become cost effective.

ICT has therefore affected the division of labour. At first, revolutionary technologies are implemented in a rather mechanical way to make it less costly to produce the same level of output. Over time, a revolutionary technology changes and amends to do new things, such as to change the way in which markets are functioning and structured, demand and supply are brought together, or to restructure the way in which a firm is organised and influence the way in which innovation activities are pursued. Is it only computers that matter for the division of labour of today? No, but as Bresnahan (1999) shows in an overview study, the "computer" as

a general purpose technology has had by far the greatest impact on the way we work; and will continue to do so in coming decades, because its diffusion is far from complete. Also, Varian (2010) presents several important ways in which ICT has lowered coordination costs.

For Smith, time reduction in communication costs as a result of the introduction of communication by water-carriage increased the incentives for specialisation. Obviously, production costs have since then decreased so much compared to communication costs that now a decline in much more subtle communication between workers in the same workplace, already makes a difference. For example, a Boeing 787 Dreamliner is presently produced by 43 firms in 135 locations all over the world. From Boeing's headquarters in Chicago 70 percent of all tasks are offshored, a way of producing an airplane that was infeasible before the 1990s. This modern way of production demands a framework of analysing tasks.

2.2. Framework

The theoretical notions and empirical observations need an analytical framework to be able to structure what is going on. In general, working activities are not carried out in isolation, but the output of some tasks is the input of others, with the end product being consumed by consumers. For physical production this means that products have to be transported from one producer to the other or to the consumer. One the one hand, carrying out related physical activities next to each other saves on transport costs. On the other hand, different locations all over the world could have costs advantages in the production of specific intermediate inputs. Beyond physical distribution, production requires coordination, consultation, and planning. Here too proximity reduces communication costs, although having different workers at specific locations might have cost advantages. The way work is organised and the resulting division of labour depend on these economic forces.

The modern economic stance on the division of labour is that computer technology affects the classical trade-off between the productivity advantages of specialisation and communication costs, as studied by Baumgardner (1988), Becker and Murphy (1992), Radner (1993) and Bolton and Dewatripont (1994). Without denying the potential for innovation that can be associated with the computer revolution, when the trade-off between the benefits of specialisation and the costs of communication determines the division of labour, it is hard to imagine that computer technology did not affect the division of labour. Yet, both increased productivity within specific tasks and increased efficiency of communication will affect the benefits of specialisation and communication costs. This process occurs at different levels: the worker, the industry and the region.

Thinking about two tasks that are needed for the production of one type of output, the decision at each level is whether to bundle these tasks (in a person, a company or a region) or to carry out the two tasks separately (by different persons, in different companies and in different regions).

When production of both tasks is combined in one unit, communication costs will be saved. The larger the costs of communication in case two tasks are carried out separately, the more *connected* these tasks are. The cost of combining tasks is that no advantage can be taken of comparative advantages of specific units of production. For example, at the individual level, a task that can be carried out equally well by two different types of workers would be allocated most optimally to the worker with the lowest wage, or if two workers have the same wage level one could be more productive in one activity while the other specialises in the other activity. The same potential to benefit from comparative advantages applies to the regional level.

These two aspects of the division of labour play a role at three levels of analyses: the worker (individual) level, the firm/industry level, and the spatial (geographical) level. The left-hand side of Figure 1 provides three pictures of the framework we have in mind. The column in the middle defines the trade-offs between connectivity and price differentials at the three different levels. The right-hand side of Figure 1 will be discussed in Section 4.

At the worker level connectivity means to what extent there are coordination costs involved when two related tasks are carried out by more than one person. If one worker carries out a set of tasks he is automatically aware of the specificities of each task, knows all the details and is aware about the progress of each of the tasks he has to carry out. Assigning these tasks to different workers might require coordination but could increase productivity due to specialisation. Comparative advantage refers to the wage/productivity differential between workers with different skills. Separating tasks makes it possible to benefit from wage or productivity differentials since the optimal skill level might be different for each task. The classical example is the manager with his secretary. For the firm a secretary is cheaper than the manager and can take over a lot of work. But, to make this team work the two need to coordinate substantially. The profitability of separating tasks or keeping them together into one occupation depends on the balance of task connectivity and comparative advantage. Technological change might affect the connectivity of tasks, while developments in the wage structure might affect the relevant comparative advantage. Borghans and Ter Weel (2006) show that technologies that improve productivity in a specific task will lead to generalisation since in relative terms coordination costs increase. Technology that facilitates communication

will lead to specialisation.

A similar trade-off can be distinguished at the firm level. A firm can buy goods and services in the market or can produce these goods and services in-house. Acquiring these goods and services at the market makes it possible to gain from the productivity and scale advantages of specialised firms. Search and contracting on the other hand lead to coordination costs. It is the balance between make or buy that determines whether tasks are carried our in-house or not. Tasks for which it is not beneficial to separate them at the individual level will also not be separated from the firm. The unbundling at the individual level is therefore a *conditio sina qua non* for this firm level unbundling.

At the third level, the spatial level, it is distance that constitutes coordination costs. For physical goods it is obvious that distance matters, but also for services it might be important that workers, although possibly working in different firms, can meet each other. There is a strong tendency for economic activities to cluster. Workers in these regions might benefit from contacts with other workers both formally and informally (e.g., Gaspar and Glaeser, 1998).[4] This proximity effect is counterbalanced by the possible cost advantage of offshoring activities to low-wage countries. It depends on the balance between proximity and cost advantages whether or not work will be offshored. At the geographical level also the distance to the customer comes into play. For products with high transportation costs proximity to the client is crucial. Goods that can easily be transported and services that can be carried out at the different location are more easily offshored.

For each combination of tasks needed for the production of a specific good or service the trade-off between connectivity and comparative advantage determines whether they are bundled (in one person, one firm, or one region) or not. What we actually observe in the data are bundles of tasks. Some of these combinations will be close to the threshold of being changed: A marginal decrease in connectivity or a marginal reduction in comparative advantage could lead to an unbundling of these tasks. With a general trend towards unbundling (e.g., Baldwin, 2010), it will be particularly these tasks that actually become unbundled. That is why we investigate in our empirical analyses whether indicators of connectivity and comparative advantage at each level predict tasks becoming less important in an occupation, industry or region. In addition, if some tasks have the potential of being taken out of the bundle of a worker, industry or region, it can be expected that fewer workers are

[4] Gaspar and Glaeser (1998) report a complementary relationship between ICT and face-to face interactions in the 1970s and 1980s in the US. Venables (2001) shows that this relationship is particularly present in production processes involving skilled activities; low-skilled work is moving to cheaper places (the standardised nature of the work implies that it hardly benefits from face-to-face interactions).

needed to carry out the work. This yields our second type of analysis, which investigates whether indicators of connectivity and comparative advantage predict a decline or rise in employment. Finally, as unbundled work might be offshored, we investigate whether unbundling at the different levels is related to indicators of outsourcing.

Of course, a general trend of unbundling of tasks does not necessarily apply to each combination of tasks or to each occupation. Our approach of documenting this development will show which occupations fit into this general pattern, but will also reveal the occupations that do not fit into this picture.

3. Data

We use several data sources to construct our indicators for connectivity and comparative advantage and the relevant outcome variables. Here we present the most salient details of how we compose the database. The interested reader can find additional and more detailed information in the Data Appendix at the end.

We use three main data sources, which are well-known and often used in Dutch labour market research. First, we use the Dutch Labour Force Survey (*Enquête Beroeps Bevolking* (EBB)) from 1996 to 2005 to gather information on employment by occupation and other relevant personal characteristics of individual Dutch workers. It also contains spatial information about where workers reside. Each wave of the EBB contains about 85,000 observations. Since the EBB does not include wage information, we merge the EBB to administrative wage data in the *Sociaal Statistisch Bestand* (SSB) and the Dutch Socio-Economic Panel (SEP). The wage data are appended to the EBB based on occupational classifications. For each occupational code we obtain a corresponding wage for each year in between 1996 and 2005.

Second, we lack information about work tasks in the Netherlands. Only for Germany (e.g., Spitz-Oener, 2006), the United States (e.g., Autor et al., 2003) and Britain (e.g., Green et al., 2007) task data are available. The main advantage of the British data is that it contains uniformly measured information about the importance of job tasks, whereas the German task data only contain information about whether the task or a bundle of tasks is present in an occupation. The US *Dictionary of Occupational Titles* (DOT) uses different scales for different tasks and requirements. Since these measures are expert ratings, they do not change over time. For our analysis of connectivity and comparative advantage, having information about the importance of job tasks is crucial. The data for Britain are also the most detailed in terms of the number of job tasks and especially designed to address questions about the

division of labour. Hence, we use task data from the *British Skills Survey* (BSS). The BSS is available for three years (1997, 2001 and 2006) and includes detailed information on the characteristics of individual workers' jobs.[5] Green (2009) documents the trends in skills requirements using these data; Borghans et al. (2008) use all three datasets to explore labour-market outcomes in Britain, Germany and the United States. From the BSS we obtain what tasks are important for different occupations and how important they are (on a scale 1 to 5, with 1 denoting 'not important at all' and 5 denoting 'essential'). The database consists of tasks, ranging from routine tasks such as the importance of using hands, tools and the importance of physical strength, to more abstract tasks such as the importance of analysing complex problems and planning the activities of others. A list of all 33 work tasks can be found in the Data Appendix.

To append the BSS to the Dutch data, we constructed a crosswalk between the British and Dutch occupational classifications and then aggregated each BSS-wave for 36 large two-digit Dutch occupational classes (see the Data Appendix for more details). We append the BSS to the Dutch data set such that each occupational class in the EBB has corresponding values that measure the importance of tasks. The assumption we make is that Dutch and British two-digit occupations consist of the same set of tasks.

Finally, to be able to calculate offshoring measures we make use of input-output (I-O) tables of Statistics Netherlands (CBS). The Dutch I-O tables yield information regarding the sales and purchases of each industry for the years in between 1996 and 2005. We construct two-digit industry measures of offshoring and add these to the information in the EBB about industry-occupation combinations.

The result of this exercise is a consistent database of personal characteristics and employment (EBB), wages (SSB and SEP), the importance of job tasks (BSS), and offshoring measures (CBS) from 1996 to 2005. We obtain this information for the 36 largest two-digit occupations and 70 two-digit industries and their interactions.

4. Measures and descriptive statistics

To document developments in the division of labour we construct measures for connectivity and comparative advantage at the three levels identified in the previous section and displayed in Figure 1. The right-hand side of Figure 1 presents the measures and below we show the

[5] BSS is conducted in 1997, 2001 and 2006. In our data set BSS 1997 refers to the year 1996 and BSS 2006 refers to 2005. We do not expect statistically significant variation in task scores between two consecutive years. To prevent any further confusion we use "task 1996 (2005)" whenever we refer to task score in 1997 (2006) in the BSS data.

equations. The Data Appendix at the end of the paper provides a more detailed overview of the measures developed below.

4.1. Workers

To measure and analyse the division of labour at the level of the worker we construct two measures: the task-occupation wage differential (to measure the potential for separating tasks by computing the differences in labour-market prices between particular tasks relative to the occupation they are in) and the task-occupation connectivity (to measure the extent to which tasks belong together).

The absolute difference between the occupation wage and the task wage determines the potential productivity advantage from unbundling tasks. The higher the difference between the occupation and task wage, the higher this advantage can be. We calculate the task-occupation wage differential ($towd_{ij}$) as the absolute difference between the occupation and task wage:

$$towd_{ij} = \left| w_i - w_j \right|, \tag{1}$$

where w_i is the occupation wage and w_j is the task wage. The index *i* indexes 36 occupations and *j* indexes 33 task measures.[6] The occupation wage w_i is observed in the data and the task wage w_j is constructed by taking the weighted average wage for each task weighting occupations by the importance of the task concerned. Higher values of $towd_{ij}$ mean a larger discrepancy between the task and the occupation wage, suggesting that based on labour-market prices the specific task belongs less naturally to an occupation relative to a task with an on average low value of $towd_{ij}$.

The second measure is task-occupation connectivity. It measures the presence of a task if another task is part of an occupation. Task-occupation connectivity (toc_{ij}) is constructed as follows:

$$toc_{ij} = \sum_{j'=1}^{j'=33} c_{jj'} m_{ij'}. \tag{2}$$

[6] Ranging from least important to most important, we use [0, 1, 2, 3, 4] as weights to calculate task wages. We experimented with two other weights to see whether this affects our findings. We have applied the rule [0, 1, 3, 6, 10] that puts more emphasis on more higher values of importance and [0, 0, 0, 0, 1] in which task wages are computed taking into consideration only the most essential task in an occupation. These measures produce task wages that display higher variance. The correlation among the three task-occupation wage differential indicators is at least 0.98 and all correlation coefficients are significant at the 1 percent level. The alternative measures yield qualitatively similar regression results.

The measure is an occupation-task specific indicator. The index *i* indexes 36 occupations and *j* indexes 33 task measures. The variable $c_{jj'}$ is an element of a correlation matrix of 33 tasks that shows how tasks are correlated at the worker level. The result is a correlation coefficient for all tasks that shows how connected task 1 is to the other 32 tasks and so on. The correlation matrices are calculated at the individual level in all three BSS rounds (1997, 2001 and 2006). Finally, the correlation coefficients are weighted by $m_{ij'}$, which is a measures of the importance of tasks within an occupation. The two indices can be aggregated by occupation and by task.

The two indices differ substantially between the 33 tasks. Figure 2 presents a plot of the relationship between the standardised average values of $towd_{ij}$ and toc_{ij} by task. A high average level of toc_{ij} implies that tasks are hard to separate from the occupation. Tasks such as "thinking of solutions", "analysing" and "writing" are relatively well-connected; whereas tasks such as "physical strength" and "selling" are not well connected. Differences between occupation and task wages suggest that it would be beneficial to assign them to separate occupations because when performed by a specialist the tasks could be carried out more efficiently. Together, the two measures determine the profitability to separate tasks from an occupation. High task-occupation connectivity, together with low task-occupation wage differentials mean that it is hard and unnecessary to separate tasks, whereas low task-occupation connectivity together with large task-occupation wage differentials yield scope for separating tasks.

For descriptive purposes we define the difference between the average $towd_{ij}$ and toc_{ij} for each occupation *i* as the contestability of that occupation. We standardise this variable such that the mean equals zero and the standard deviation equals 1. The net effect of the two measures is an indicator of the probability that this occupation is offshored. Figure 3 presents the change in employment by occupation against this measure of contestability.[7] The size of the dots represents the size of the occupations. The pattern in the figure suggests that there is a negative correlation between contestability and changes employment at the occupation level. This relationship seems to become somewhat blurred towards very high levels of contestability, which can be observed by a tendency towards a positive relationship on the right side of the picture. The most likely explanation for this is one of selection. Although these kinds of occupations are very contestable, the fact that they still exist in the Dutch

[7] When we use the change in the hours worked by occupation we obtain similar results. This holds for all analyses throughout the paper.

labour market implies that some of them are still needed in the labour market for reasons not caught by our indicators. The absolute level of employment of these occupations is very low though (small dots), suggesting that these occupations how been under pressure already in the past. Indeed, closer inspection shows that typical occupations in this area of Figure 3 are elementary or low-skill occupations and low-end service occupations.

4.2. Industry

To measure trends over the last decade in the division of tasks across industries we construct a measure of task-industry connectivity (tic_{jr}), where *r* indexes 70 industries. We assume that there are no task-occupation wage differentials between industries (i.e., $tiwd_{jr} = 0$ by definition). In practice there can be differences in the average wages of workers with the same occupation or set of tasks in different industries. We consider these differences to reflect productivity differentials between sectors due to the selection of workers into industries, which are irrelevant for our analysis of the division of labour.

If it is possible to separate tasks from a worker and assign these tasks to other workers, it is not necessarily the case that these tasks will leave the firm (or the country). Since it is not possible to construct a database that shows tasks (and occupations) by firm for the Netherlands, we use two-digit industry level data to carry out the analysis. The measure of task-industry connectivity is composed as follows:

$$tic_{jr} = \sum_{j'=1}^{j'=33} c_{jj'} m_{j'r} \,, \qquad (3)$$

where $c_{jj'}$ now measures the task correlations at the industry level. This means that in all three BSS waves the individual level data is first aggregated to Dutch industries. The cross-section industry level data show the importance of tasks for each industry across all three years. These correlations are then weighted by the importance level of tasks within an industry ($m_{j'r}$).

The measure of connectivity of tasks at the industry level (tic_{jr}) yields a picture of the extent to which tasks are connected to an industry. Similar to tasks connected to occupations (toc_{jr}), we expect tasks that are relatively well-connected to industries to be less likely to be leaving the industry. Again the indices can be aggregated by task or by industry.

Figure 4 shows a scatter plot of the average tic_{jr} and toc_{jr} by task. The points represent the average levels of connectivity across all three waves of the data. The correlation

is positive and significant at the one percent level; the coefficient equals 0.912. We have included a 45-degree line and expect all tasks to be below this line because it seems easier to separate tasks from a worker than from an industry, i.e. reshuffling the tasks across workers is a *sine qua non* for outsourcing the task elsewhere. The graph indeed suggests that tasks can be assigned to a specific person but that it is harder to set these tasks apart from the industry. The figure also shows heterogeneity across tasks. Tasks closer to the 45-degree line have a more similar probability of being separated, while tasks further away are more easily separated from the worker relative to the firm. For example, tasks such as physical strength have a more or less equal probability of being separated from the worker and the firm, while analysing is more easily split off a worker's occupation relative to the firm.

4.3. Space

The final step of the analysis is space. When it is possible to separate tasks from occupations and from industries, it does not necessarily lead to the offshoring of these tasks abroad. In the spatial dimension there could be advantages to bundle activities, since this reduces transport costs and makes communication between people involved in different related processes easier. Therefore, if occupations are well-connected to other occupations across space, there might be less scope for offshoring. In the spatial dimension also the link between production and consumption becomes relevant. If tasks serve local demand, they are scattered around the whole (or a large part) of the Netherlands. To measure the development of the division of labour across space we construct two measures: spatial occupation concentration (to measure the potential for separating occupations from others) and occupation-space connectivity (to measure how well occupations are connected).

We measure spatial occupation concentration and occupation-space connectivity in terms of occupations instead of tasks. The reason is that although task measures are much more detailed and taken from a unique data source, they are still too abstract to distinguish between regional patterns in a relatively small country such as the Netherlands. For example, in the metal industry and the chemical industry, physical strength is an important task for many blue-collar occupations. The metal industry is concentrated around city *X*, while the chemical industry is concentrated mainly around city *Y*. So, in terms of the importance of tasks we do not see much of a difference between these cities, while in terms of the probability of offshoring there might be substantial differences. These differences will not be picked up by an analysis of tasks.

The measure of spatial occupation concentration (soc_i) is an adjusted version of concentration index proposed by Ellison and Glaeser (1997). The spatial occupation concentration index is calculated as follows:

$$soc_i = \sum_{v=1}^{v=17} \left| occ_{iv} - ps_i \right| . \quad (4)$$

In this equation occ_{iv} is the occupation share of region *v* and ps_i its population share.[8] We use a regional classification that divides the Netherlands into 17 different regions. In the equation the first term acts as local employment and the second term as local demand. The difference is traded outside the region. Thus, domestically traded occupations are expected to be internationally tradable as well (e.g., Jensen and Kletzer, 2005). A higher score on this measure suggests that occupations are relatively concentrated. More concentration increases the scope to transfer the activity elsewhere.

Occupation-space connectivity (osc_i) is measured based on the distribution of occupations. We construct an index of occupation connectivity that originates from a matrix of correlations of the share of occupations. Each observation is a region and occupations are variables, so that each cell contains the share of an occupation in a particular region. We obtain a correlation matrix of the share of occupations from this database and apply the same procedure we use to calculate task-occupation connectivity:

$$osc_i = \sum_{i'=1}^{i'=36} c_{ii'} m_{i'} , \quad (5)$$

where $c_{ii'}$ is an element of the correlation matrix of occupations that shows the correlation of the share of occupation *i* with other occupations. The correlation matrix is calculated from the dataset that shows occupation shares for each region. These correlations are weighted by the importance of an occupation, the overall share of occupations in total employment $m_{i'}$. A higher score on this measure indicates a higher level of occupation-space connectivity. Higher levels suggest that it is harder to move this occupation elsewhere since it is well-connected to other occupations.

Figure 5 shows the correlation between the measures soc_i and osc_i. The dots represent occupations and the size of the dots the size of these occupations in the Netherlands.

[8] This geographic concentration index is proposed by Spieza (2003). We calculate a second index similar to Ellison and Glaeser (1997) as the square of equation (4). However, this measure is sensitive to the level of aggregation. At the regional level the index may under or overestimate the actual spatial occupation concentration due to the fact that differences in occupation and population shares are squared. It is for this reason that we use an adjusted version. The correlation between two indices is 0.81, significant at the one percent level.

Again the dotted lines present median values of the two variables. The interpretation of Figure 5 is similar to the interpretation of Figure 2. The difference is that we do not measure task-occupation wage differentials but spatial-occupation concentration as a measure of separating tasks. Indeed, the higher the level of soc_i , the more contestable an occupation is likely to be. So, again the south-east quadrant (defined by the medians of both variables) is the one we expect to be mostly affected by offshoring: these occupations are relatively low-connected and score high on concentration. By contrast, occupations located towards the north-west of Figure 5 seem to be less contested at this time because they are relatively more spread over the country and relatively well-connected geographically to other occupations. This makes it relatively difficult to offshore such occupations.

A simple measure of contestability can be constructed similar to the one we composed for individual workers. We now define the difference between soc_i and osc_i for each occupation *i* as the contestability of that occupation. We standardise this variable such that the mean equals zero and the standard deviation equals 1. The net effect of the two measures is an indicator of the probability that this occupation is offshored similar to the one we plotted in Figure 3 above. Figure 6 presents the change in employment by occupation against this measure of contestability. The size of the dots represents the size of the occupations. The relationship between this measure of contestability and employment changes is (similar to the relationship documented in Figure 3) negative suggesting that the more contestable occupations have been facing the least employment growth since 1996.

4.4. Offshoring

The final measure we need to construct is a measure of offshoring. The three types of measures developed above are able to explain the connectivity and separability of tasks and occupations but need to be related to a direct measure of offshorability.

Feenstra and Hanson (1996) measure offshoring based on a proxy of the share of non-energy imported intermediate goods in total non-energy intermediate inputs. The intuition for this way of approaching offshoring is the following: part of the goods that are now offshored have to be brought back to the sending country to be further assembled and/or made ready for final consumption. We calculate an offshoring indicator that shows the amount of imported inputs needed to produce one unit of output taking all embodied imports into account:

$$offshoring_i = \sum_{r=1}^{r=70} imp_r c_{ri} , \qquad i=1,...,70 \text{ and } r=1,...,70 \tag{6}$$

where imp_r shows non-energy intermediate input purchases of industry *r* as a share of all input purchases. The second component c_{jr} is an element of the Leontieff inverse matrix $(I-A)^{-1}$ that takes all direct and indirect processes to produce one unit of a product. *A* is a 70×70 matrix where the input-output coefficients a_{ir} show intermediate purchases of industry *i* directly used to produce one unit of industry *r* output. The result, *offshoring,* shows embodied imported inputs for each industry. We append this information to the individual level data such that each person has an offshoring indicator depending on the industry of employment. When this is aggregated across occupations we obtain an occupation specific offshoring indicator.

Figure 7 ranks each occupation according to the exposure to offshoring in 1996. The bars are the changes in employment and hours worked in the period 1996-2005. The pattern that emerges is one that suggests that employment and hours worked have diminished in occupations that are more heavily exposed to offshoring. The correlation between the offshoring measure and the two measures of contestability shown in Figures 3 and 6 is 0.267 and 0.105, respectively. This pattern reassures us that our measure of offshoring picks up the right phenomenon.

5. The importance of tasks

To check the empirical relevance of our indicators for the division of labour we first examine to what extent connectivity and wage differentials at the beginning of the period of analysis (i.e., 1996) are important for explaining changes in the importance of job tasks in the period 1996-2005 at the worker and industry level.

To investigate this we first run simple regressions with the difference in task importance as the dependent variable and task-occupation connectivity and task-occupation wage differentials as the main independent ones. We also add the task importance in 1996 as a covariate to address level effects. All regression equations include task and occupation dummies too. All indicators in these regressions have been standardised: a coefficient of one implies that a one standard deviation change in the independent variable changes the dependent variables by one standard deviation (variables that indicate differences are differences of the standardised scores; not the standardised differences). We have chosen this way of reporting because not all variables have a natural metric.

Table 1 shows the results of this exercise at the level of individual workers. Column (1) shows the effects over the entire sample period. The estimates reveal that tasks that are

more connected in 1996 become more important over time. In addition, larger task-occupation wage differentials in 1996 result in a fall in task importance within jobs over time. Borghans and Ter Weel (2006) describe that the simultaneous development of communication and information technologies can lead to more specialisation in certain occupations and tasks and to generalisation in others. The pattern in the data suggests generalisation, although at the margin tasks are unbundled pointing at specialisation. See also Bloom et al. (2009) and Ter Weel et al. (2010) for a discussion of models of specialisation and generalisation.

Column (2) shows the results of the same analysis with only the ten least important tasks within each occupation included; column (4) presents estimates of including the ten most important job tasks; and the estimates in column (3) use the thirteen tasks in the middle. The estimates reveal the same pattern suggesting that we are not picking up the effects of changes in particularly important or unimportant tasks. The effects seem to be present across all tasks. What is worth noticing from columns (2)-(4) in Table 1 is that the task-occupation wage differential is more important for explaining changes in the importance the least important tasks and not of significant importance for explaining changes in the most important job tasks. This suggests that relatively important tasks are core to the job, whereas relatively unimportant tasks are not core to the job. This difference in importance is revealed in differences in their prices.

Finally, we repeat the analysis for two sub-periods, 1996-2001 and 2001-2005. Columns (5) and (6) in Table 1 show the estimates. For the first sub-period the results lead to similar conclusions; for the period 2001-2005 we observe that the task-occupation wage differential does not significantly matter for explaining changes in the importance of job tasks. The estimates suggest that in the second half of the analysed time interval only task-occupation connectivity is important for explaining changes in the importance of job tasks. The task-occupation wage differential seems to have its main effect in the first half of the sample period.[9]

Overall this first set of results points towards a pattern of specialisation of work in the Dutch labour market over the course of the sample period. High-connected tasks seem to gain importance and the coefficients for task-occupation wage differentials suggest that tasks with relatively large task-wage gaps lose importance and could be separated from the occupation.

[9] There is a possibility that due to changes in task composition, the measure for task-occupation wage differentials and task-occupation connectivity are affected. To account for this possibility we present estimates in column (6) of Table 1 with regressors of task-occupation connectivity in 1996 and task-occupation wage differentials in that year. The dependent variable is the change in task importance 1996-2005. We obtain similar point estimates to the ones reported in the other columns of Table 1.

This effect is particularly present in the first half of the sample period and for the least important tasks. Hence, workers seem to give up tasks that do not belong to the core of their job, whereas core tasks (i.e., those with high levels of task-occupation connectivity and low task-occupation wage differentials) gain importance.

A similar analysis is relevant to examine the task indicator at the industry level. In Table 2 we present the results of a regression analysis to investigate whether our measure of task-industry connectivity correlates with changes in the importance of tasks at this level of analysis. We present estimates for the entire period and two sub-periods and control for the initial level of task importance. All regressions include industry and task dummies too.

The estimates presented in column (1) of Table 2 suggest that there is a positive correlation between task-industry connectivity and the change in the importance of tasks, which is consistent with the findings for the occupation-task analysis. In columns (2) and (4) we present estimates for the ten least and the ten most important tasks; column (3) presents the estimates from the thirteen tasks in the middle. These estimates are also in line with the ones presented in Table 1. Finally, we split the sample into two sub-periods. The estimate of task-industry connectivity for the first period (1996-2001) presented in column (5) is positive but insignificant, the estimate for the second period (2001-2005) is positive and significant (column (6)). These latter two estimates suggest that the effect of connectivity on the change in the importance of tasks at the industry level is especially present in the most recent period.[10]

Overall, the estimates in Tables 1 and 2 yield a picture consistent with the framework developed in Section 2: higher levels of connectivity are positively correlated with the importance of the task to do the job at both levels of analysis and higher levels of task-wage differentials are negatively correlated with core tasks suggesting that there is scope for separating these tasks from the occupation.

6. Results

Based on the set of indicators for the division of labour we are now able to investigate to what extent changes in the composition of employment can be explained by the process of unbundling of tasks. We proceed in Section 6.1 with presenting simple regression results to examine employment changes. The next section shows what fraction of the changes in employment we are able to capture with our approach. Finally, we analyse the impact of

[10] The issue of causality might be a problem here too (see footnote 9).

offshoring on employment in the Netherlands in the period 1996-2005.

6.1. Changes in employment

Table 3 presents the results of a simple regression analysis in which we explain changes in employment over the period 1996-2005 by task-occupation connectivity, task-occupation wage differentials and a number of covariates. The first column presents OLS estimates. The estimates suggest that the more connected tasks are the higher (and more positive) the employment change has been. For the task-occupation wage differential we find no effects. In column (2) we present the results when adding the average level of education in an occupation at the start of the regression period and the log of the level of employment in each occupation. The results remain similar, although the effect of task-occupation connectivity doubles in terms of magnitude. Now a one standard deviation change in task-occupation connectivity increases employment by 0.153 of a standard deviation. The next two columns present the results of a weighted least squares approach. This set of estimates points at two developments. First, tasks that are well-connected have experienced positive employment changes. This is consistent with the notion that the least connected tasks are more likely to be separated from a worker's job. Second, tasks with larger wage-differentials have experienced no significant employment changes in the OLS regressions and correlate positively with employment changes in the WLS setting. This suggests that although these tasks have a higher probability to be separated from occupations, this does not necessarily imply that they lose in terms of employment. The pattern of contestability at the task level in Figure 3 is consistent with this observation.

The next step is to investigate the effects of connectivity of tasks at the industry-task level on employment changes within occupations. Since we assume that there are no inter-industry wage differentials, the variable of interest is task-industry connectivity. We run a number of regressions to see whether there is a correlation between employment changes and task-industry connectivity. We do so by regressing task connectivity and a number of control variables on employment changes in the period 1996-2005. Table 4 presents the estimation results. Similar to the results present in Table 3, task-industry connectivity contributes to positive changes in employment in the period 1996-2005. This is both true for the OLS and WLS regressions and for a number of different specifications.

Finally, a similar regression analysis at the spatial level confirms the pattern of findings in Tables 3 and 4. Spatial occupation concentration is negatively correlated with employment changes, while occupation-space connectivity relates positively to employment

change. Table 5 shows these regression results in two specifications. The first column presents the results of a simple regression analysis in which we explain changes in employment between 1996 and 2005 with spatial occupation concentration and occupation-space connectivity and a number of usual suspects. The second column documents the estimates when we weight by occupation size. The results of these two exercises are similar. The fact that we do not find significant coefficients for occupation-space connectivity might be caused by the fact that we have been able to include only 17 different regions in the Netherlands in the analysis. The final two columns repeat the analysis without our measures of concentration and connectivity. The explanatory power of these analyses is much lower, while the coefficients on the covariates education and log wages in 1996 remain similar. The effect of log employment in 1996 cannot be distinguished from zero here, while it has a small and negative effect when including concentration and connectivity.

Together the estimates in Tables 3-5 suggest that our measures correlate with employment changes consistent with the framework of the division of labour developed above.

6.2. Explanatory power

We explore the economic meaning of these results by expressing the contribution of task-occupation connectivity and task-occupation wage differentials to the changes in employment over the last decade. The results of this exercise are documented in Figure 8. This figure presents a scatter plot of the actual change in employment and the predicted change for each occupation in the database. A similar picture for the industry-level analysis is presented in Figure 9 and for the spatial level in Figure 10. We have added a 45-degree line along with a regression line to give an impression of the average predictions of our approach. Ideally all points would be on the 45-degree line.

The regression line in Figure 8 reveals that we overestimate the employment changes when they are employment losses and do a good job when we predict employment growth. This seems consistent with Figure 3 in which we plot contestability. There some jobs are extremely contestable according to our measures, but have experienced employment growth over the last decade. These are by and large the same occupations for which we predict employment deterioration in Figure 8. The predicted changes in Figure 9 are relatively good. We only understate some effects towards the high-growth occupations. The same argument goes for our predictions at the spatial level in Figure 10.

What is interesting to note is that we are most off when jobs consist of relatively many

routine tasks, such as elementary occupations and low-skilled service occupations. According to our measures these jobs could be outsourced because they do not connect very well at the worker and industry level. However, at the spatial level we are fairly good at predicting employment changes in these occupations. In addition, our measures do not predict changes in public sector jobs very well. For example, the employment growth of teachers and public sector caring and medical jobs is not very well predicted by our measures.

In the Data Appendix we provide a list of all occupations and our predictions at the different levels of aggregation.

6.3. Offshoring

The final step of the empirical analysis is to estimate the relationship between offshoring and spatial occupation concentration and occupation-space connectivity. Figures 11 and 12 present scatter plots of the relationship between our measures of offshoring and job concentration and job connectivity. For spatial occupation concentration Figure 11 suggests that job concentration is positively correlated to changes in offshoring. So, it seems to be the case that more concentrated jobs have been more contestable since 1996. Figure 12 plots the correlation between changes in offshoring and job connectivity. Although eyeball econometrics would suggest a negative correlation between these two variables, the pattern is not very clear. We expect more connected jobs to be less contestable. When we exclude two observation (high-level economic jobs (91) and high-level legal jobs (93) the relationship is indeed negative, and significantly so. Both figures are consistent with the evidence on the contestability measure in Figure 6.

The patterns present in these pictures are confirmed by a regression analysis in which we try to explain offshoring by job concentration and job connectivity and a number of covariates. Table 6 lists the results of this regression analysis. The dependent variable is the change in offshoring. The independent variables are job concentration, job connectivity and the level of offshoring in 1996. When we carry out the analysis at the individual worker level and at the industry level, we obtain insignificant estimates. This suggests that offshoring is best explained at the spatial level of the division of labour.

7. Conclusions

The main goal of this paper has been to develop measures of division of labour and to document and understand trends in the unbundling of tasks in the Netherlands in the period 1996-2005. We have shown that looking at current trends in the structure of employment can

be understood from a framework of unbundling of tasks. It is important to distinguish three levels of aggregation at which developments take place: the individual level, the industry level and the spatial level. An important conclusion is that globalisation not just affects all the work, but only specific tasks and occupations that are most contestable, whereas others remain unaffected.

The analyses in this paper show that in the period 1996-2005 there has been a tendency of unbundling tasks in the Netherlands. When thinking about the threat of offshoring for employment in the Netherlands, it has to be kept in mind that not every occupation and not every task in every occupation is subject to the process of unbundling and this wave of globalisation. Our indicators show determinants of task unbundling and potential offshoring. They are able to document which tasks and which occupations might be contestable and which are not. At the same time, and based on the same logic, this type of globalisation also offers opportunities for the Netherlands to inshore tasks. That is why we also find some tasks and occupations to be growing over time, which is a sign of comparative strength of the Netherlands.

When looking at the kinds of tasks that are relatively easily unbundled from the task bundle of an individual worker, our analyses reveal that especially physical tasks are not very connected to other tasks. In general these tasks can be carried out by other workers whose earnings are substantially lower. Some less obvious tasks seem to be contestable as well. For example, selling, doing statistical analysis and performing calculations are tasks observed to be relatively less connected to others tasks. For a task such as giving speeches there is a relatively large comparative advantage that can be obtained from specialisation in this task. Possibilities for unbundling at the individual level are the main restriction for unbundling at the industry level. Especially for the statistical and calculation tasks, connectivity at the industry level is higher than at the individual level. This limits the possibilities to outsource this work to other firms, although it can easily be taken out of the bundle of tasks of the individual worker. At the spatial level, research in math and science is the most obvious example of work that could be easily moved to other places: There is not strong link to the location of the customers and this work is not strongly connected to other economic activities. Also agriculture, transport and remarkably some safety occupation fall into this category.

The analyses show that unbundling accounts for substantial changes in the employment of occupations and accounts for – especially at the spatial level – a substantial share of the increase in offshoring of activities abroad. While some occupations lost employment and offshoring increased, other occupations gained employment. This indicates

that international developments are important for determining Dutch task bundles, and not just that the Netherlands has lost employment. There is a restructuring of employment rather than a loss of employment.

For individual tasks the low-educated workers are faced with this loss of employment, while high-educated workers seem to gain. Since unbundling at the individual level and unbundling at the industry level are highly correlated, this also holds for the industry developments. At the spatial level the story is different though. Since the link between production and the customer has a stronger influence on employment changes and offshoring than job connectivity, here the low-educated gain from their position. Offshoring tasks such as cleaning and other types of low-skilled service tasks seem to be impossible.

Overall there is no strong sign of polarisation of the Dutch labour market as observed in the United States in the 1990s. If anything, polarisation has taken place across regions. To strengthen the Dutch labour market, thinking in terms of the connectivity of activities at the spatial level can be a very effective approach. In the Netherlands the Randstad region and the region of Eindhoven have grown in the past decades. They have become the most important centres of productivity and employment, most likely because of tendencies for certain tasks and occupations to cluster together. An interesting challenge is to see whether also in other regions of the country clusters of tasks are likely to emerge. Such clusters are able to reduce the contestability of economic activities and resist the strong forces of globalisation.

In further research the indicators introduced in this paper could be further developed, fitting them more accurate in a theoretical model of the division of labour. In this paper we had to rely on British tasks data. The collection of data for the Dutch labour market about employment in terms of tasks is very important to gain more insight in current and future labour-market developments in the Netherlands.

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Figures and tables

Figure 1 - Framework

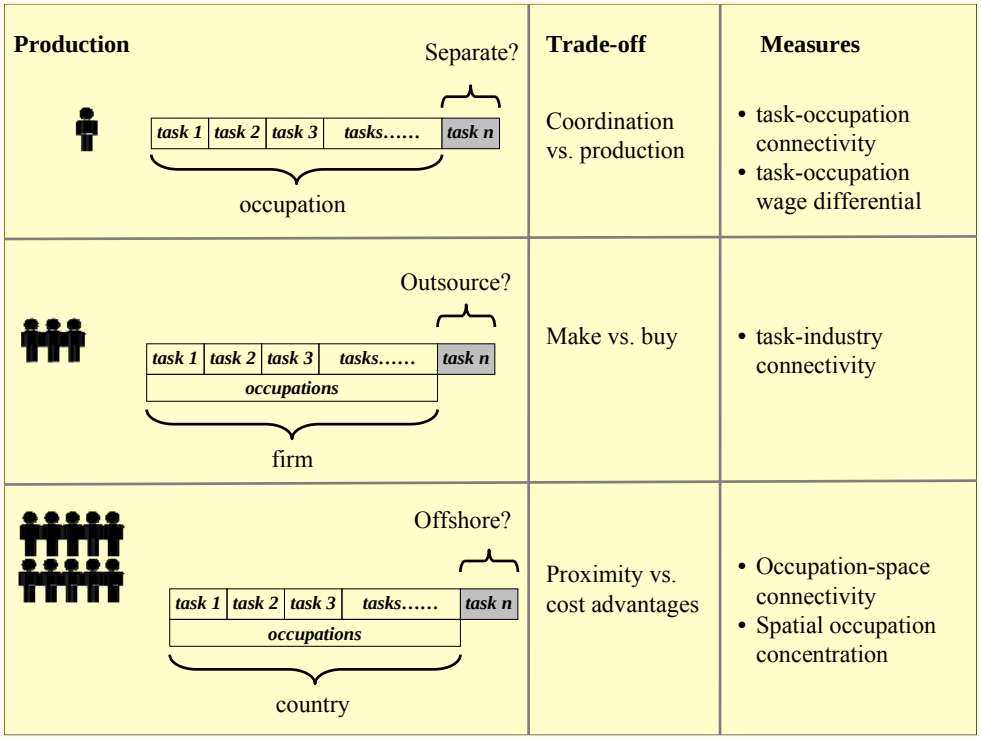
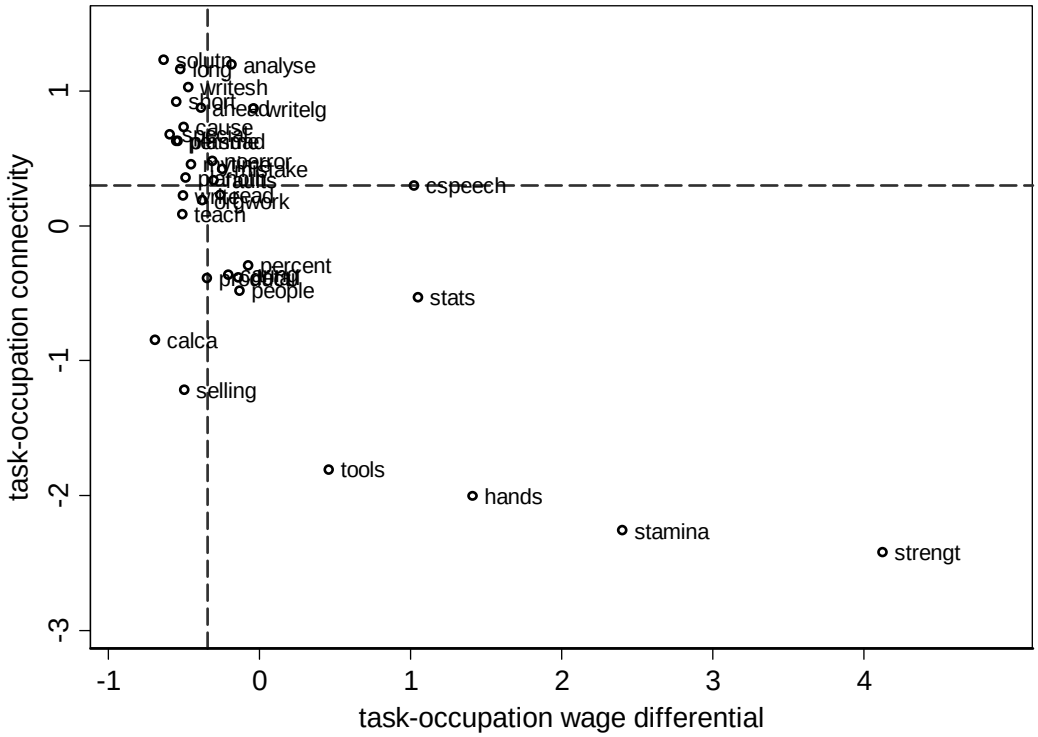
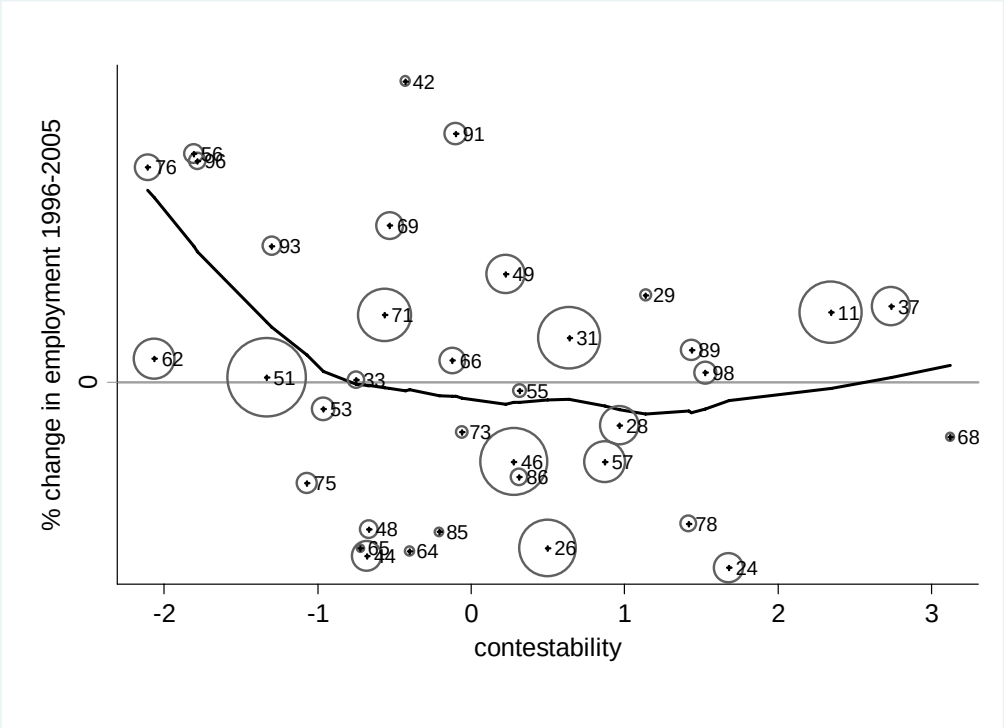


Figure 2 - Task-occupation connectivity and task-occupation wage differentials



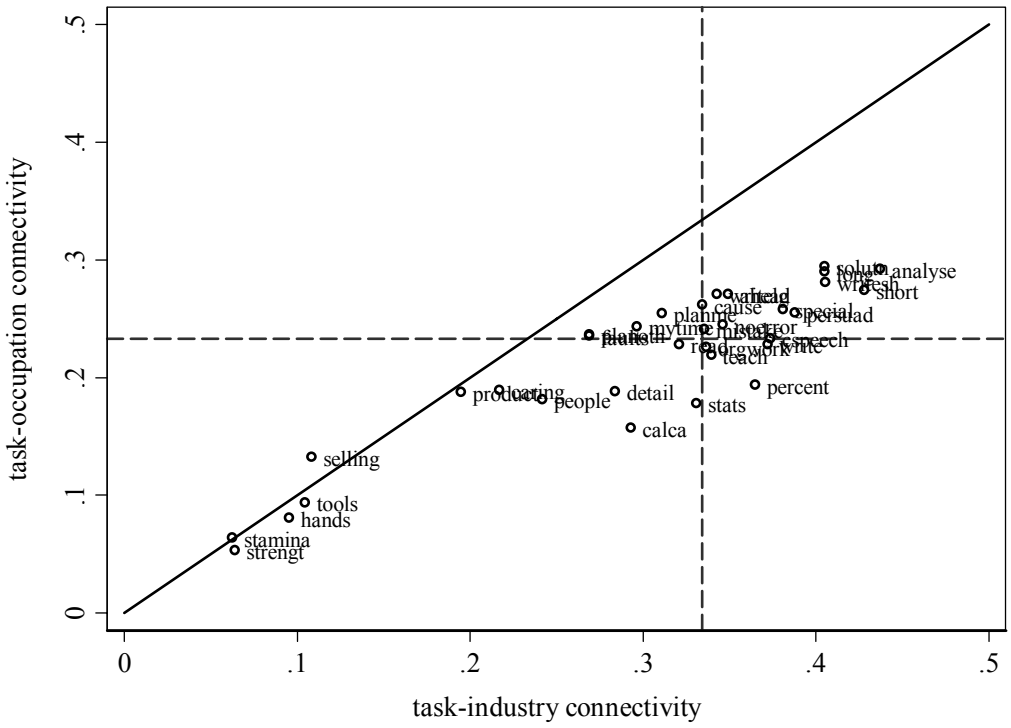
Note: The dotted lines reflect median values. A detailed list of tasks in provided in the Data Appendix. The task-occupation wage differential is defined in equation (1) and task-occupation connectivity is defined in equation (2). The measures are standardised such that mean is 0 and variance is 1.

Figure 3 - Contestability of tasks and changes employment, 1996-2005



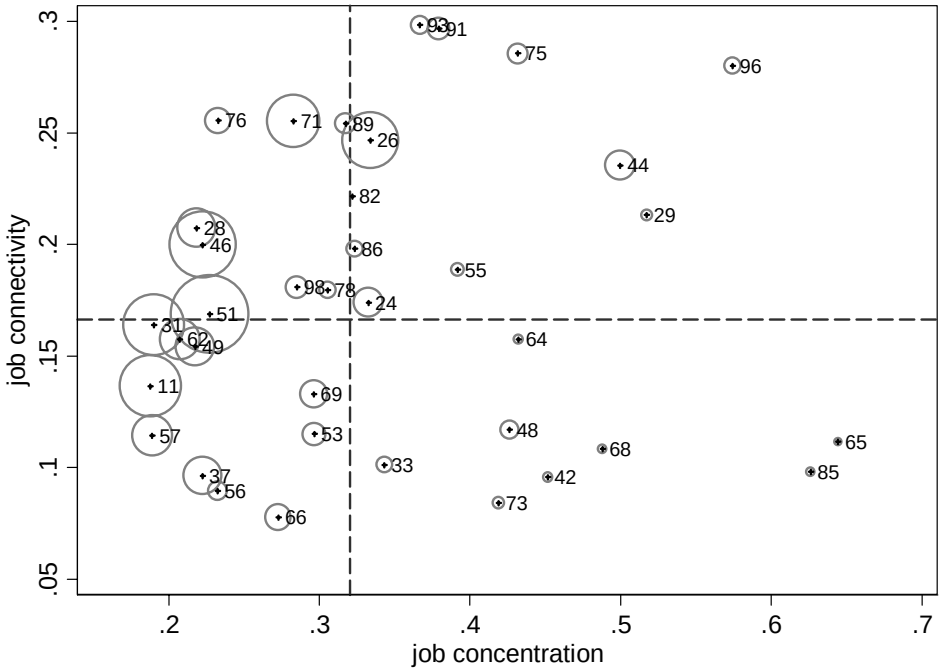
Note: The dots refer to occupations and the size of the dots reflects the size of an occupation. The data appendix provides a list of all occupations. Contestability is defined as the difference between the task-occupation wage differential as defined in equation (1) and task-occupation connectivity as defined in equation (2). The measure of contestability is normalised, see the main text for details.

Figure 4 - Correlation between task-occupation connectivity and task-industry connectivity



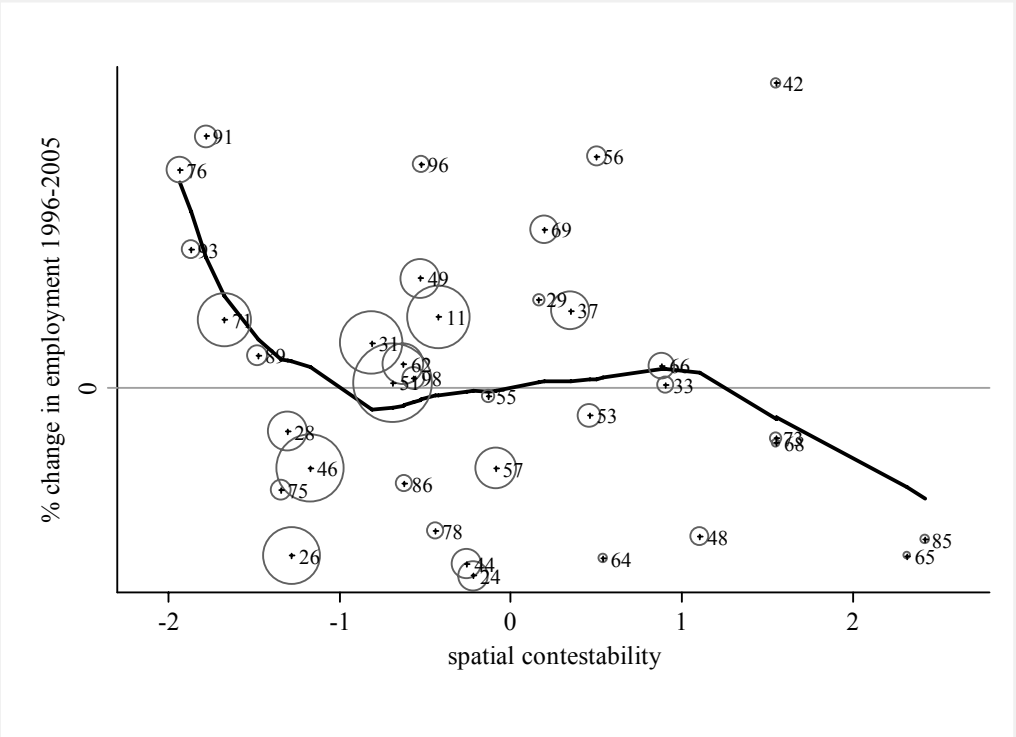
Note: The dotted lines reflect median values. A detailed list of tasks in provided in the Data Appendix. The task-industry connectivity is defined in equation (3) and task-occupation connectivity is defined in equation (2).

Figure 5 - Spatial occupation concentration and occupation-space connectivity



Note: The dotted lines reflect median values. A detailed list of occupations in provided in the Data Appendix. The spatial occupation concentration is defined in equation (4) and occupation-space connectivity is defined in equation (5).

Figure 6 - Spatial contestability and changes in employment, 1996-2005



Note: The dots refer to occupations and the size of the dots reflects the size of an occupation. The data appendix provides a list of all occupations. Contestability is defined as the difference between the spatial occupation concentration as defined in equation (4) and occupation-space connectivity as defined in equation (5). The measure of contestability is normalised, see the main text for details.

Figure 7 - Employment change 1996-2005 ranked according to embodied imports in 1996

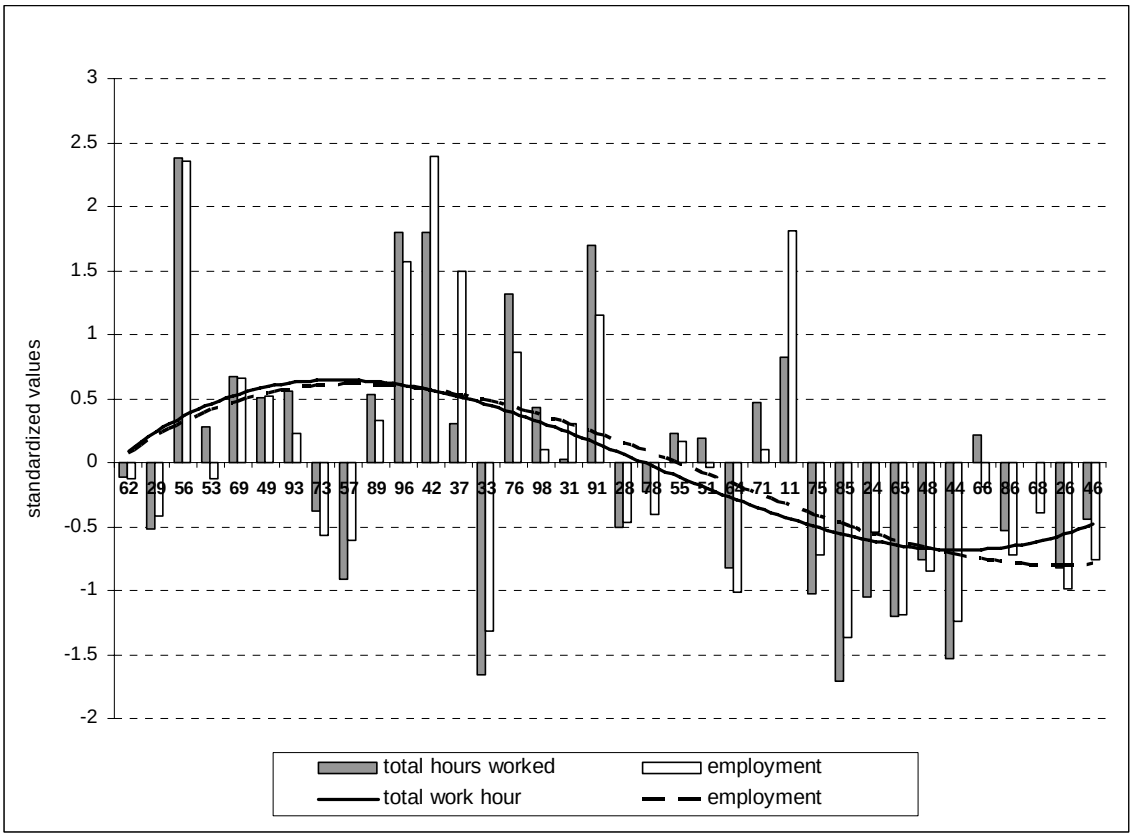


Figure 8 - Employment change 1996-2005 and predicted change at the task level

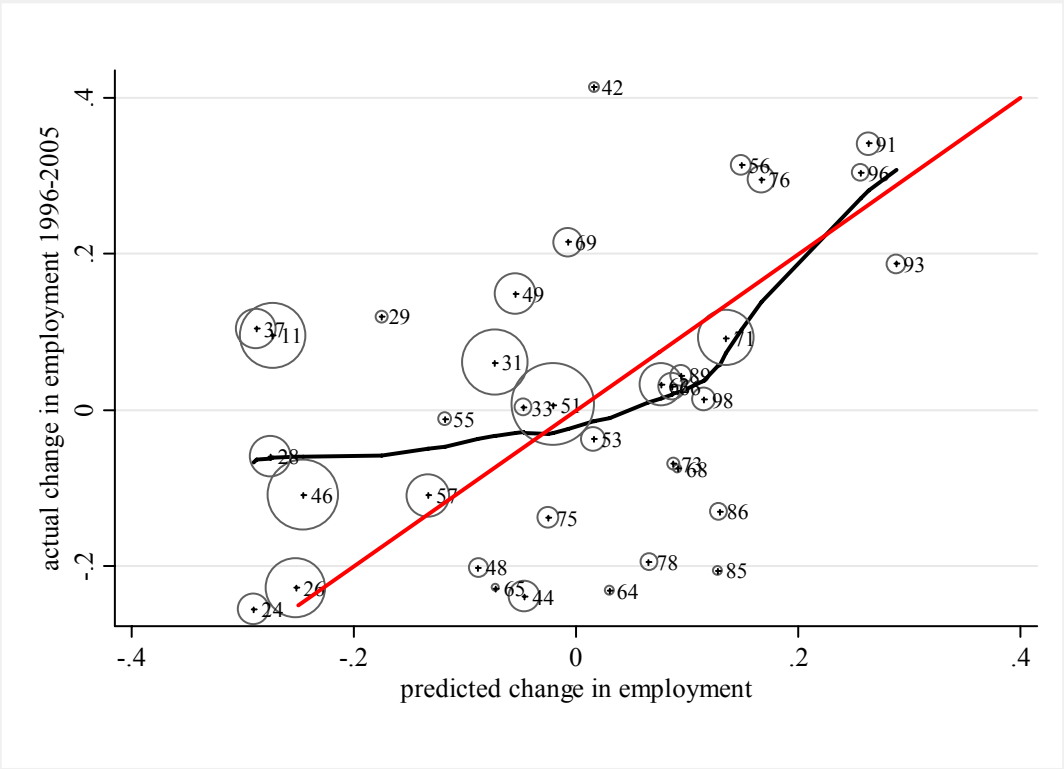


Figure 9 - Employment change 1996-2005 and predicted change at the industry level

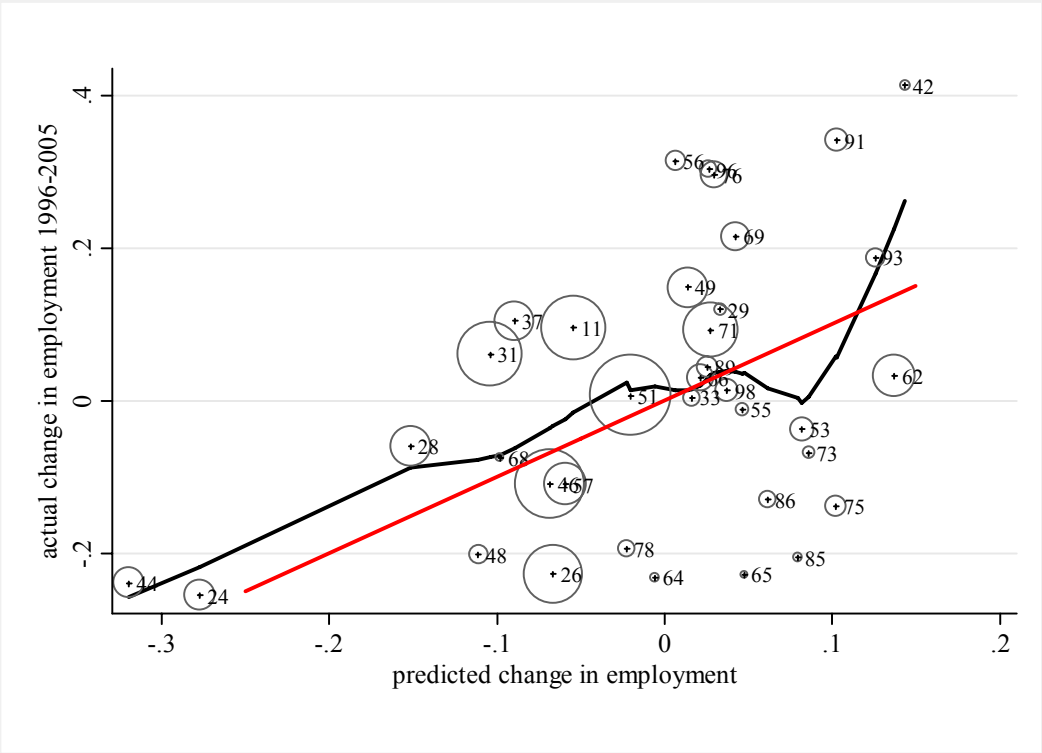


Figure 10 - Employment change 1996-2005 and predicted change at the spatial level

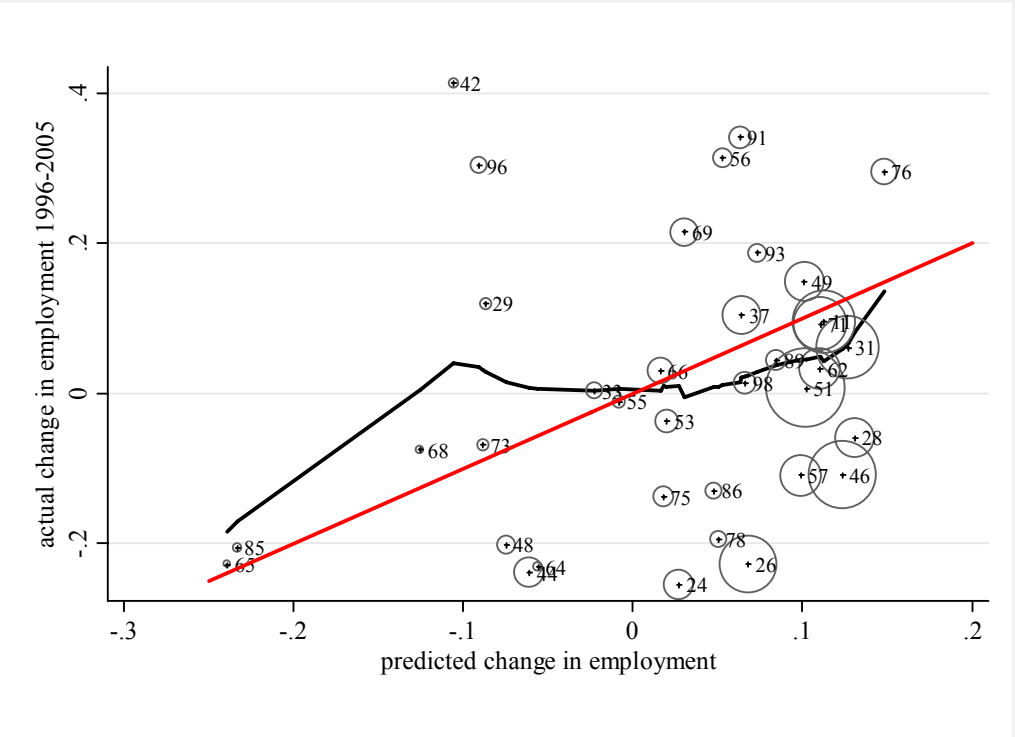


Figure 11 - Changes in offshoring and spatial occupation concentration, 1996-2005

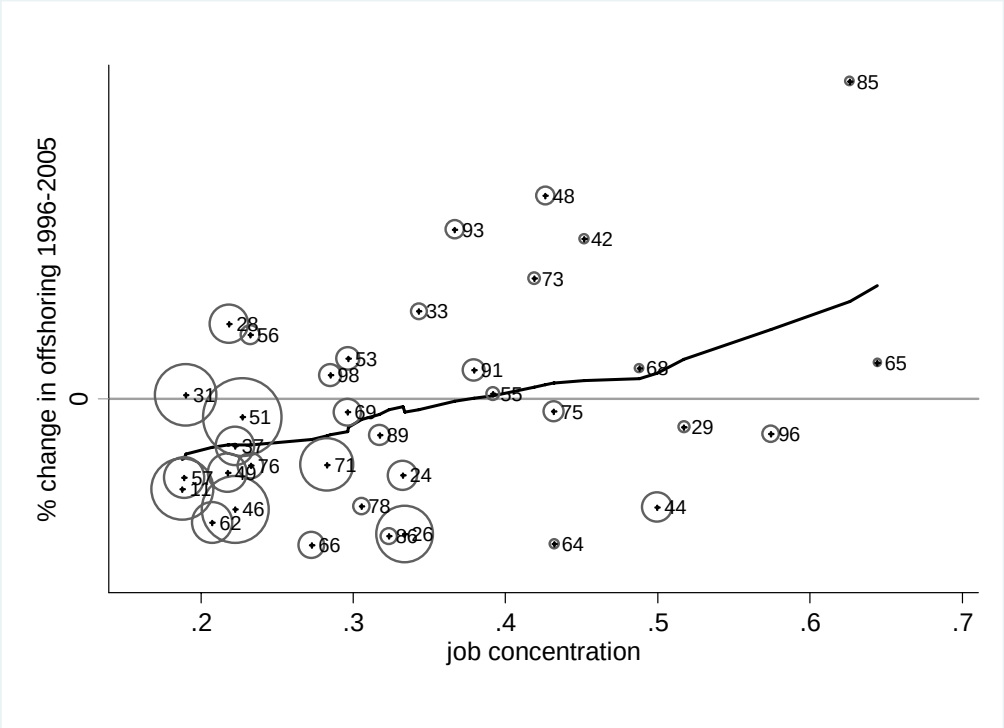


Figure 12 - Changes in offshoring and occupation-space connectivity, 1996-2005

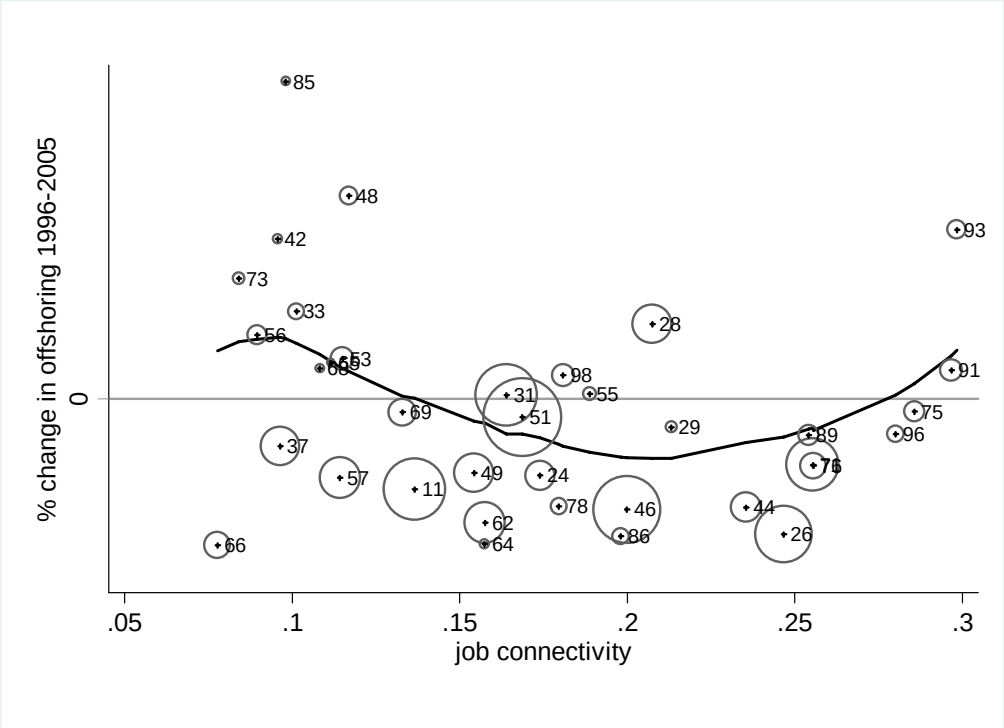


Figure 13 - Actual and predicted change in employment at the task level ranked according to education in 1996

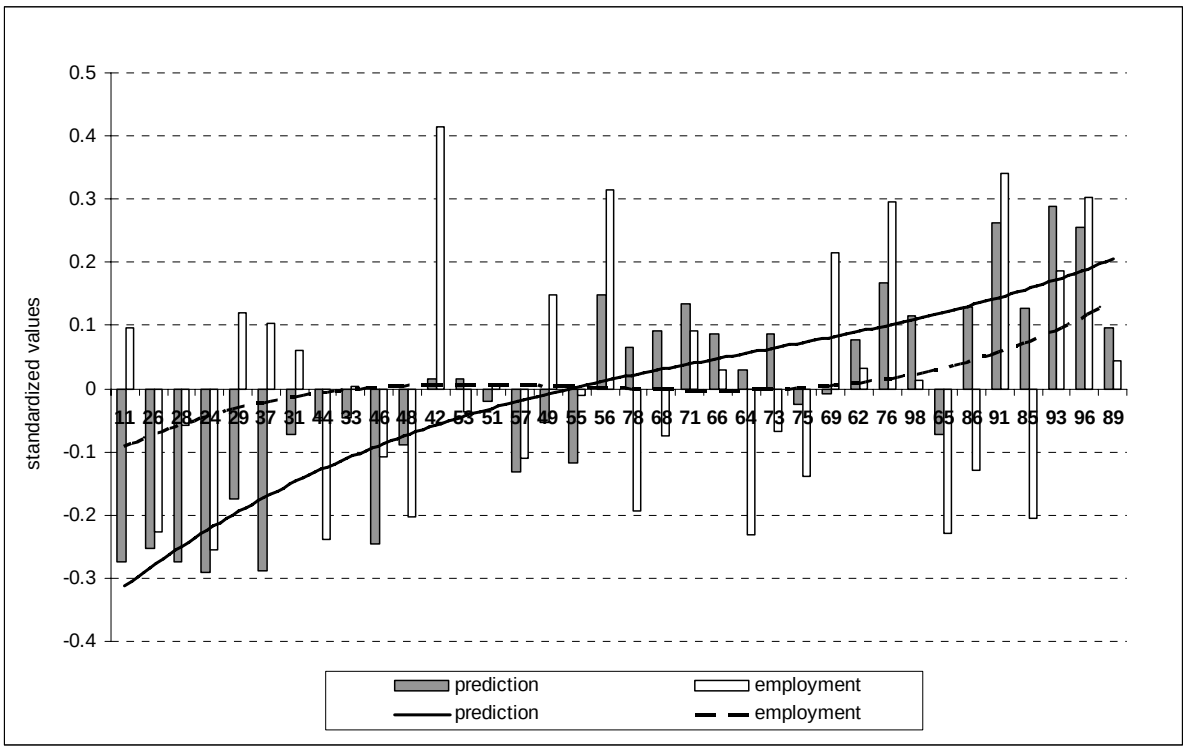


Figure 14 - Actual and predicted change in employment at the industry level ranked according to education in 1996

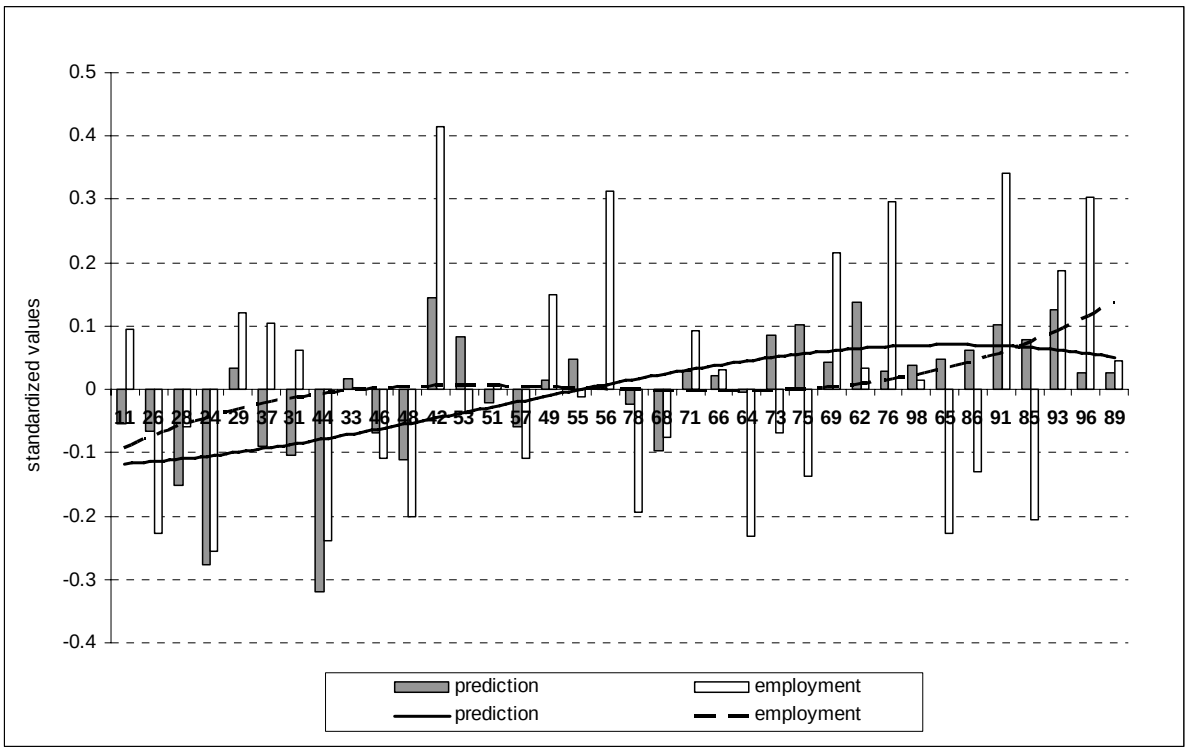


Figure 15 - Actual and predicted change in employment at the spatial level ranked according to education in 1996

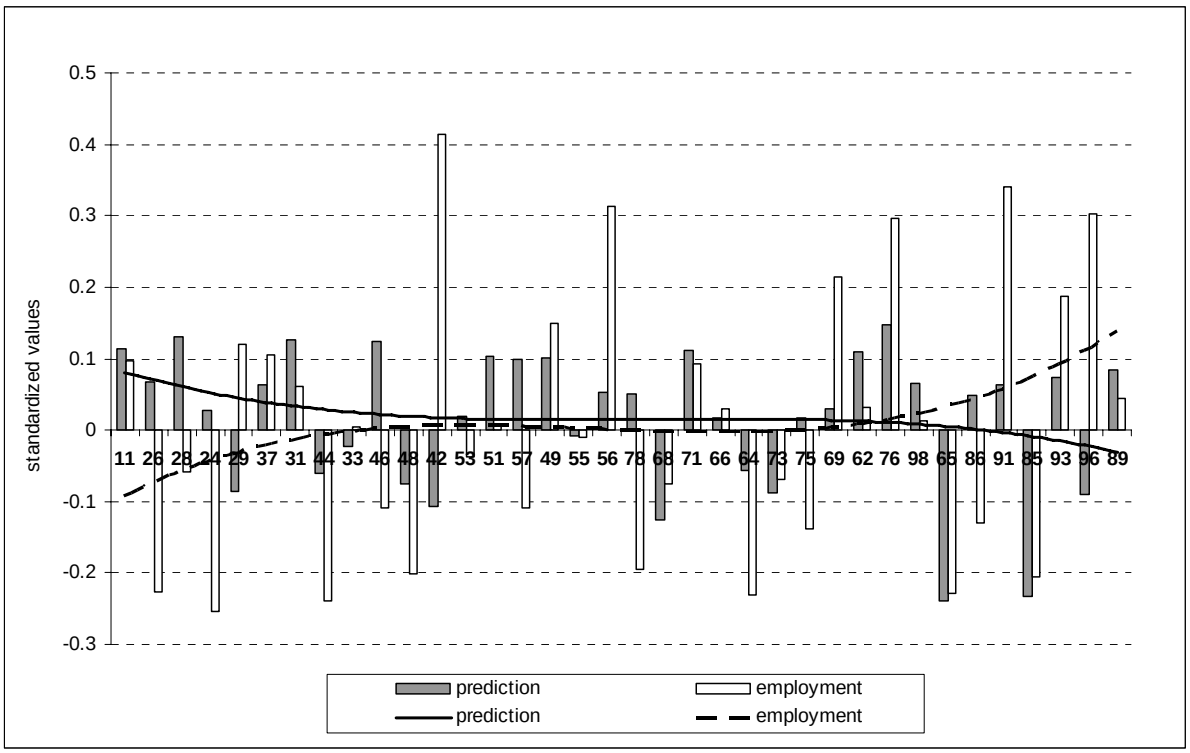


Table 1 - Explaining changes in the importance of job tasks from task-occupation connectivity and task-occupation wage differentials

Dependent variable	(1) Change in task importance 1996-2005, all tasks	(2) Change in task importance 1996-2005, ten least important tasks	(3) Change in task importance 1996-2005, middling important tasks	(4) Change in task importance 1996-2005, ten most important tasks	(5) Change in task importance 1996-2001, all tasks	(6) Change in task importance 2001-2005, all tasks
task-occupation connectivity 1996	3.048***	2.821**	2.407***	1.106*	2.685***	
	(0.485)	(0.843)	(0.537)	(0.640)	(0.434)	
task-occupation wage differential 1996	-0.661**	-0.754**	-0.211	-0.087	-0.776**	
	(0.290)	(0.221)	(0.276)	(0.470)	(0.353)	
task importance 1996	-1.169***	-1.369***	-1.872***	-1.529***	-1.189***	
	(0.149)	(0.154)	(0.129)	(0.117)	(0.120)	
task-occupation connectivity 2001						2.821***
						(0.462)
task-occupation wage differential 2001						-0.222
						(0.356)
task importance 2001						-0.701***
						(0.125)
constant	5.622***	0.360	-0.299	3.977**	3.459**	6.233***
	(1.106)	(1.446)	(0.900)	(1.737)	(1.290)	(1.043)
Observations	1,188	360	468	360	1,188	1,188
R-squared	0.563	0.589	0.757	0.780	0.587	0.401

Note: Robust standard errors clustered at the occupation level in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the difference in task importance between year X and year Y. All variables are standardised such that the mean is 0 and the variance is 1. All estimations include task and occupation dummies. Columns (2), (3) and (4) replicate the analysis in column (1) for the ten least, the thirteen tasks in the middle, and the ten most important tasks within each occupation, respectively. Columns (5) and (6) present the results of the analysis for two different sub-periods. The variable task-occupation connectivity is an index showing the degree of connectedness among different tasks (see equation (2) and the corresponding explanation). The difference between task and occupation wages are calculated as the absolute value of the wage differential between the occupation and task wage in 1999 (see equation (1) with task wages being calculated with [0 1 2 3 4] as weights.

Table 2 - Explaining changes in the importance of job tasks from task-industry connectivity

Dependent variable	(1) Change in task importance 1996-2005, all tasks	(2) Change in task importance 1996-2005, ten least important tasks	(3) Change in task importance 1996-2005, middling important tasks	(4) Change in task importance 1996-2005, ten most important tasks	(5) Change in task importance 1996-2001, all tasks	(6) Change in task importance 2001-2005, all tasks
task-industry connectivity 1996	2.264***	1.798***	1.286***	1.782***	1.384	
	(0.349)	(0.674)	(0.450)	(0.510)	(0.953)	
task importance 1996	-1.050***	-1.134***	-1.626***	-1.529***	-0.910***	
	(0.095)	(0.118)	(0.066)	(0.101)	(0.095)	
task-industry connectivity 2001						1.694***
						(0.615)
task importance 2001						-1.000***
						(0.117)
constant	-2.369***	1.281***	-2.189***	3.498***	-1.312	2.292*
	(0.394)	(0.206)	(0.267)	(1.165)	(1.134)	(1.368)
Observations	2,274	690	897	687	2,274	2,277
R-squared	0.526	0.570	0.716	0.803	0.441	0.462

Note: Robust standard errors clustered at the industry level in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the difference in task importance between year X and year Y. All variables are standardised such that the mean is 0 and the variance is 1. All estimations include task and industry dummies. Columns (2), (3) and (4) replicate the analysis in column (1) for the ten least, the thirteen tasks in the middle, and the ten most important tasks within each occupation, respectively. Columns (5) and (6) present the results of the analysis for two different sub-periods. Task-industry connectivity is an index that shows the degree of connectedness among different tasks (see equation (3) and the corresponding explanation).

Table 3 - Explaining changes in occupation employment by task-occupation connectivity and task-occupation wage differentials

Dependent variable: Change in employment, 1996-2005	(1) OLS	(2) OLS	(3) WLS	(4) WLS
task-occupation connectivity	0.075**	0.153***	0.058**	0.075**
	(0.030)	(0.048)	(0.023)	(0.032)
task-occupation wage differential	0.003	0.032	0.067**	0.083***
	(0.024)	(0.026)	(0.026)	(0.028)
education 1996		-0.084		-0.011
		(0.059)		(0.044)
log employment 1996		0.029		0.031
		(0.027)		(0.022)
Constant	0.012	-0.173	0.053**	-0.183
	(0.029)	(0.189)	(0.021)	(0.176)
Observations	36	36	36	36
R-squared	0.168	0.273	0.329	0.370

Note: Robust standard errors in parentheses. The standard errors in the weighted least squares estimations in columns (3) and (4) are clustered at the occupation level. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the percentage change in occupational employment between 1996 and 2005. Task-occupation connectivity and task-occupation wage differentials are averages of all available years in our database by occupation and weighted by the importance of each task in an occupation.

Table 4 - Explaining changes in occupation employment by task-industry connectivity

Dependent variable: Change in employment, 1996-2005	(1) OLS	(2) OLS	(3) WLS	(4) WLS
task-industry connectivity	0.084***	0.102***	0.081***	0.074**
	(0.022)	(0.032)	(0.021)	(0.033)
education 1996		-0.006		0.011
		(0.043)		(0.053)
log employment 1996		0.034		0.003
		(0.024)		(0.019)
constant	0.012	-0.212	0.031	0.014
	(0.028)	(0.163)	(0.026)	(0.152)
Observations	36	36	36	36
R-squared	0.208	0.259	0.246	0.248

Note: Robust standard errors in parentheses. The standard errors in the weighted least squares estimations in columns (3) and (4) are clustered at the occupation level. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the percentage change in employment from 1996 to 2005. Task-industry connectivity is calculated by aggregating the task-industry connectivity across occupations and weighing the numbers by the industry employment share within each occupation (equation (3) in the main text).

Table 5 - Explaining changes in occupation employment by spatial occupation concentration and occupation-space connectivity

Dependent variable: Changes in employment, 1996-2005	(1) OLS	(2) WLS	(3) OLS	(4) WLS
spatial occupation concentration	-0.142**	-0.135**		
	(0.069)	(0.058)		
occupation-space connectivity	0.039	0.029		
	(0.034)	(0.029)		
education 1996	0.102***	0.133***	0.118***	0.154***
	(0.037)	(0.031)	(0.034)	(0.034)
log employment 1996	-0.049	-0.017	0.020	0.025
	(0.043)	(0.027)	(0.025)	(0.019)
log wage 1996	-0.326***	-0.285***	-0.326***	-0.333***
	(0.113)	(0.091)	(0.102)	(0.093)
constant	3.078***	2.276***	2.373**	2.390***
	(0.966)	(0.720)	(0.880)	(0.717)
Observations	36	36	36	36
R-squared	0.364	0.472	0.270	0.411

Note: Robust standard errors in parentheses. Weighted Least Squares (WLS) standard errors are clustered at the occupation level. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the percentage change in employment from 1996 to 2005. All variables are standardised such that mean is 0 and variance is 1. Spatial occupation concentration is the geographic concentration index that measures the degree of job concentration in a region adjusted by population shares (equation (4)). Occupation-space connectivity measures how jobs are connected at the regional level (equation (5)). See the text in section (4) for further explanation.

Table 6 - Explaining changes in offshoring by spatial job connectivity and spatial job concentration

Dependent variable: Changes in offshoring, 1996-2005	(1) OLS	(2) OLS	(3) OLS	(4) WLS
spatial occupation concentration	0.059**		0.060**	0.029
	(0.025)		(0.023)	(0.023)
occupation-space connectivity		-0.020	-0.021	-0.005
		(0.015)	(0.013)	(0.012)
offshoring 1996	-0.023*	-0.014	-0.023*	-0.022**
	(0.012)	(0.085)	(0.011)	(0.010)
constant	0.024*	0.017	0.024*	0.007
	(0.014)	(0.013)	(0.013)	(0.015)
Observations	36	36	36	36
R-squared	0.248	0.090	0.317	0.218

Note: Robust standard errors in parentheses. Weighted Least Squares (WLS) standard errors are clustered at the occupation level. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the percentage change in offshoring (embodied imports) from 1996 to 2005. All variables are standardised such that mean is 0 and variance is 1. Spatial occupation concentration is the geographic concentration index that measures the degree of job concentration in a region adjusted by population shares (equation (4)). Occupation-space connectivity measures how jobs are connected at the regional level (equation (5)). See the text in section (4) for further explanation.

Data Appendix

A.1. Variable definitions

Variable	Definition
worker	
task 1996-2005	Difference in task importance between BSS 1997 and BSS 2006 (Occupation-task specific). Source: BSS and EBB.
task 1996-2001	Difference in task importance between BSS 1997 and BSS 2001 (Occupation-task specific). Source: BSS and EBB.
task 2001-2005	Difference in task importance between BSS 2001 and BSS 2006 (Occupation-task specific). Source: BSS and EBB.
task importance 1996 (2001)	Occupation-task specific task importance within an occupation class for 1996 (2001). Source: British Skills Survey (BSS) 1997 (2001).
task-occupation connectivity 1996 (2001)	Occupation task specific index that measures the connectedness of a task to other tasks in 1996 (2001). See equation (2). Source BSS and EBB.
task-occupation wage differential 1996 (2001)	Absolute value of the difference between occupation and task wages in 1996 (2001). The earliest wage information that is available for Dutch occupation classes is for 1999. Therefore 1999 wages are used. Task wages are calculated by multiplying the wage by task importance (weight is [0 1 2 3 4] from least important to most important) at the individual level and then calculating averages by Dutch occupation classes. See equation (1) and the corresponding explanation. Source: EBB, SSB and BSS.
contestability	contestability measuring offshorability calculated as task-occupation wage differential minus task-occupation connectivity. Source: BSS.
task-occupation connectivity	Occupation specific measure obtained by weighting task-occupation connectivity by task importance and aggregating over occupations. Average of three years 1996, 2001 and 2005. Source: BSS
task-occupation wage differential	Occupation specific measure obtained by weighting the task-occupation specific wage differential by task importance and aggregating over occupations. Average of three available years 1996, 2001 and 2005. Source BSS
industry	
task-industry connectivity 1996 (2001)	Industry-task specific index that measures the connectedness of a task to other tasks in 1996 (2001). See equation (3). Source BSS 1997, 2001, 2006 and EBB.
task-industry connectivity	Occupation specific measure obtained by aggregating the task-industry specific connectivity over industries and merging to occupation-industry data. We aggregate task-industry connectivity over occupations by weighting it by the share of industry employment within each occupation. The result is an occupation specific measure. Average of three years 1996, 2001 and 2005. Source: BSS, EBB
spatial	
spatial occupation concentration (soc)	Occupation specific index measuring spatial job concentration adjusted by population share of the region. We used RBA definition that divides the Netherlands in 17 regions. See equation (4) and the corresponding explanation. Source: EBB 1996.
occupation-space connectivity (osc)	Index that measures job connectivity at the regional level. We used RBA definition that divides the Netherlands in 17 regions. See equation (5) and the corresponding explanation. Source: EBB 1996.
offshoring 1996	Level of offshoring in 1996 that shows the amount of imported inputs needed to produce one unit of output taking all embodied imports into account. The numbers are then merged to individual level data such that every individual in the same industry class has the same value and then aggregated over 2-digit occupations. Source. Input-Output tables of the Netherlands, CBS
change in offshoring 1996-2005	percentage change in offshoring from 1996 to 2005. Offshoring measure is calculated as above. Source. Input-Output tables of Netherlands, CBS
other variables	
education 1996	education level for each occupational class in 1996. Source EBB.
log employment 1996	log of employment for each occupational class in 1996. Source EBB.
log wage 1996	log of wage for each occupational class in 1996. Source: SSB.
change in employment,1996-2005	percentage change in employment 1996-2005. Source: EBB

A.2. Summary statistics

Variable	Mean	Std. Dev.	Min	Max
worker				
task importance 1996	3.550	0.90	1.00	5.00
task importance 2001	3.605	0.81	1.16	5.00
task importance 2005	3.652	0.82	1.24	5.00
task 1996-2005	0.102	0.41	-1.66	2.24
task 1996-2001	0.055	0.41	-1.73	2.74
task 2001-2005	0.046	0.29	-1.17	1.11
task-occupation connectivity 1996	0.226	0.07	0.029	0.334
task-occupation connectivity 2001	0.204	0.06	0.036	0.304
task-occupation connectivity 2005	0.209	0.07	0.041	0.314
task-occupation wage differential 1996	708.99	526.23	0.34	2724.42
task-occupation wage differential 2001	830.91	651.41	1.34	3418.18
task-occupation connectivity	0.0066	0.0002	0.0060	0.0071
task-occupation wage differential	22.91	16.03	2.23	72.30
contestability	0.051	1.304	-2.11	3.12
industry				
task importance 1996	3.360	0.793	1.00	5.00
task importance 2001	3.464	0.784	1.00	5.00
task importance 2005	3.536	0.742	1.00	5.00
task 1996-2005	0.176	0.493	-2.77	4.00
task 1996-2001	0.102	0.527	-4.00	4.00
task 2001-2005	0.071	0.480	-3.05	2.72
task-industry connectivity 1996	0.313	0.109	0.034	0.481
task-industry connectivity 2001	0.293	0.121	0.017	0.505
task-industry connectivity 2005	0.285	0.101	0.034	0.469
task-industry connectivity	0.299	0.004	0.287	0.305
spatial				
spatial occupation concentration	0.344	0.125	0.187	0.644
occupation space connectivity	0.173	0.067	0.078	0.298
offshoring 1996	0.128	0.048	0.041	0.225
change in offshoring 1996-2005	0.015	0.080	-0.087	0.259
change in employment 1996-2005	0.008	0.184	-0.255	0.413
log employment 1996	6.60	1.26	4.35	9.00
education 1996	3.35	0.82	2.09	4.89
log wage 1996	7.64	0.33	6.99	8.19

A.3. List of occupations according to Dutch Occupation Classification 92

NLSBC92 code	occupation
11	elementary occupations
24	agricultural (low)
26	technical (low)
28	transport (low)
29	(para)medical (low)
31	administrative, commercial, economic (low)
33	security (low)
37	care taking (low)
42	teachers (low)
44	agricultural (medium)
46	technical (medium-low)
48	transport (medium)
49	(para)medical (medium-low)
51	administrative, commercial, economic (medium-low)
53	security (medium-low)
55	linguistic, cultural (low)
56	societal, governmental (medium)
57	care taking (medium)
62	teachers (medium)
64	agricultural (high)
65	scientific (medium)
66	technical (medium-high)
68	transport (high)
69	(para)medical (medium-high)
71	administrative, commercial, economic (medium-high)
73	security (medium-high)
75	linguistic, cultural (high)
76	societal, governmental (medium-high)
78	managers (medium)
85	scientific (high)
86	technical (high)
89	(para)medical (high)
91	administrative, commercial, economic (high)
93	security (high)
96	societal, governmental (high)
98	managers (high)

A.4. List of task in BSS

Task	Importance of task:
detail	paying close attention to detail
people	dealing with people
peach	teaching people (individuals or groups)
speech	making speeches/ presentations
persuad	persuading or influencing others
selling	selling a product or service
caring	counselling, advising or caring for customers or clients
strength	physical strength (e.g., to carry, push or pull heavy objects)
stamina	physical stamina (e.g., to work for long periods on physical activities)
hands	skill or accuracy in using hands/fingers (e.g., to mend or repair, assemble etc.)
tools	knowledge of use or operation of tools/equipment machinery)
product	knowledge of particular products or services
special	specialist knowledge or understanding
orgwork	knowledge of how organisation works
faults	spotting problems or faults (in your own work or somebody else's work)
cause	working out cause of problems/ faults (in your own work or somebody else's work)
solutn	thinking of solutions to problems (in your own work or somebody else's work)
analyse	analysing complex problems in depth
noerror	checking things to ensure no errors (in your own work or somebody else's work)
mistake	noticing when there is a mistake (in your own work or somebody else's work)
panme	planning own activities
planoth	planning the activities of others
mytime	organising own time
ahead	thinking ahead
read	reading written information (e.g., forms, notices and signs)
short	reading short documents such as reports, letters or memos?
long	reading long documents such as long reports, manuals, articles or books
write	writing materials such as forms, notices and signs
writesh	writing short documents (e.g., reports, letters or memos)
writelg	writing long documents with correct spelling and grammar
calca	adding, subtracting, multiplying and dividing numbers
percent	calculations using decimals, percentages or fractions
stats	Calculations using more advanced mathematical or statistical procedures

A.5. Most and least connected tasks according to task-occupation connectivity (ranked by 2005 score)

	task-occupation connectivity 1996	task-occupation connectivity 2005	Difference 1996-2005
analyse	0.308	0.296	-0.012
writesh	0.284	0.284	0.001
long	0.302	0.284	-0.018
short	0.278	0.283	0.005
solutn	0.312	0.280	-0.032
writelg	0.290	0.267	-0.023
ahead	0.273	0.260	-0.013
special	0.269	0.251	-0.018
persuad	0.268	0.248	-0.020
cause	0.279	0.246	-0.033
planoth	0.255	0.238	-0.018
write	0.226	0.237	0.011
noerror	0.260	0.237	-0.023
planme	0.263	0.235	-0.028
mytime	0.242	0.235	-0.007
mistake	0.252	0.235	-0.017
orgwork	0.232	0.234	0.002
speech	0.241	0.234	-0.007
faults	0.250	0.232	-0.018
read	0.231	0.230	-0.001
teach	0.241	0.226	-0.016
listen	0.223	0.223	0.000
usepc	0.184	0.195	0.011
caring	0.193	0.191	-0.002
teamwk	0.181	0.190	0.009
people	0.190	0.184	-0.006
detail	0.200	0.184	-0.017
percent	0.221	0.175	-0.046
stats	0.185	0.171	-0.015
product	0.214	0.165	-0.049
calca	0.183	0.141	-0.043
selling	0.155	0.105	-0.050
tools	0.089	0.086	-0.004
hands	0.075	0.074	-0.001
stamina	0.053	0.068	0.015
strengt	0.042	0.055	0.013

A.6. Task-occupation connectivity and task-occupation wage differential by occupation

NLSBC92 code	occupation	task-occupation connectivity 1996	task-occupation connectivity 2005	task-occupation wage differential 1999
11	elementary occupations	0.216	0.201	909.9
24	agricultural (low)	0.214	0.202	488.3
26	technical (low)	0.218	0.204	287.3
28	transport (low)	0.216	0.204	380.4
29	(para)medical (low)	0.218	0.206	855.8
31	administrative, commercial, economic (low)	0.225	0.207	813.7
33	security (low)	0.225	0.210	179.4
37	care taking (low)	0.215	0.201	1116.7
42	teachers (low)	0.228	0.210	463.5
44	agricultural (medium)	0.233	0.207	415.4
46	technical (medium-low)	0.219	0.204	164.4
48	transport (medium)	0.225	0.209	116.8
49	(para)medical (medium-low)	0.226	0.208	669.5
51	administrative, commercial, economic (medium-low)	0.227	0.211	146.2
53	security (medium-low)	0.226	0.213	346.7
55	linguistic, cultural (low)	0.223	0.208	381.6
56	societal, governmental (medium)	0.231	0.215	517.8
57	care taking (medium)	0.221	0.207	718.8
62	teachers (medium)	0.230	0.213	76.1
64	agricultural (high)	0.230	0.210	599.0
65	scientific (medium)	0.223	0.208	225.0
66	technical (medium-high)	0.228	0.213	813.8
68	transport (high)	0.226	0.211	2478.8
69	(para)medical (medium-high)	0.227	0.210	427.3
71	administrative, commercial, economic (medium-high)	0.231	0.214	750.6
73	security (medium-high)	0.231	0.212	945.7
75	linguistic, cultural (high)	0.228	0.210	177.1
76	societal, governmental (medium-high)	0.233	0.214	188.1
78	managers (medium)	0.228	0.210	1445.5
85	scientific (high)	0.233	0.212	1194.9
86	technical (high)	0.230	0.213	1182.3
89	(para)medical (high)	0.227	0.212	1382.6
91	administrative, commercial, economic (high)	0.233	0.216	1221.1
93	security (high)	0.234	0.218	1074.8
96	societal, governmental (high)	0.232	0.218	625.6
98	managers (high)	0.228	0.212	1743.2

A.7. Most and least connected tasks according to task-industry connectivity (ranked by 2005 score)

tasks	task-industry connectivity 1996	task-industry connectivity 2005	Difference 1996-2005
analyse	0.443	0.446	0.004
special	0.428	0.427	-0.001
short	0.434	0.419	-0.015
long	0.346	0.414	0.068
solutn	0.451	0.391	-0.060
writesh	0.413	0.361	-0.052
persuad	0.397	0.358	-0.039
ahead	0.357	0.357	0.001
write	0.385	0.348	-0.037
percent	0.385	0.341	-0.044
orgwork	0.305	0.336	0.031
speech	0.414	0.335	-0.080
mytime	0.246	0.328	0.081
cause	0.353	0.325	-0.028
noerror	0.339	0.319	-0.019
teach	0.372	0.319	-0.053
stats	0.375	0.289	-0.086
planme	0.326	0.282	-0.044
faults	0.280	0.281	0.001
people	0.274	0.280	0.007
mistake	0.360	0.279	-0.081
calca	0.344	0.279	-0.065
read	0.345	0.276	-0.069
caring	0.193	0.245	0.052
writelg	0.370	0.236	-0.134
planoth	0.325	0.234	-0.091
detail	0.329	0.233	-0.095
product	0.265	0.229	-0.037
selling	0.089	0.137	0.049
tools	0.139	0.101	-0.038
hands	0.128	0.083	-0.045
strengt	0.066	0.067	0.000
stamina	0.065	0.059	-0.005

A.8. Task-industry connectivity by industry

EBB Industry code	industry	task-industry connectivity 1996	task-industry connectivity 2005
1	Agriculture and fishery	0.301	0.277
2	Mining and Quarrying	0.315	0.289
3	Manufacturing food products	0.309	0.278
4	Manufacture of textiles	0.309	0.277
5	Manufacturing of wearing apparel	0.308	0.284
6	Manufacture of leather and footwear	0.292	0.275
7	Manufacture of wood	0.303	0.279
8	Manufacture of paper	0.312	0.281
9	Publishing	0.313	0.293
10	Extraction and agglomeration of peat	0.313	0.282
11	Extraction of crude petroleum and gas	0.319	0.289
12	Manufacture, chemicals/ chemical product	0.324	0.288
13	Manufacture, rubber/plastic products	0.304	0.280
14	Quarrying and winning of sand	0.307	0.276
15	Manufacture of basic metals	0.307	0.282
16	Manufacture,. fabricated metal products	0.314	0.283
17	Machine industry	0.312	0.284
18	Manufacturing of electrical machinery	0.316	0.288
19	Manufacturing of audio equipment	0.312	0.293
20	Manufacturing of medical equipment	0.318	0.285
21	Manufacture of motor vehicles	0.311	0.283
22	Manufacture of transport equipment	0.315	0.285
24	Manufacture of furniture	0.310	0.284
25	Energy and water supply	0.323	0.292
26	Construction	0.309	0.281
27	Building and construction	0.309	0.281
28	Building and installation	0.309	0.276
29	Sale and repair of motor vehicles	0.308	0.282
30	Wholesale agricultural products	0.313	0.283
31	Wholesale of food	0.313	0.285
32	Wholesale of intermediate goods	0.313	0.283
33	Wholesale of machines and equipment	0.313	0.291
34	Other wholesale	0.313	0.288
35	Retail sale, warehouses and supermarkets	0.307	0.279
36	Retail sale, supermarkets in foods	0.307	0.280
37	Other retail trade	0.307	0.281
38	Hotels and Restaurants	0.305	0.277
39	Land transport, transport via pipelines	0.306	0.281
40	Other transport	0.306	0.281
41	Water transport	0.310	0.284
42	Air transport	0.321	0.283
43	Travel agencies and tour operators	0.317	0.290

44	Renting of motor vehicles	0.317	0.282
45	Post and telecommunications	0.313	0.285
46	Financial activities, banks	0.322	0.295
47	Insurance and pension funds	0.325	0.297
48	Other financial services	0.324	0.294
49	Real estate and renting	0.322	0.291
50	Computer services, information technology	0.318	0.293
51	Research and development	0.328	0.292
52	Legal/economic activities	0.320	0.297
53	Architectural and engineering activities	0.320	0.292
55	Cleaning activities	0.320	0.281
56	Other business activities	0.320	0.288
57	Public administration	0.321	0.292
58	basic and special education	0.322	0.290
59	Secondary education	0.322	0.292
60	Higher education	0.322	0.295
61	Other education	0.322	0.290
62	Hospitals	0.315	0.287
63	Other health related services	0.315	0.287
64	Nursing and retirement homes	0.315	0.287
65	Other self-care activities	0.315	0.287
66	Sewage refusal and disposal, sanitation	0.306	0.278
67	Activities of membership organisation	0.321	0.293
68	Recreational, cultural and sporting activities	0.311	0.285
69	Laundry, personal care	0.307	0.277
70	Private household activities	0.299	0.276
71	Extraterritorial organisations and bodies	0.310	0.292

A.9. Actual change in employment and predicted values at each stage

NLSBC92 code	occupation	employment change 1996-2005	Prediction (worker)	Prediction (industry)	Prediction (spatial)
11	elementary occupations	0.096	-0.273	-0.054	0.113
24	agricultural (low)	-0.255	-0.290	-0.277	0.027
26	technical (low)	-0.227	-0.252	-0.066	0.068
28	transport (low)	-0.059	-0.275	-0.151	0.131
29	(para)medical (low)	0.120	-0.175	0.033	-0.087
31	administrative, commercial, economic (low)	0.061	-0.073	-0.104	0.127
33	security (low)	0.004	-0.047	0.017	-0.022
37	care taking (low)	0.104	-0.288	-0.089	0.064
42	teachers (low)	0.414	0.017	0.144	-0.106
44	agricultural (medium)	-0.239	-0.046	-0.320	-0.061
46	technical (medium-low)	-0.109	-0.245	-0.068	0.124
48	transport (medium)	-0.202	-0.088	-0.111	-0.075
49	(para)medical (medium-low)	0.149	-0.054	0.014	0.101
51	administrative, commercial, economic (medium-low)	0.007	-0.021	-0.020	0.102
53	security (medium-low)	-0.037	0.016	0.082	0.020
55	linguistic, cultural (low)	-0.011	-0.118	0.047	-0.008
56	societal, governmental (medium)	0.314	0.149	0.007	0.053
57	care taking (medium)	-0.109	-0.133	-0.059	0.099
62	teachers (medium)	0.032	0.077	0.137	0.110
64	agricultural (high)	-0.232	0.030	-0.006	-0.056
65	scientific (medium)	-0.228	-0.072	0.047	-0.239
66	technical (medium-high)	0.030	0.087	0.021	0.016
68	transport (high)	-0.075	0.092	-0.098	-0.125
69	(para)medical (medium-high)	0.215	-0.007	0.042	0.031
71	administrative, commercial, economic (medium-high)	0.092	0.135	0.028	0.111
73	security (medium-high)	-0.068	0.088	0.086	-0.088
75	linguistic, cultural (high)	-0.138	-0.025	0.102	0.018
76	societal, governmental (medium-high)	0.296	0.167	0.029	0.148
78	managers (medium)	-0.194	0.066	-0.023	0.051
85	scientific (high)	-0.205	0.128	0.079	-0.233
86	technical (high)	-0.130	0.129	0.062	0.048
89	(para)medical (high)	0.044	0.095	0.025	0.085
91	administrative, commercial, economic (high)	0.341	0.263	0.103	0.063
93	security (high)	0.187	0.289	0.126	0.074
96	societal, governmental (high)	0.304	0.256	0.026	-0.090
98	managers (high)	0.013	0.116	0.037	0.066

A.10. Correlation among variables

	change in employment	change in hrs worked	task-occ connectivity	task-occ wage diff	task-ind connectivity	job concentration	contestability	job connectivity	offshoring 1996	change in offshoring	log employment 1996	education 1996
change in employment	1.00											
change in hrs worked	0.98*	1.00										
task-occ connectivity	0.41*	0.49*	1.00									
task-occ wage diff	0.08	0.07	0.15	1.00								
task-ind connectivity	0.46*	0.48*	0.59*	0.06	1.00							
job concentration	-0.21	-0.18	0.24	0.08	0.12	1.00						
Contestability	-0.25	-0.32*	-0.65*	0.65*	-0.41*	-0.13	1.00					
job connectivity	0.14	0.20	0.25	0.01	0.03	0.05	-0.18	1.00				
offshoring 1996	-0.60*	-0.55*	-0.30*	0.05	-0.45*	0.22	0.27	0.02	1.00			
change in offshoring	0.13	0.11	0.24	0.04	0.27	0.41*	-0.16	-0.24	-0.18	1.00		
log employment 1996	0.05	0.03	-0.35*	-0.29*	-0.35*	-0.77*	0.05	0.20	0.05	-0.45*	1.00	
education 1996	0.20	0.26	0.82*	0.36*	0.60*	0.35*	-0.36*	0.30*	-0.16	0.17	-0.43*	1.00
log wage 1996	-0.23	-0.12	0.58*	0.39*	0.18	0.29*	-0.15	0.24	0.23	0.04	-0.32*	0.64*

Note: *n*=36. * significant at least at 10 percent.

A.11. Data sources

We have used a number of data sources to compile the dataset with which we have carried out the empirical analysis.

A.11.1. British Skill Surveys (BSS)

BSS is a data set that comprises particular information about the job-content of individuals: what tasks are exercised in a particular job and the importance of these tasks? The data set includes detailed information regarding the firm that the interviewee works (if employee), qualifications, education and other skills of the interviewee as well as personal data such as age, experience and gender of the interviewee.

BSS is conducted in three waves: 1997, 2001 and 2006. There are 2,467 observations in 1997; 4,470 observations in 2001 and 7,787 observations in 2006 wave, respectively. The questions for the importance of 36 tasks that we have employed in this study are asked in all years and measured exactly the same way in all three waves. There were some other questions measuring tasks importance in 2006 which were not asked in the earlier waves. We included only the tasks that are considered in all three waves. A typical question on tasks starts with a general explanation "You will be asked about different activities which may or may not be part of your job. At this stage, we are only interested in finding out what types of activities your job involves and how important of these are" followed by the question "In your job how important is …". The answer categories range from (1) "essential" to (5) "not at all important". We adjusted this scale so that the scale increases with the importance of a task:

(5) “task is essentially important” and (1) “task is not important at all”.

The information on 36 tasks and other relevant variables are linked to EBB by using two-digit occupation codes. For each round of BSS, we came up with a correspondence table linking UK occupation classification [*Standard Occupation Classification* (SOC 1990)] codes to Dutch occupation classification [*Standaard Beroepenclassificatie* (SBC 1992)]. The crosswalk is first done at the two-digit level. For the occupation groups that we are not certain about the quality of the matching, we used three-digit codes. After reviewing the crosswalk, if we are still not satisfied, we used four-digit occupation codes. This procedure resulted in a correspondence table that matches 161 two, three and four-digit SOC codes to 36 SBC two-digit codes. We omitted all the codes that refer to general occupation classes such as 20, 40, 60 etc. This is first because, these classes do not have exact occupation definitions and more importantly the number of individuals registered to these occupation classes vary in great extent from year to year. For instance, occupation class 80 varies between 98 and 370 individuals, changing from year to year without a pattern. This applies for the other general groups as well. Some smaller categories that have less than 0.1 percent of total employment are also not considered. The omitted 9 occupation classes in total correspond to less than 1 percent of total employment. Once these classes are omitted we end up with 38 two-digit occupations. The three waves of BSS are aggregated for this 38 Dutch occupation classes. The correspondence table is available upon request.

A.11.2. Enquête Beroepsbevolking (EBB)

We use the Dutch Labour Force survey from 1996 to 2005 for employment figures per occupation (2-digit, 1992 Dutch occupation classification, 47 occupation classes) and industry (2-digit, 1993 Dutch industry classification, 70 industry classes). EBB also comprises data on personal characteristics such as age, education, qualifications, gender, ethnic background and some other information regarding the content of the job. Unfortunately, EBB doesn’t include wage data. We gathered wage data from the SSB at the occupation level from 1999 to 2005 and merge it to EBB. Wage data for earlier years are gathered from the Dutch Socio-economic Panel (SEP). For years 1999 and 2000 the wage data is present in both SSB and SEP. We used these two years to interpolate wages from 1996 to 1998. The number of observations in each EBB round ranges between 80,541 to 99,137 with an average of 89,746.

A.11.3. Input-output tables

Input-output tables from 1996 to 2005 at CPB are used to compute the import component of inputs for each industry. We used both the total and import input-output tables for the Netherlands. The input-output tables comprise information on sales and purchases of each industry from and to other industries with additional information on other variables such as exports, final demand, total salary payments and social security contributions etc. giving a full account of the Dutch economy.

The industry classification of the I-O tables does not exactly follow the standard industry classifications. The I-O tables present detailed information for some two-digit

industries. For instance, Chemical Industry is a standard two-digit class in *Standaard Bedrijfsindeling* 1993, but to provide better information this class is divided into five sub-categories in I-O tables. The tables are available for 112 industry classes and sub-classes (112 by 112 matrix for each year). To match with the standard classification we constructed a correspondence table matching each 112 industry code to a two-digit *Standaard Bedrijfsindeling* 1993. This resulted in 70 two-digit industry classes. For each class we calculated offshoring and narrow offshoring indicators as explained in the main text. The correspondence table is available upon request.

A.12 Dataset

For the purpose of this project, the EBB data 1996-2005 is stacked in one large data set that comprises all relevant information from EBB for 10 years (the master data). This resulted in a data set of over a million observations. Then we add the necessary information from other data sets in 3 steps.

- First, we append wage information. By using data from SSB and SEP as described above we came up with a data set of wages that comprise wage information for every two-digit occupation code from 1996-2005. This data is matched to the master data so that each two-digit occupation code has a corresponding wage for each year.
- Second, we add information from the BSS. We aggregated the data on tasks from BSS for Dutch two-digit occupations as explained above and than append this information to EBB master data such that each two-digit occupation code has a corresponding task measure for each year. Since there are only three waves of BSS, years 1996-1997 corresponds to BSS 1997 task values; 1998-2001 corresponds to BSS 2001 task values; and 2002-2005 corresponds to BSS 2006 task values.
- Third, we append the offshoring measures that we calculated from the I-O tables. The 112 industry groups in the I-O tables were matched to 70 two-digit industry classes in the EBB as explained above. In the resulting data set each two-digit industry code has a corresponding offshoring coefficient.

The resulting master data set comprise information on age, education, gender, ethnicity, wages, tasks, other relevant information regarding the occupation and offshoring indicators. The data set has information for 10 years, 36 two-digit occupation classes and 70 two-digit industries. This data set can be aggregated in many ways, such as year-occupation, year-industry and even year-occupation-industry cells, depending on the analysis to be conducted.

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