The Wage and Employment Effects of Outsourcing: Evidence from Danish Matched Worker-Firm Data

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Abstract: We employ a unique matched worker-firm dataset from Denmark to measure how outsourcing shocks affect wages and employment at the firm and worker level. Because we observe the specific products and source countries for imported inputs purchased by Danish firms we can construct instruments for outsourcing decisions that are time varying and exogenous to the firm. This allows us to identify the causal effect of outsourcing on worker's wages and employment transitions. We also relate wage effects to occupational characteristics to identify which tasks are relatively sensitive to outsourcing shocks.

June 2009: Preliminary and incomplete: Please do not cite without permission

I. Introduction

A key feature of global trade in the new century is the rapid growth of outsourcing (Feenstra and Hanson 2003, Grossman and Helpman 2002), and trade in intermediate goods (Hummels et al. 2001, Yi 2003). How has outsourcing affected workers' wages and employment opportunities? The answer to this question is not theoretically obvious. At some level purchasing an input from a foreign source must replace a task previously done by a domestic worker, which would suggest displacement and lower wages. However the ability to use foreign inputs may lower a firm's costs and raise its productivity (Amiti and Konings 2007; Kasahara and Rodrigue 2007; Grossman and Rossi-Hansberg 2008), allowing it to expand output and employment and raise wages. Nor is the causality easy to sort out: a firm enjoying increased productivity may expand outsourcing, output and wage simultaneously.

The empirical literature has shed light on the interactions between globalization and key labor market outcomes. Using industry-level data, Feenstra and Hanson (1997, 1999) and Hsieh and Woo (2005) examine the effect of outsourcing on the demand for skilled labor relative to unskilled labor in Mexico, the US, and Hong Kong; Bergin, Feenstra and Hanson (2009) study the relationship between outsourcing and changes in employment volatility; and Amiti and Wei (2006, 2007) study how services outsourcing affects industry productivity. Using firm-level data, Biscourp and Kramarz (2007) study the effects of final goods imports on firm-level employment, and Amiti and Davis (2008) examine how imports of intermediates affect average wages at the firm level.

While much has been learned from this work, the empirical literature on outsourcing to date lacks data on individual workers, their wages, characteristics and occupations. This creates three difficulties. One, previous authors cannot separate changes in wages for individual workers from changes in the composition of the workforce within a firm, except by employing relatively simple controls such as the share of skilled workers in employment. Two, they cannot assess labor market outcomes for workers who are displaced from outsourcing firms, a group for which wage effects might be especially pronounced. Three, they cannot perform detailed analysis of how wage changes are affected by workers' characteristics such as education or occupation.

As a consequence, little is known about the characteristics of the tasks offshored by firms: whether they are routine or non-routine, manual or cognitive, or intensively employ skilled or unskilled labor. This is unfortunate because recent trade models with heterogeneous workers such as Yeaple (2005) and Antras, Caricano and Rossi-Hansberg (2006) argue that the effects of trade shocks depend on worker characteristics and may vary across employees within the same firm. And the predictions of explicit models of offshoring depend on the characteristics of tasks offshored. (Feenstra 2008, Grossman and Rossi-Hansberg 2007, 2008, 2009).

Further, there is growing evidence that specific worker characteristics might be essential for understanding labor market outcomes. For example, Autor, Katz and Kearny (2006) show that the earnings of the middle class grew more slowly than both the rich and the poor in the 1990s in the U.S., and argue that the nature of the tasks that workers perform (whether they are routine or non-routine) is central to understanding the "polarization" of the labor market.[1]

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[1] Goos and Manning (2007) and Manning, Goos and Salomons (2009) show that labor markets are also polarized in U.K. and Europe.

The relationship between outsourcing and task specialization is also of considerable policy interest, as reflected by repeated efforts to measure how many U.S. jobs have been lost to outsourcing, and to understand which occupations are most easily outsourced (e.g. Blinder 2005). Using subjective rankings, Blinder (2007) argues that the "offshorability" of an occupation has little correlation with its skill requirement. Jensen and Kletzer (2007) use geographical concentrations to measure "offshorability" and produce a different ranking across occupations. Not surprisingly, no consensus has emerged.

In this paper we overcome these difficulties by employing matched worker-firm data from Denmark that is linked to firm-level data on imports and exports. Our worker-firm data cover the *population* of the Danish labor force (all Danish individuals aged 15-74 and employees in all plants in Denmark during 1995-2006).[2],[3] This broad coverage allows us to assess whether a change in outsourcing status affects wages for a given worker, and how these wage effects relate to that worker's characteristics. For example, by observing how the effects of outsourcing vary with worker characteristics we are able to infer the characteristics of the tasks offshored. Further, since we see specific workers before, during, and after their employment in specific firms we can also assess labor market transitions associated with outsourcing.

[2] This firm-worker data set has been used previously in the labor literature (e.g. Eriksson and Westergaard-Nielsen 2007). Our contribution in this context is to link the worker-firm data with product (HS6)-level trade data from Danish customs.

[3] Ours is not the first study to employ matched worker-firm data in a trade context. Menezes-Filho and Muendler (2007) study the effect of trade liberalization on labor reallocation across industries in Brazil. Their data include the firm's exporter status but they lack firm-level data on imported inputs. Kramarz (2008) has worker-firm data from France along with data on imported inputs but focuses on a setting with imperfect labor markets where firms and unions bargain over wages. Hakkala, Heyman and Sjoholm (2009) study the effects of multinational activities and foreign acquisitions on relative labor demand at the firm level in Sweden.

Our product-level trade-data includes detailed information on the inputs these firms purchase – which goods and from which sources – and the products these firms sell, both domestically and abroad. This allows us to solve a final significant problem with efforts to associate wage and employment effects with outsourcing at the firm level. The literature on heterogeneous firms suggests that high productivity firms are different from low productivity firms in almost every measurable respect. High productivity firms export more, produce higher quality goods, engage in more R&D, use more capital, and critically for this paper, are more likely to pay higher wages and buy imported inputs.

To combat this problem we employ time varying data on the source country and specific product being imported to construct instruments that are correlated with a firm's decision to increase outsourcing, but are not correlated with the firm's ability level or its wage structure. Our instruments include tariffs, the exchange rate between Denmark and partner country, constructed measures of transportation costs, and world-wide shocks to export supply and import demand for the relevant partner country x product being traded. These instruments enable us to trace out patterns of firm-specific outsourcing that are time varying and exogenous to the firm in question.

We employ these data to estimate how an exogenous shock to outsourcing affects the wages and job separation probabilities of individual workers, after controlling for either worker fixed effects or worker-job spell fixed effects and a long list of time-varying worker and firm characteristics. We examine how these estimates depend on the source of the inputs and the skill and occupational characteristics of the workers. This allows us to paint a picture of which workers and occupations are most sensitive to outsourcing.

Our key findings are these. One, exogenous outsourcing shocks lower wages and increase the probability of separation for workers. Two, controlling for the endogeneity of outsourcing is critical. Instrumental variables estimates of the effect of outsourcing on wages yield either different signs or coefficients an order of magnitude larger than those found when estimating these effects using OLS or worker-firm fixed effects. Three, the source of imported inputs interacts with the skill composition of the worker in a way broadly consistent with factor proportions theory. Increasing purchases from high income countries lowers wages for high skill workers while raising wages for low skill workers. The reverse occurs when inputs are sourced from low income countries. Four, the wage effects of outsourcing share similar features with the wage effects of technology as documented in Autor, Levy and Murname (2003). That is, occupations employing cognitive skills are less sensitive to outsourcing pressures than are occupations that require physical labor or manual dexterity.

Exploring occupational characteristics allows us to identify two additional and unique relationships. First, occupations that expose workers to potentially unsafe working condition experience relatively large wage drops after outsourcing. Second, not all degrees are created equal. Occupations that intensively employ knowledge sets from social science and languages are systematically less affected by outsourcing shocks, while those that employ knowledge sets from natural sciences and engineering are no more or less insulated from outsourcing shocks than the average manufacturing worker.

The paper proceeds as follows. Section II describes the data on firms, workers, trade, and our instruments for outsourcing. Section III analyzes wage effects at the worker level. Section IV provides a detailed analysis of outsourcing effects across occupations and task characteristics. Section V (incomplete) analyzes employment transitions. Section VI concludes.

II. The Danish Labor Market and Data Sources

We begin with a discussion of the Danish labor market, some characteristics of which are summarized and contrasted with other countries in Table 1. The Danish labor market is strongly unionized even by European standards. More than three quarters of all workers are union members and bargaining agreements are extended to cover most of the labor market. There are three different levels at which wages can be negotiated: the Standard-Rate System, the Minimum-Wage and Minimum Pay System; and Firm-level Bargaining. Under the Standard-Rate System the wages of workers are set by the industry collective agreement and the wages are not modified at the firm level. The Minimum-Wage System and the Minimum-Pay System are two-tiered systems in which wage rates negotiated at the industry level represent a floor which can be supplemented by local firm-level negotiations. Under Firm-Level Bargaining wages are negotiated at the firm level without any centrally bargained wage rates.

The Danish labor market has been undergoing a process of decentralization. Since 1991 less than 20 percent of the private labor market is covered by the Standard-Rate System and an increasing share of wage contracts are negotiated exclusively at the worker-firm level. As a consequence, while the influence of unions means that the Danish wage structure is still relatively compressed, the decentralization process has implied that wages are more in accordance with individual workers' marginal productivity. Dahl et al. (2009) show that decentralization has increased wage dispersion in the Danish labor market.

Compared to other continental European labor markets the Danish labor market is more flexible as employment protection is relatively weak.. While unemployment insurance replacement ratios are high, this is coupled with a strict 'activation' regulation. Together these ingredients form what has been called the 'flexicurity' model. Danish firms may adjust employment with relative ease. As compensation for high job turnover workers receive relatively generous UI benefits when unemployed, but incentives to search for jobs during unemployment are reinforced by monitoring and sanctions.

This labor market model has led to turnover rates and an average tenure which are in line with those of the Anglo-Saxon countries. In 1995 the average tenure in the Danish labor market was the lowest in continental Europe with 7.9 years just exceeding the number for UK (7.8 years) while average tenure in the German labor market was 9.7 years, cf. OECD (1997).

II.A. Data Sources

Our data on firms, workers and trade are drawn from several administrative registers in Statistics Denmark. At the core of the data is the FIDA data, a matched worker-firm longitudinal dataset covering the total Danish population of workers and firms for the years 1995-2006. Workers and firms are associated with a unique identifier, and all employed workers are linked with a firm identifier. FIDA contains firm-level data on total sales, number of full-time employees and a six digit NACE industry code. From the Account Statistics Register we construct the firm's capital stock defined as the value of land, buildings, machines, equipment and inventory. We restrict our sample to include manufacturing firms that import at least one year in the sample period and have at least one employee.

The worker data is extracted from the Integrated Database for Labor Market Research (IDA), which contains a long list of socio-economic characteristics at annual frequencies. As outcome measures we focus on individual worker wages and labor market status. The hourly wage rate is calculated as annual labor income plus mandatory pension fund payments divided by annual hours. Labor market status (employed, unemployed or out of the labor force) is recorded in week 48 each year. In addition we use control variables such as age, sex, education, labor market experience, tenure and occupation.

We will distinguish between high-skilled, medium-skilled and low-skilled workers. High-skilled workers refer to persons with a tertiary education corresponding to the two highest categories (5 and 6) in the International Standard Classification of Education (ISCED). Medium-skilled workers have a vocational education defined as the final stage of secondary education that prepares students for entry into the labor market. As a result, persons with the equivalent of high school education or less are classified as low-skilled workers. Labor market experience is measured as actual time in employment since 1964. Tenure is measured as time in the job since 1980. The occupation variable is based on a Danish version of the International Standard Classification of Occupations (ISCO-88) developed by the International Labour Office (ILO).

Of particular interest is data for firm level international trade. The Danish External Trade Statistics Register provides product-level origin/destination country-specific import and export data for the years 1990-2006. Trade flows are recorded according to the eight-digit Combined Nomenclature product code which encompasses approximately 10,000 different product categories. For each trade flow there is information about the trade value in DKK (fob for exports and cif for imports) and the weight in kilos. The External Trade Statistics Register is compiled in two systems; Extrastat (trade with non-EU countries) and Intrastat (trade with EU countries). The coverage rate in Extrastat is close to complete as all trade flows with non-EU countries are recorded by customs authorities. For intra-EU trade firms are only obliged to report trade if the annual trade value exceeds a threshold value.[4] Some firms fail to report data to the Intrastat system, and as a result around 90 percent of intra-EU trade by value is captured in Intrastat.

We also merge firm-level domestic sales to the core dataset for the years 1996-2006. Domestic sales are obtained from surveys Statistic Denmark carry out every quarter. Manufacturing firms are asked to report sale values and weights of every ten-digit product they sell in Denmark. The sampling units are manufacturing firms with at least 10 full-time employees two years prior to the sampling year. According to Statistics Denmark, this survey design samples firms which account for roughly 93% of total domestic sales in the manufacturing sector.

After merging data on workers, firms, domestic sales and trade flows, we have a combined dataset that is described in Table 2. We have 56,236 manufacturing firm-years and 3.55 million worker-years in our data, with averages of 4686 firms and 295,849 employees per year. Our sample represents approximately 20 percent of manufacturing firms, but 75 percent of employment in manufacturing. Consistent with other firm-level datasets, firms that are globally engaged in trade tend to be much larger than other firms.

[4] In 2002 the thresholds were DKK 2.5 million for exports and DKK 1.5 million for imports.

II.B. Outsourcing

A major advantage of the data is that we can construct a firm specific measure of outsourcing based on imported products that are used as inputs in the firm's production process. We define materials as HS6 products that are imported by the firm but not sold domestically or abroad. For firm *j* at time *t* outsourcing is then given as follows:

$$(1) \qquad OUTS_{jt} = \sum_{c,k} M_{jtck},$$

where M_{jtck} is the value of firm j's import of material *k* from source country *c*.

Table 2 reports the number of products imported and exported each year, where each unique firm-HS6 product flow is counted. On the importing side, approximately 25 percent of the import product flows lie within the same HS6 category of products that the firm also sells domestically or exports. We refer to these as "final goods".[5] The remaining imported products are intermediate inputs. The mean firm in our data purchases imported inputs in 9.4 distinct HS 6 categories (with 14.6 distinct exporter-HS 6 flows) in 1995 and purchases inputs in 12.1 distinct HS 6 categories (with 19.7 distinct exporter-HS 6 flows) in 2006. The top panel of Figure 1 shows growth in imports and growth in intermediate inputs for these firms. Note that both the number of imported inputs and the quantity per input has grown throughout this period. Inputs are between 30 and 40 percent of Danish imports in this period.

[5] Kramarz 2008 similarly eliminates import flows for products that the firm also sells, but his French data allow this comparison at a much broader 3 digit industry aggregate.

We also distinguish between materials from high- and low-income countries as firms may have different motives for sourcing products from these two groups of countries. We use a classification from the World Bank which groups all countries into i) high income countries and ii) low and middle income countries to divide the outsourcing variable into two, $OUTS_{jt}^{H}$ and $OUTS_{jt}^{L}$. In panels C and D in Figure 1, outsourcing is distinguished by country-of-origin. While foreign inputs originating from high income countries comprise the majority of input trade by value, input trade with low and middle income countries has grown much more rapidly in this period. The low/middle income share in inputs rose from from 5 percent in 1995 to 16 percent in 2005.

The distribution of imported inputs is highly skewed across firms. We provide the distribution of input purchases, both in the aggregate and as a share of gross output in Figure 2. For the mean firm that outsources, foreign inputs represent 7 percent of gross output. Critically for our identification, the distribution of outsourcing varies considerably across firms in each year and over time.

Outsourcing firms are different from non-outsourcers. Table 3 reports the result of simple regressions at the firm level in which the dependent variable is a firm characteristic and the explanatory variable is an indicator for whether the firm outsources. The first column contains only the outsourcing indicator. Coefficients are interpreted as percentage differences, so that outsourcers have 115 percent higher employment than non-outsourcers. What we see is that outsourcers are different in every respect – they have higher sales, more employment, more skilled employment, a larger capital/worker ratio, and pay higher wages. These difference persist when including industry fixed effects and firm size (employment) as additional controls.

These differences, consistent with findings in the literature from other countries, suggest an important identification problem. It may be that outsourcing causes these firms to be better: larger, more skilled and pay higher wages. Or it may be that all these outcomes are jointly determined as a result of variation across firms in productivity or demand for their products. If so, correlations between outsourcing and wages do not indicate a causal effect. Table 3 indicates the need to identify exogenous variation in outsourcing.

II.C. Instruments

In our empirical specifications we will relate time varying labor market outcomes (wages and job separation probabilities at the worker level) to time varying firm-level measures of outsourcing in an effort to identify how rising outsourcing affects these outcomes. This relationship would not be identified if firms experience demand or productivity shocks that affect both outsourcing and wage setting or employment. To address this problem, we construct four instruments for the outsourcing variable that are correlated with the decision to outsource but uncorrelated with changes in the firm's ability and wage structure.

The instruments are exchange rates (E), tariffs (τ), transport costs (tc), and world export supply (WES). The first three capture shocks to the delivered price of inputs purchased by Denmark. The last captures changes in comparative advantage for the exporting country, whether arising from changes in production price, product quality, or variety. Details on each instrument follow, but first we discuss aggregation.

We calculate each variable specifically for every source country x HS 6 product that the firm buys. We then aggregate across inputs to get a single value for each firm using a share weighted average of the importance of each input in the firm's purchase bundle. These shares based on firm-specific sourcing patterns in pre-sample years and are fixed over time for the firm so that time series change in the aggregated instrument arises from underlying changes in exchange rates, tariffs, transport costs, and world export supply. However, there is variation across Danish firms in the importance of each input, and this share weighting causes the time series change to impact each firm differentially.

The idea behind this strategy is the following: for some reason firm *j* sources a particular input *k* from country *c*. Firm *j* may have a long standing business relationship with a firm in *c*, or the inputs that *c* makes might be a particularly good fit for firm *j*. That relationship is set in the initial year. Then over time there are shocks to the desirability of purchasing input *k* from country *c*. Perhaps country *c* experiences changes in its production costs, production variety or quality that are exogenous to firm *j*, and these are reflected in changing export supply to the world as a whole. Because firm *j* intensively uses input *k* from country *c* more than other firms it disproportionately benefits from that growth. Similarly, an appreciation of the DKK against currency *c*, or a decline in tariffs or transport costs for input *k* from country *c* will disproportionately benefit firms that intensively use that input.

More formally, let I_{ckt} represent instrument $I \in (tc, \tau, E, WES)$ for exporting country c, selling HS 6 product k, at time t, and let s_{jck} represent the share of *c*-*k* in total materials imports for firm j in the pre-sample years (1992-1993). Then to construct a time varying instrument for firm j we have

$$I_{jt} = \sum_{c,k} s_{jck} I_{ckt}$$

We now discuss each particular instrument. The exchange rate E_{ct} is the annual average rate, denoted in foreign currency *c* per DKK so that an increase in E_{ct} is an appreciation of the DKK. Since we are aggregating over source countries, we normalize E_{ct} by its over-time mean value to remove unit differences. Tariffs, τ_{ckt}, are taken from TRAINS data on Danish MFN tariffs which vary by product and time period. In addition, tariffs vary over source countries for a given product and time period due to zero tariff EU preferences. For some Eastern European countries that join the EU within our sample, tariffs switch from MFN rates to the EU zero tariff in 2004. World export supply WES_{ckt} is country *c*'s total supply of product *k* to the world market (minus its supply to Denmark) in period t. These data are constructed from COMTRADE bilateral trade data at the HS6 level.

Finally, we construct transport costs that capture shocks hitting Danish importers that are country c, product k, time t specific. Following Hummels (2007) we estimate transport cost functions in which the dependent variable is the ad-valorem transportation charge for product k shipped from c at time t in mode m (air, ocean, rail, truck). These charges depend on transport mode, a product category fixed effect, product weight/value, the distance the product is shipped, oil prices, and an interaction between distance and oil prices. All estimated coefficients are mode-specific. To construct the instrument for Danish firms, we calculate the predicted value of ad-valorem costs for an input, $\hat{\tau}_{tck}$, given the transport mode, oil prices in that time period, product weight/value, and distance to partner using the transport cost coefficients estimated above. The transport mode and product weight/value are set in the base year.[6] For reference, in 2000, 15.1 percent of Danish imports arrived by air; 60.6 percent by ocean; and 24.4 percent by rail & truck.

Full details on this estimation are captured in an appendix. The key factor for our purposes is the estimates show a pronounced difference between modes in the interaction between oil prices and distance and that, during our sample period, fuel prices fell and then rose sharply (see Figure 3). Rising fuel prices have similar effects on air and ocean costs for countries at the distance mean (8000 km), but the interaction effect is much stronger for air. This implies that changes over time in fuel prices affect the level of costs, the relative cost of employing air v. ocean v. land transport and the relative cost of distant versus proximate partners.

Two final notes on our instruments are in order. First, some of our firms either enter or begin outsourcing within sample, while others dramatically change sourcing patterns within the sample. For the firms who enter or begin outsourcing within the sample we use sourcing patterns in their first year of outsourcing and employ data from year 2 and onwards for the wage and separation regressions. For the firms who dramatically change sourcing patterns the pre-sample weights may be of limited use. Accordingly, we experiment with calculating average import shares over the entire time period to construct the aggregated outsourcing instruments. This approach is valid so long as time-varying shocks to wage setting (or job separations) behaviour are not correlated with the share distribution of material inputs.

Second, in other contexts worker wages have been shown to be correlated with firms' exporting behaviour, though Munch and Skaksen (2008) provide evidence that there

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[6] Since transport modes are not observed for most shipments from other EU countries after 1992 we use the latest observed transport modes in 1990-1996. See appendix for more details.

is no strong correlation in the Danish data. Since our exchange rate and transport cost instruments likely also affect the extent of exporting, one might worry that they fail the exclusion restriction for instruments. To address this, we include firm-level exports in all of our second-stage regressions, and construct analogous instruments for exports. That is, we observe the value of exports from firm *j*, to importing country *i*, in HS6 product *k* at time *t*. We employ exchange rates, tariffs facing Danish exporters, constructed measures of transport costs for these exports, and world import demand (importer i's purchases of product k from all sources other than Denmark) that are specific to each *i*-*k*-*t*. We then weight these by the share of *i*-*k* in firm j's exports in pre-sample years to construct an aggregated instrument.

II.C. Occupational Characteristics

In Section IV we provide regressions that interact outsourcing with occupations and then systematically characterize these effects using occupational characteristics data. Our occupational characteristics data come from O*NET (release 13). These characteristics fall into six categories, "Abilities" (e.g. fluency of ideas), "Skills" (e.g. active listening), "Knowledge" (e.g. mathematics), "Work Styles" (e.g. persistence), "Generalized work activities" (e.g. "communicating with person outside organization"), and "Work Context" (e.g. "exposed to contaminants"). We concord the O*NET data into the ISCO-88 classification system using the crosswalk at the National Crosswalk Center.[7] See the Appendix for more details.

[7] ftp://ftp.xwalkcenter.org/DOWNLOAD/xwalks/.

For each characteristic in the categories "Abilities"-"Generalized work activities", we have two numerical metrics, level and importance, both of which are ordinal. For example, for directors and chief executives (occupation 1210) the importance of "originality" is 75 (important) and its level 64 (just enough to "redesign job tasks to be interesting for employees" but not enough to "invent a new type of man-made fiber"). The level metric is similar to the historic data used in Autor, Levy and Murname (2003). Its numerical values are pinned down by occupational specific "anchors" (e.g. with level-30 "originality" one can "use a credit card to open a locked door") and not directly comparable across occupations. The importance metric has a common interpretation across occupations and is directly comparable across them. For the characteristics in the category "Work Context" the metric is frequency (e.g. "how often does this job require working exposed to contaminants…") whose interpretation is occupation specific. We normalize all metrics to a range of 0-100.

III. The effect of outsourcing on individual worker wages

Our empirical strategy is to relate changes in individual worker's wages to exogenous changes in outsourcing for the firms that employ them, after controlling for worker-firm "job-spell" fixed effects (see e.g. Abowd et al. (1999).), and time varying characteristics of the firm and worker. The traditional approach is to assume wages are determined by a simple Mincer human capital wage equation of the form

(2) $$\log w_{ijt} = \alpha_{ij} + \gamma_1 \ln(OUTS_{jt}) + \gamma_2 \ln(EXP_{jt}) + x_{it}\beta + z_{jt}\gamma + \varphi_t + \varphi_{IND} + \varphi_R + +\varepsilon_{ijt},$$

where $\log w_{ijt}$ is the log hourly wage of worker *i* in firm *j* at time *t*. We capture time invariant unobserved worker and firm heterogeneity by including fixed effects for each pair of worker and firm, α_{ij}. As a result, identification is based on within-firm variation in outsourcing over time for workers staying in the firm. We treat firm-level outsourcing and exports as endogenous and instrument for them using exchange rates, tariffs, transportation costs, and world export supply (for outsourcing) and world import demand (for exports) as described in Section II.B. Individual-level characteristics such as age, experience, job tenure, and education (some college = high skill; vocational education = medium skill; high school only = low skill), are included in x_{it}. Firm characteristics such as number of employees, gross output, value-added per worker, capital per worker, and the share of high-skilled and share of medium-skilled workers in employment are included in z_{jt}. Finally, we include fixed effects for years, φ_t, regions, φ_R, and industries, φ_{IND}.

Table 4 reports results of the first stage. In column I and III we use instruments constructed with pre-sample weights, that is, the share of input k from country c in the basket of firm j in years before our employment sample. In columns II and IV we use instruments constructed using sample average weights, that is, the over time average share of c-k for firm j. The idea of using over-time average weights is to better fit those firms with significant changes in the input basket over time. For example, if a firm had no inputs sourced from low income countries in the base year then began purchasing in high volume from China in later years, our pre-sample year weighting would miss this change entirely.

We find that all of our instruments are significantly correlated with outsourcing, and all have the predicted signs (except for exchange rates in the pre-sample weights). Their magnitudes are similar whether using pre-sample or average-sample weights. The F-stat on the excluded instruments has a value of 811 in the pre-sample and 1550 in the average sample, which suggests we do not have a weak instruments problem. The "strongest" instruments, in terms of the variation they explain, are the world export supply and transportation cost instruments. This is likely because they exhibit much more time-series variation across inputs and source countries. In contrast, exchange rates and tariff rates are both identified primarily from intra-EU v. extra-EU variation and so have similar effects, and tariffs move over time only for Eastern European countries that receive EU membership late in the sample.

Table 5 compares wage regressions estimated in three ways. The first two columns treat outsourcing and exporting as exogenous and provide OLS (omitting α_{ij} and so exploiting variation over all workers, firms and time periods) and job-spell fixed effects (exploiting only within worker-firm variation) estimation. The third and fourth columns report IV estimates with job-spell fixed effects included, using pre-sample weights or average sample weights.

When ignoring the endogeneity of outsourcing we find a negative effect on wages in the OLS specification and a positive effect in the FE estimates, but the magnitudes are very small in both cases. However, when instrumenting for outsourcing the impact is an order of magnitude larger. Doubling outsourcing lowers a worker's wage by 4 to 5%. This is a sizeable impact, comparable to losing 10 years of employment in the firm.

In Table 6 we explore whether the effect of outsourcing depends on worker education levels as well as interactions with the source country of imported inputs. In the first two columns we interact worker education level and outsourcing in the aggregate. In the last two columns we exploit the special nature of our data and the ability to discern from where each input is purchased. We split outsourcing into high and low income sources (separately instrumenting for each) and include interactions with worker skill. All the previously included control variables are included in these regressions, but are omitted from the table for brevity.

In the first two columns we find that aggregate outsourcing reduces wages at all education levels, but the effect is most pronounced for medium skill workers. The last two columns indicate that the source country composition of outsourcing has important composition effects. The results using pre-sample weights are especially interesting because they show results broadly consistent with a factor proportions view of outsourcing. An exogenous shock to outsourcing from low income countries depresses the wage of low and medium skill workers and raises the wage of high skill workers. An exogenous shock to outsourcing from high income countries does the opposite, depressing the wages of high skill workers and raising the wages of low and medium skill workers.

IV. Wage Effects by Occupation and Task Characteristics

Our data also contains information on the occupations of each worker, which we can use to separately identify the impact of outsourcing by occupational category and associated characteristics. We interact outsourcing with occupational categories and estimate

(3) $$\log w_{ijt} = \alpha_{ij} + \sum_{p} \gamma_{1p} D_p \ln(OUTS_{jt}) + \gamma_2 \ln(EXP_{jt}) + x_{it}\beta + z_{jt}\gamma + \varphi_t + \varphi_{IND} + \varphi_R + + \varepsilon_{ijt},$$

where p indexes occupations and D_p's are occupational dummies. We estimate equation (3) for all 1- -digit (ISCO-88) occupations and the largest 4-digit (ISCO-88) occupations, as ranked by employment. We explore both pre-sample-weighted and average-sample-weighted instruments and obtain very similar results. Henceforth, we only present the results based on pre-sample weighted instruments.

According to columns 3 and 4 of Table 7, the wage effects of outsourcing are similar across 1-digit occupations, varying from -4.1% to -4.6%. Within 1-digit occupations, however, the wage effects of outsourcing have substantial heterogeneity, as shown by columns 5-9 of Table 7. For example, within "plant and machine operators and assemblers" there are 17 4-digit occupations, and the standard deviation of their γ_{1p} is 19% of the median while the range (max – min) of their γ_{1p} is 79% of the median. Overall, the wage effects of outsourcing vary from -2.0% to -5.9% for 4-digit occupations, suggesting that outsourcing reduces wages across the board.

The left panel of Table 8 shows the 10 4-digit occupations with the smallest wage declines from outsourcing (i.e. the wages of these occupations rise relative to the population of workers employed by manufacturing firms). There is a mix of blue-collar and white-collar occupations on the list, with "authors, journalists and other writers" (2451) topping the list followed by "directors and chief executives" (1210) and "paper-products machine operators" (8253). The right panel of Table 8 shows the 10 4-digit occupations experiencing the greatest declines in wage from outsourcing (i.e. the wages of these occupations decline relative to the population). Again, the list consists of both blue-collar (e.g. meat- and fish-processing-machine operators, 8271) and white-collar (e.g. secretaries, 4115) occupations.

Are there occupational characteristics that can explain the dispersion in estimated wage effects across occupations? To answer this question we relate estimated wage changes by occupation to characteristics of those occupations taken from the O*NET data. For each occupational characteristic *a*, we estimate the following regression across 4-digit occupations *p*,

(4) $$\log \gamma_p = \alpha^a + \delta^a O_p^a + \varepsilon_p^a,$$

The dependent variable is the coefficient on the outsourcing x occupation p interaction taken from estimation of equation (3), and O_p^a is the numerical value of characteristic *a* (e.g. the level of "trunk strength") in occupation p (e.g. "heavy truck and lorry drivers"). We collect, by occupational characteristics *a*, the coefficient δ_a and its t-statistics, plus the R^2 of regression (4).

There are 232 occupational characteristics in the O*NET data. Of these 96 show significant positive correlations with the wage effects. That is, the γ_p for these occupations is closer to zero, so outsourcing has a smaller effect on wages for occupations where the characteristic score is higher. 33 of the characteristics have significant negative correlations, meaning γ_p is further from zero and outsourcing has a larger effect on wages for occupations where the characteristic score is higher. The remaining 103 characteristics show no correlation with the wage effects.

To get a better picture of how the correlations captured by regression equation (4) work, Figure 4 plots the wage effects of outsourcing against the importance of critical thinking. Some blue-collar occupations exhibit a high importance of critical thinking and high wage effects by outsourcing (e.g. "paper products machine operators", 8253, and "printing machine operators", 8251). Some white-collar occupations have low importance for critical thinking and low wage effects by outsourcing (e.g. “secretaries”, 4115, and “other office clerks”, 4190).

Figure 5 plots the wage effects of outsourcing against the importance of trunk strength. Among white-collar occupations trunk strength is more important for “other department managers …” (1239) than for “authors, journalists and other writers” (2451). Among blue-collar occupations the importance for trunk strength for “compositors, typesetters and related workers” (7341) is among the lowest and that by “structural metal preparers and erectors” (7214) among the highest.

Figure 6 plots the wage effects of outsourcing against the frequency of wearing safety gear on the job. There is substantial heterogeneity within both blue-collar (e.g. “heavy truck and lorry drivers”, 8324, versus “dairy-products machine operators”, 8274) and white-collar (e.g. “directors and chief executives”, 1210, versus “other department managers…”, 1239) occupations.

To see these patterns systematically, we first consider those characteristics with a negative correlation with the wage effects of outsourcing (i.e. those with t-stat for δ_a < -1.96).[8]. Out of that set of 33, the right panel of Table 9 reports the 15 with the largest R^2 in regression (4). The occupational characteristics on this list describe the requirements for physical and manual inputs on the job (e.g. trunk strength, manual dexterity, arm-hand steadiness, and write-figure speed), or the degree to which workers are exposed to hazardous conditions and job-related injuries (e.g. “wearing common protective or safety equipment…”, and “exposed to minor burns, cuts, bites, or stings”).

[8] For the characteristics with both the level and importance metrics we report the metric with the higher R^2. The choice of metric has no effect on the statistical significance of the correlation (i.e. for a given occupational characteristic, the level metric has significant correlation with wage effects if and only if the importance metric does).

Next consider those occupational characteristics with significant and positive correlations with the wage effects of outsourcing (i.e. those with t-stat for $\delta_a > 1.96$). Out of that set of 96, the left panel of Table 9 reports the 15 with the largest R^2 in regression (4). Some of these occupational characteristics describe the requirements of mental inputs (e.g. critical thinking, initiative, "developing objectives and strategies", and originality), some describe language skills (e.g. native language, writing, and reading comprehension), and some others describe inter-personal interactions (e.g. "communicating with persons outside organization", social perceptiveness, and persuasion).

Notably, knowledge and skills in natural sciences and engineering (e.g. mathematics, chemistry) fail to make the list on the left panel of Table 9. To further explore this point we focus on the levels of the occupational characteristics in the category "Knowledge" as they closely resemble types of college and graduate degrees. Table 10 lists the interpretations of the level metric for several "Knowledge" occupational characteristics. While low levels probably involve high-school education or less (e.g. level 14 mathematics is "add two numbers" and level 29 engineering is "install a door lock"), higher levels involve college or graduate education (e.g. level 57 economics and accounting is "develop financial investment programs for individual clients" and level 100 biology is "isolate and identify a new virus").

Figures 7 and 9 plot the wage effects of outsourcing against "native language" and "economics and accounting", respectively. Both show positive correlations between the estimated wage effects and characteristic intensities. Figure 8 is a similar scatter plot for mathematics and it shows no correlation between wage effects and characteristic intensities. Table 11 shows, for all the occupational characteristics in the category

“Knowledge”, their R^2 and t-stats for δ_a from regression (4). The left panel displays social sciences and language. 14 out of 19 characteristics have positive and significant correlations with the wage effects of outsourcing, including “history and archeology”, “sociology and anthropology”, “fine arts”, and “psychology”. The right panel has natural sciences and engineering and 11 out of 14 show no correlation, including “engineering and technology”, physics, chemistry and biology. This suggests that advanced degrees in social sciences and language are relatively well insulated from the wage effects of outsourcing shocks. However, workers employed in occupations that require knowledge of natural sciences and engineering are no more insulated from outsourcing shocks than the typical manufacturing worker. Not all degrees are created equal.

V. Worker outcomes: employment transitions (incomplete)

Our wage regressions focus on those workers who remain employed at the firm engaging in increased outsourcing. It therefore misses any effects for those workers who experience job separations, a category for which wage effects may be even more pronounced. As a starting point we examine whether an outsourcing shock affects the probability of separation.

The estimation is similar to the wage regressions, but with a few important differences. We define a dummy variable that is equal to 0 if the worker in period t+1 remains with his/her current period t firm and 1 otherwise. In other words if a worker in the next period relocates to another firm, becomes unemployed or leave the labor force, this “separation”-dummy is equal to 1. Note that we cannot discern whether a worker voluntarily separates from his/her employer, but we do observe if he or she leaves for a new job, for unemployment or for nonparticipation. (For those who take a new job we can also identify their new wage, along with the characteristics of their new employer and occupation. We plan to exploit this information in future drafts.)

With a binary outcome variable the natural specification of the empirical model could either be a probit, logit or duration model. However, we want to exploit the unique nature of our data to control for unobserved worker heterogeneity with fixed effects and to instrument for our endogenous variable of interest, outsourcing. To the best of our knowledge a non-linear model handling these issues is yet to be developed.[9] Therefore we will proceed by estimating a linear probability model for our employment outcome variable resembling the approach for wages in equation (2). In principle this could create a problem with predicted values that are outside the (0,1) bounds, but we think it may nevertheless be a good approximation.

Our estimating equation is

(4) $$SEP_{ijt} = \alpha_i + \gamma_1 \ln(OUTS_{jt}) + \gamma_2 \ln(EXP_{jt}) + x_{it}\beta + z_{jt}\gamma + \varphi_t + \varphi_{IND} + \varphi_R + +\varepsilon_{ijt},$$

Note that we now have worker, rather than worker-firm fixed effects, since within a "job-spell" the separation variable is always 0 by definition. We follow the progression of the wage regressions, incorporating outsourcing in levels, then interacted with worker skill, interacted with outsourcing by country income level, and finally interacting with occupation characteristics.

Table 12 shows the OLS, FE, and IV-FE estimates for separations. As with wages, the OLS and FE estimates that ignore the endogeneity of outsourcing find minimal effects on

[9] Two recent papers study the impact of industry level outsourcing on individual labor market transitions. Egger et al. (2007) estimate a multinomial logit model with worker fixed effects, and Munch (2009) estimates a proportional hazard duration model with worker random effects. None of these papers deal with unobserved firm heterogeneity or endogenous outsourcing.

separation probabilities. However, the IV estimates show that doubling outsourcing results in between a 5 and 10 percent increased probability of separation. Table 13 shows that these separation probabilities do not vary much over skill types.

VI. Conclusions and Future Directions

We employ a unique matched worker-firm dataset from Denmark to measure how outsourcing shocks affect wages and employment at the worker level. Because we observe the specific products and source countries for imported inputs purchased by Danish firms we can construct instruments for outsourcing decisions that are time varying and exogenous to the firm. This allows us to identify the causal effect of outsourcing on worker's wages and employment transitions.

Our key findings are these. One, exogenous outsourcing shocks lower wages and increase the probability of separation for workers. Two, controlling for the endogeneity of outsourcing is critical. Instrumental variables estimates of the effect of outsourcing on wages yield either different signs or coefficients an order of magnitude larger than those found when estimating these effects using OLS or worker-firm fixed effects. Three, the source of imported inputs interacts with the skill composition of the worker in a way broadly consistent with factor proportions theory. Increasing purchases from high income countries lowers wages for high skill workers while raising wages for low skill workers. The reverse occurs when inputs are sourced from low income countries. Four, wage and separation effects vary significantly across occupational categories in a way that is broadly consistent with the insights of Autor et al. That is, occupations employing cognitive skills are less sensitive to outsourcing pressures than are occupations that require physical labor or manual dexterity.

Exploring occupational characteristics allows us to identify two additional and unique relationships. First, occupations that expose workers to potentially unsafe working condition experience wage drops after outsourcing. Second, not all degrees are created equal. Occupations that intensively employ knowledge sets from social science and languages are systematically less affected by outsourcing shocks, while those that employ knowledge sets from natural sciences and engineering are no more or less insulated from outsourcing shocks than the average manufacturing worker.

All of our wage results condition on workers remaining employed within the outsourcing firm. Our separation regressions show this misses an important set of workers, those who separated from firms in the aftermath of an outsourcing shock. In future drafts of this work we intend to more carefully track what happens to those displaced workers. We can then estimate how the associated wage effects depend on transitions to new firms and new occupations, and whether they are larger or smaller than those estimated for workers who remain employed.

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Figure 1: The Growth in Outsourcing for Denmark

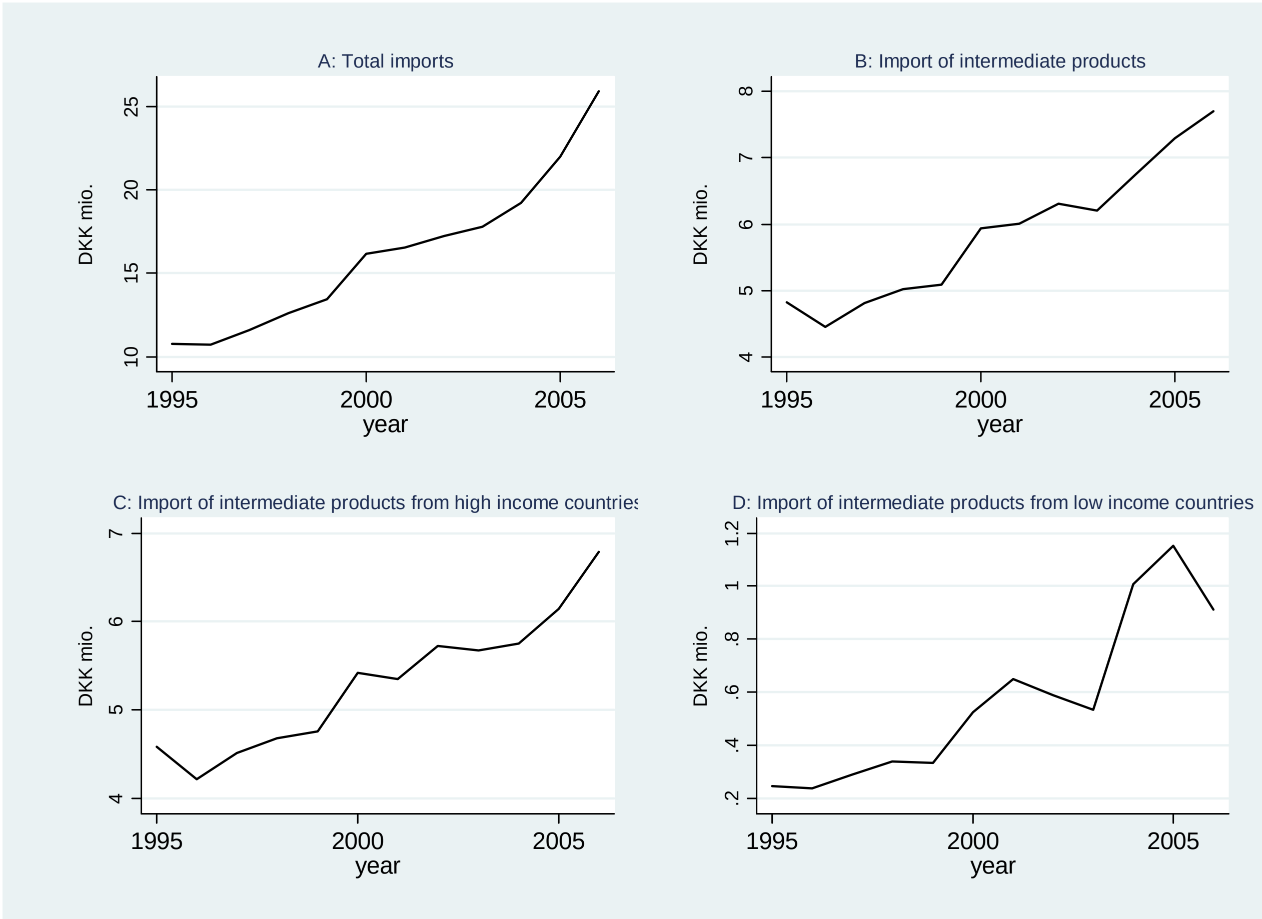

Figure 2: The Distribution of Outsourcing Across Firms and Over Time

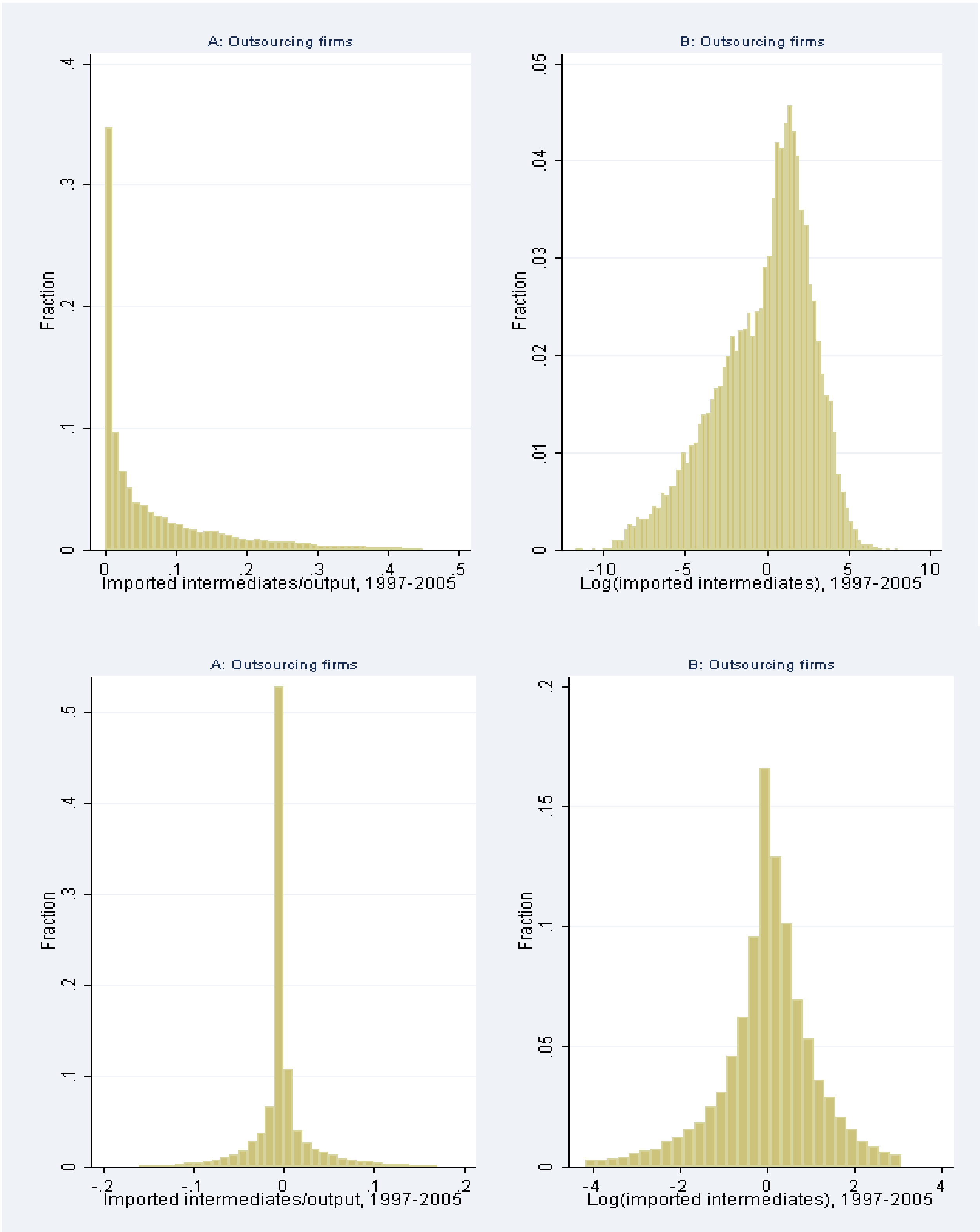

Figure 3: Oil Prices and the Transportation Cost Instrument

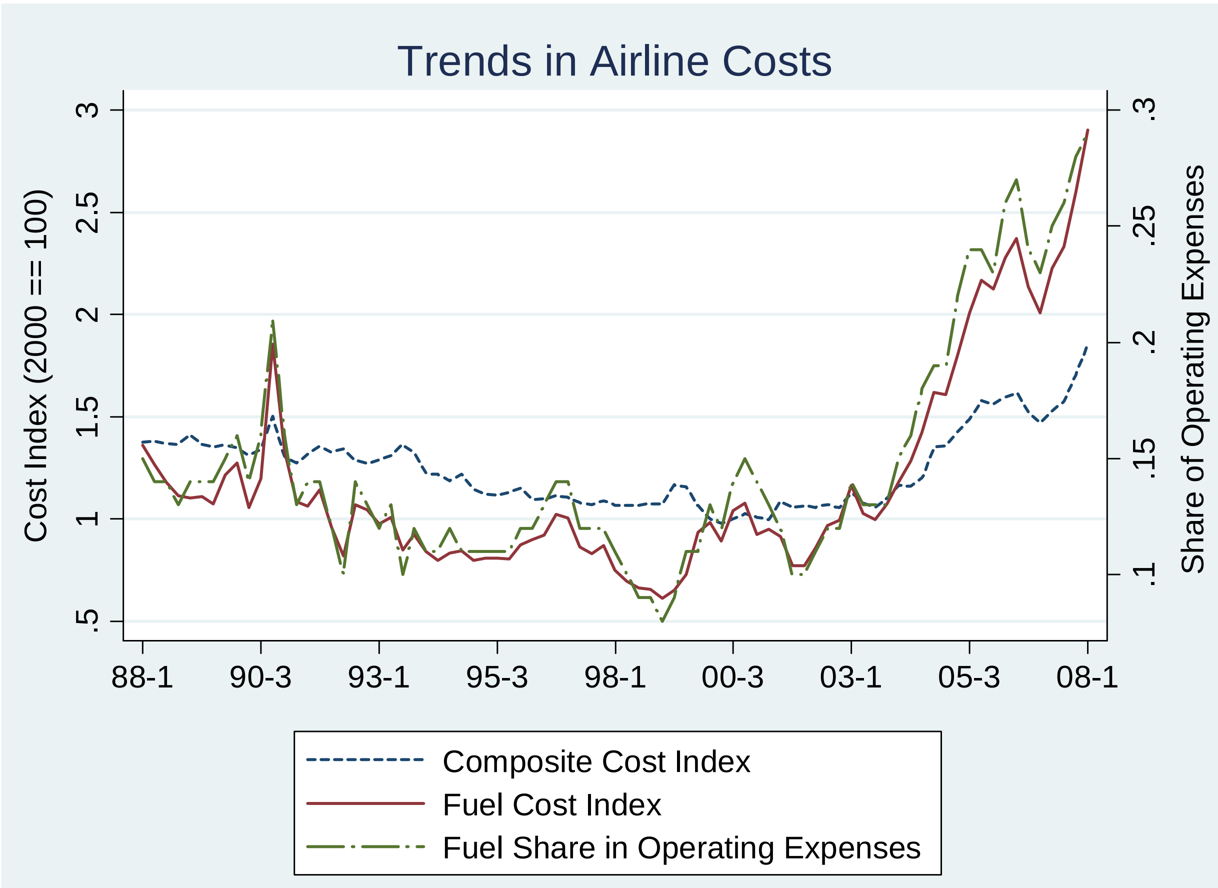

Figure 4 Correlation of Wage Effects with Critical Thinking

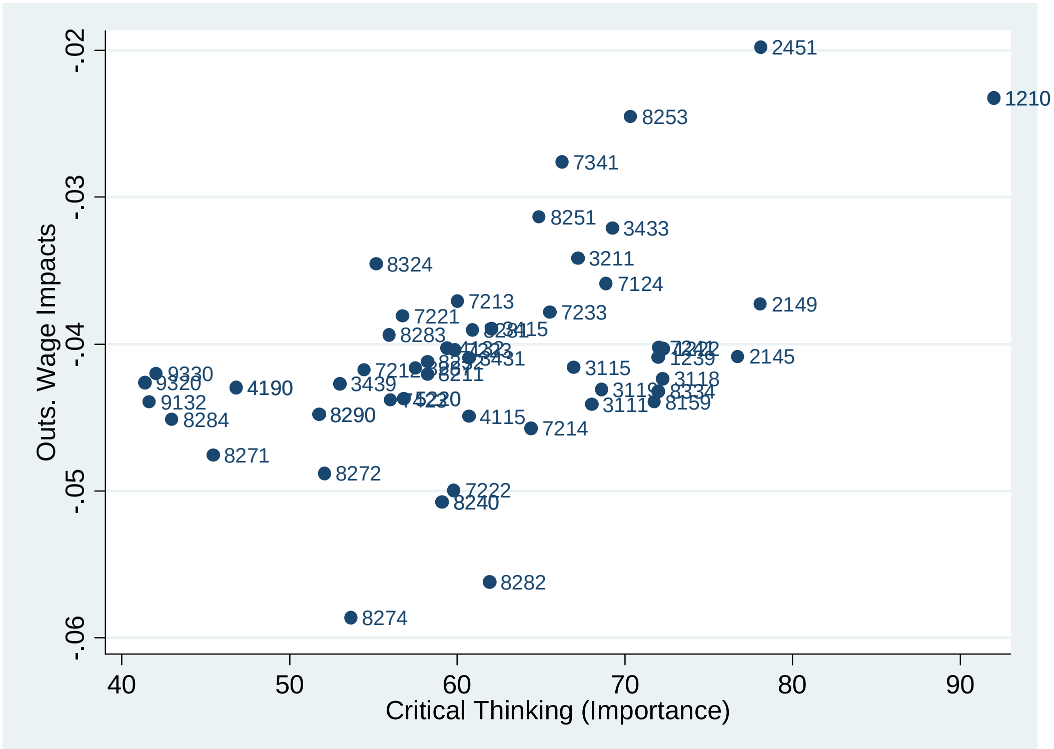

Figure 5 Correlation of Wage Effects with Trunk Strength

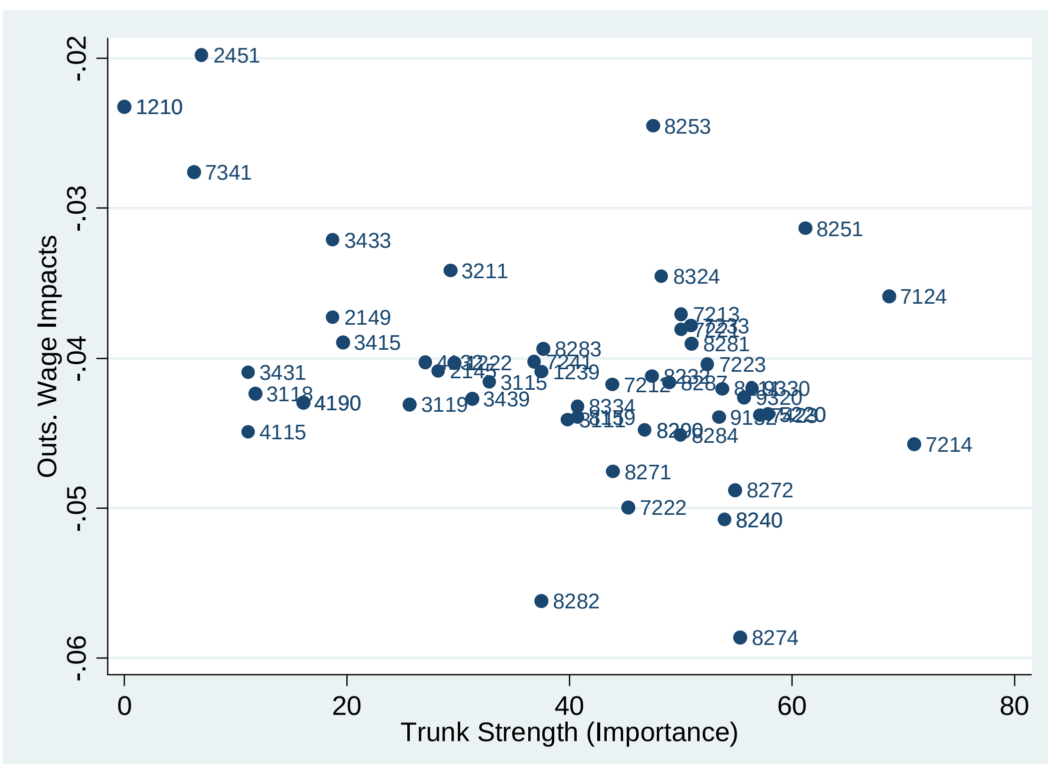

Figure 6 Correlation of Wage Effects with Safety Gear

Figure 7 Correlation of Wage Effects with Native Language

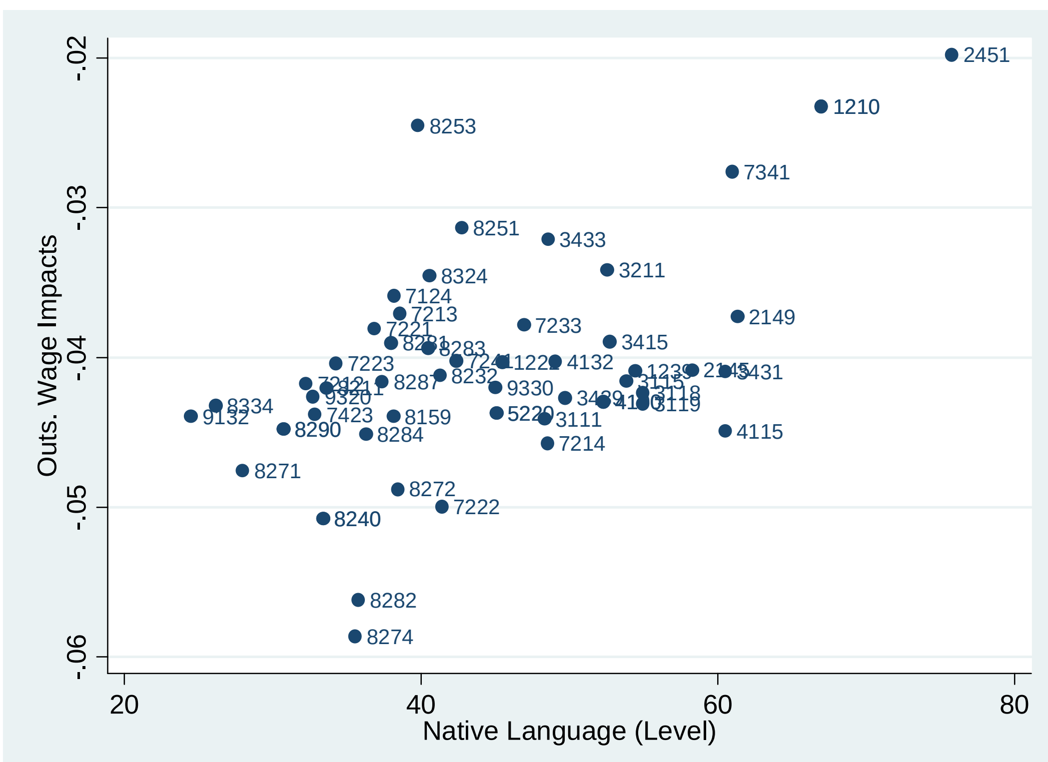

Figure 8 Correlation of Wage Effects with Mathematics

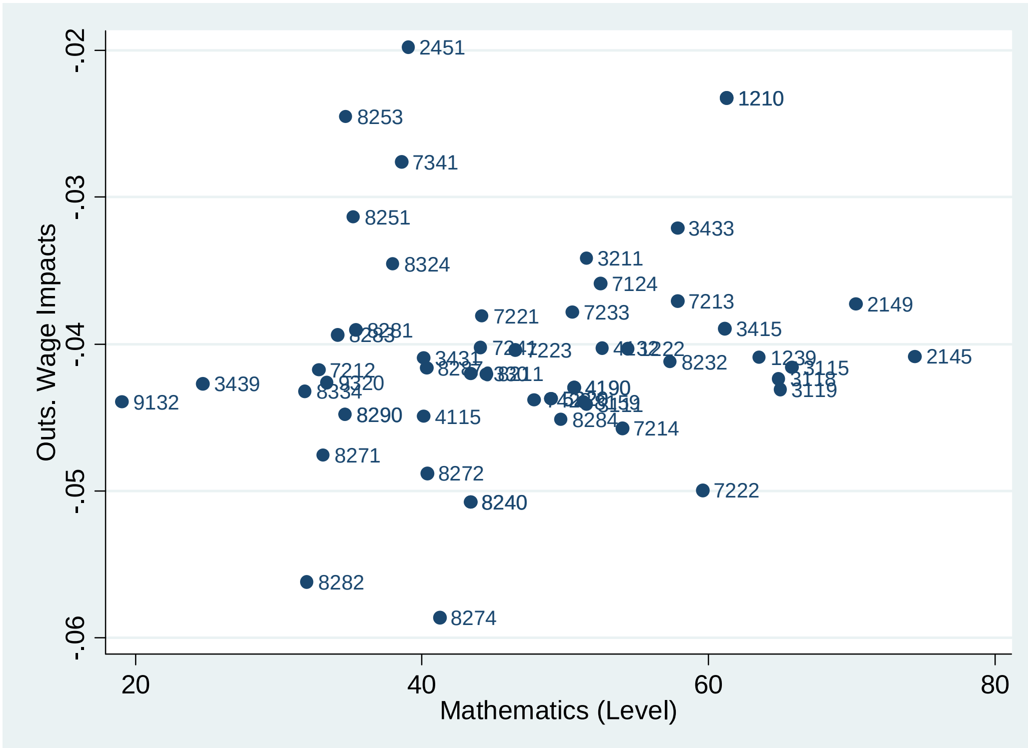

Figure 9 Correlation of Wage Effects with Economics and Accounting

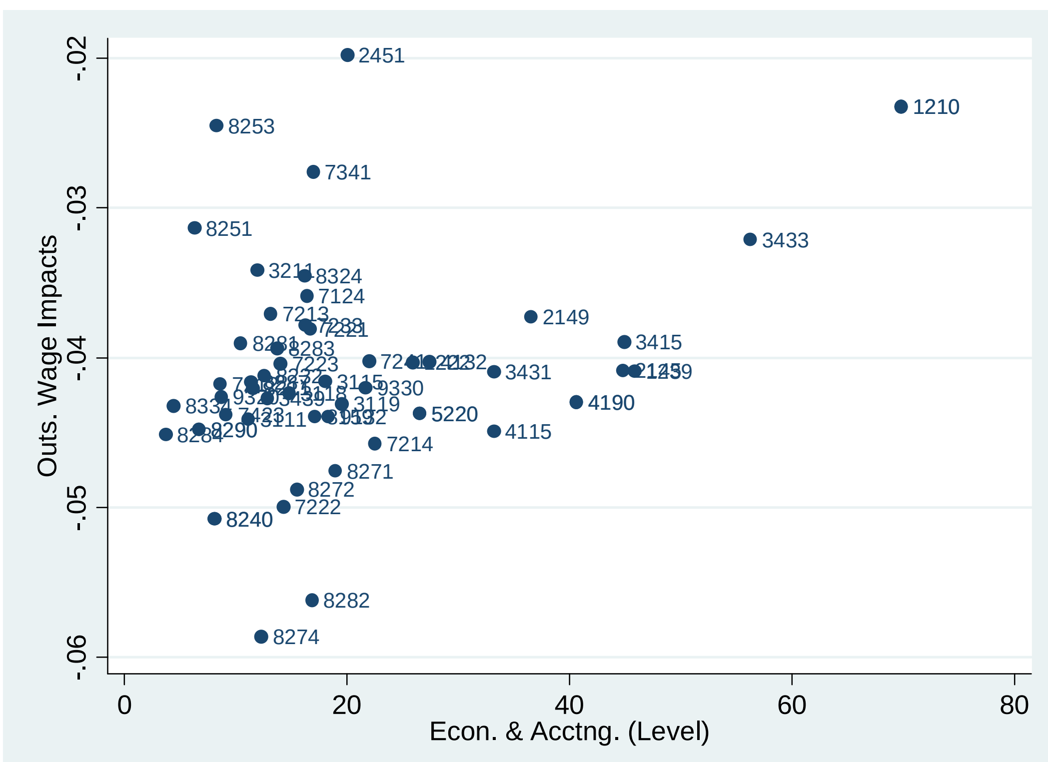

Table 1: Labor market characteristics for selected countries

	Denmark	France	Germany	UK	US
Union density (%, 1996-1998)	76	10	27	35	14
Collective bargaining coverage (%, 1994)	69	95	92	40	17
Co-ordination index (1995-1999)	2.00	1.50	2.50	1.00	1.00
Employment protection index (1998)	0.70	1.40	1.30	0.35	0.10
UI replacement ratio (1999)	0.66	0.59	0.37	0.17	0.29
Expenditure on ALMP (% of GDP, 1998)	1.66	1.30	1.26	0.34	0.17

Source: Nickell, Nunziata and Ochel (2005).

Notes: The co-ordination index measures the extent to which employment implications of wage determination are taken into account in wage negotiations. The employment protection index measures the strictness of employment protection legislation.

Table 2: Summary statistics for the sample of manufacturing firms with imports >0

Year	# Firms	# Employees	Share of manufacturing firms	Share of manufacturing employment	# Imported HS6 products	# Imported HS6 products *x* exporter country
1995	4,560	276,153	0.154	0.665	43,073	66,599
1996	4,534	275,096	0.157	0.670	42,916	66,706
1997	4,516	282,146	0.164	0.692	42,112	65,769
1998	4,571	292,368	0.166	0.707	44,755	69,827
1999	4,611	301,899	0.170	0.741	47,680	74,494
2000	4,681	310,903	0.203	0.756	49,285	77,832
2001	4,723	311,553	0.210	0.764	52,482	83,064
2002	4,719	310,007	0.222	0.788	53,244	84,595
2003	4,794	301,498	0.201	0.796	54,338	86,523
2004	4,810	297,872	0.205	0.817	55,151	88,831
2005	4,843	293,970	0.207	0.829	55,545	89,895
2006	4,874	296,717	0.208	0.833	59,200	95,779

Table 3: Characteristics of outsourcing firms in 2005

	Outsourcing firms	
Log employment	1.147	-
Log employment, low-skilled	0.979	0.051
Log employment, medium-skilled	0.913	-0.080
Log employment, high-skilled	0.993	0.115
Log total sales	1.410	0.239
Log value-added per worker	0.092	0.086
Log capital per worker	0.078	0.022
Log wage bill per worker	0.057	0.036
Controls:	None	Industry fixed effects, log employment

Note: All results are from regressions of the firm characteristics in the first column on a dummy indicating the outsourcing status.

Table 4: First stage FE-IV regressions

	Log(Outsourcing)		Log(Exports)	
	Pre-sample weights	Average weights	Pre-Sample Weights	Average weights
Log(World Export Supply), outsourcing	0.1339***	0.3524***	-0.0646***	0.1062***
	[46.20]	[83.12]	[-21.74]	[24.48]
Log(1+Tariff), outsourcing	-2.2991***	-2.8599	-1.7016***	11.3881***
	[-5.43]	[-1.29]	[-3.96]	[5.05]
Log(Exchange rate), outsourcing	-0.1412***	0.4481***	0.0624***	0.5465***
	[-9.69]	[27.51]	[4.17]	[32.76]
Log(Transport cost), outsourcing	-5.4263***	-4.7099***	-3.9552***	-4.8095***
	[-26.82]	[-23.43]	[-19.03]	[-23.28]
Log(World Import Demand), exports	-0.0662***	-0.0501***	0.2566***	0.3937***
	[-23.36]	[-19.83]	[87.49]	[150.93]
Log(1+Tariff), exports	1.7376***	2.7856***	1.1359***	4.3329***
	[34.84]	[44.91]	[22.20]	[67.32]
Log(Exchange rate), exports	-0.2696***	-0.4927***	0.6282***	0.7794***
	[-20.76]	[-32.80]	[47.34]	[49.56]
Log(Transport cost), exports	10.6636***	9.0083***	3.4196***	1.8923***
	[42.87]	[36.54]	[13.39]	[7.47]
Log(Output)	0.1914***	0.1751***	0.2623***	0.2456***
	[82.19]	[75.21]	[110.62]	[103.65]
Log(Employment)	0.6056***	0.6001***	0.6167***	0.6182***
	[171.42]	[171.78]	[170.94]	[173.35]
Log(Value-added per worker)	-0.0618***	-0.0559***	0.0665***	0.0672***
	[-28.02]	[-25.47]	[29.56]	[30.05]
Log capital per worker	0.0028*	0.0026*	-0.0394***	-0.0086***
	[1.81]	[1.72]	[-25.26]	[-5.52]
Share of high-skilled workers	-0.3547***	-0.2850***	-0.7481***	-0.7983***
	[-14.15]	[-11.43]	[-29.03]	[-31.13]
Share of medium-skilled workers	0.1065***	0.0906***	0.4445***	0.4251***
	[4.89]	[4.19]	[19.68]	[18.93]
High-skilled worker	0.0147	0.0112	-0.0834***	-0.0853***
	[1.36]	[1.03]	[-7.55]	[-7.74]
Medium-skilled worker	0.0024	0.0011	-0.0065	-0.0154**
	[0.33]	[0.15]	[-0.88]	[-2.10]
Age	-0.0061***	-0.0163***	0.0552***	0.0364***
	[-3.24]	[-8.68]	[28.85]	[18.96]
Age2	0.0001***	0.0001***	-0.0002***	-0.0001***
	[3.62]	[3.53]	[-8.65]	[-7.39]
Experience	-0.0130***	-0.0130***	-0.0018	-0.0012
	[-8.88]	[-8.91]	[-1.19]	[-0.80]
Experience2	0.0000	0.0000	0.0001***	0.0001***
	[0.56]	[1.06]	[2.71]	[4.34]
Tenure	0.0095***	0.0095***	0.0023***	0.0040***
	[20.80]	[20.80]	[4.96]	[8.67]
Tenure2	-0.0001***	-0.0001***	-0.0003***	-0.0004***
	[-4.35]	[-4.43]	[-11.93]	[-19.51]
Union member	-0.0066**	-0.0076**	0.0030	0.0058*
	[-2.09]	[-2.42]	[0.93]	[1.81]
Married	-0.0051*	-0.0041	0.0003	-0.0003
	[-1.96]	[-1.57]	[0.13]	[-0.13]
Observations	2,204,007	2,211,510	2,171,657	2,178,448
Number of job spells	615,344	618,016	608,349	610,926
F-statistics of instruments	810.82***	1,550.00***	1,362.68***	7,284.78***
R-squared	0.0657	0.0691	0.1104	0.1215

Note: *** p<0.01, ** p<0.05, * p<0.1. All specifi

Table 5: Worker-Level Wage Regressions

	Dependent variable: worker-level hourly wage			
			FE-IV	
	OLS	Job Spell Fixed Effects	Pre-Sample Weights	Sample Average Weights
Firm-level variables:				
Log(outsourcing)	-0.0039***	0.0014***	-0.0424***	-0.0533***
	[-28.12]	[10.75]	[-19.31]	[-33.41]
Log(exports)	-0.0044***	0.0035***	0.0273***	0.0275***
	[-51.05]	[27.80]	[16.50]	[28.63]
Log(Output)	0.0359***	0.0122***	0.0141***	0.0160***
	[78.70]	[31.18]	[17.93]	[30.35]
Log(Employment)	-0.0166***	0.0143***	0.0247***	0.0312***
	[-36.05]	[23.84]	[12.43]	[26.51]
Log(Value-added per worker)	0.0240***	0.0022***	-0.0025***	-0.0029***
	[46.11]	[6.02]	[-6.02]	[-7.23]
Log capital per worker	0.0060***	0.0041***	0.0048***	0.0049***
	[26.54]	[16.07]	[18.23]	[18.64]
Share of high-skilled workers	0.3138***	0.0420***	0.0477***	0.0405***
	[155.03]	[10.00]	[10.48]	[9.28]
Share of medium-skilled workers	0.4430***	-0.0087**	-0.0106***	-0.0075**
	[218.71]	[-2.40]	[-2.76]	[-2.00]
Worker-level variables:				
High-skilled worker	0.2983***	0.3280***	0.3323***	0.3323***
	[579.19]	[180.06]	[178.82]	[179.35]
Medium-skilled worker	0.0687***	0.3546***	0.3554***	0.3554***
	[183.27]	[290.88]	[287.02]	[287.34]
Age	0.0239***	0.0375***	0.0360***	0.0361***
	[137.73]	[119.14]	[107.96]	[111.67]
Age2	-0.0003***	-0.0002***	-0.0002***	-0.0002***
	[-147.17]	[-68.53]	[-65.65]	[-65.67]
Experience	0.0078***	0.0017***	0.0011***	0.0009***
	[80.34]	[6.93]	[4.33]	[3.75]
Experience2	-0.0000***	-0.0002***	-0.0002***	-0.0002***
	[-10.19]	[-49.72]	[-48.77]	[-48.75]
Tenure	0.0084***	0.0044***	0.0048***	0.0049***
	[96.47]	[57.40]	[59.00]	[61.51]
Tenure2	-0.0003***	-0.0002***	-0.0002***	-0.0002***
	[-75.55]	[-53.05]	[-51.09]	[-51.58]
Union member	-0.1005***	0.0044***	0.0040***	0.0039***
	[-199.68]	[8.20]	[7.29]	[7.22]
Married	0.0197***	0.0011**	0.0009*	0.0008*
	[54.33]	[2.57]	[1.95]	[1.80]
Observations	2,267,212	2,267,212	2,171,657	2,178,448
No. job spells		646,586	608,349	610,926
R2	0.3405	0.2030	0.2051	0.2052

Note: *** p<0.01, ** p<0.05, * p<0.1. All specifications include industry, time and regional fixed effects.

Table 6: Worker-Level Wage Regressions: Skill Interactions

	FE-IV			
	Pre-Sample Weights	Sample Average Weights	Pre-Sample Weights	Sample Average Weights
Worker-level variables:				
High-skilled worker	0.3344***	0.3495***	0.4062***	0.3761***
	[21.66]	[22.96]	[20.16]	[22.59]
Medium-skilled worker	0.4282***	0.4502***	0.2781***	0.3881***
	[40.81]	[43.39]	[20.04]	[33.05]
Log(outsourcing) x low-skilled	-0.0210***	-0.0307***		
	[-16.01]	[-27.05]		
Log(outsourcing) x medium-skilled	-0.0253***	-0.0362***		
	[-18.19]	[-30.11]		
Log(outsourcing) x high-skilled	-0.0211***	-0.0317***		
	[-13.88]	[-23.52]		
Log(outsourcing, high income) x low-skilled			0.0193***	-0.0114***
			[11.50]	[-8.98]
Log(outsourcing, high income) x medium-skilled			0.0151***	-0.0188***
			[8.62]	[-14.08]
Log(outsourcing, high income) x high-skilled			-0.0076***	-0.0330***
			[-3.95]	[-22.17]
Log(outsourcing, low income) x low-skilled			-0.0125***	-0.0030***
			[-20.18]	[-6.62]
Log(outsourcing, low income) x medium-skilled			-0.0029***	0.0037***
			[-4.76]	[8.81]
Log(outsourcing, low income) x high-skilled			0.0153***	0.0211***
			[23.49]	[42.64]
Observations	2,171,657	2,178,448	1,057,737	1,641,494
No. job spells	608,349	610,926	293,971	499,210
R2	0.2051	0.2051	0.2103	0.2062

Note: *** p<0.01, ** p<0.05, * p<0.1. All specifications include industry, time and regional fixed effects.

Table 7 Wage Effects of Outsourcing by Occupation: Summary Statistics

				4-digit Occupations				
Occup. Code	Occupation Title	Outsourc. Impact	t Stat	median	sd/median	(max-min) / median	fraction sig. coeff.	Nos. Of sub_cat.
1	Legislators, senior officials and managers	-0.041	-18.2	-0.040	-0.249	-0.438	1	3
2	Professionals	-0.041	-18.0	-0.037	-0.302	-0.565	1	3
3	Technicians and associate professionals	-0.044	-20.0	-0.042	-0.101	-0.289	1	9
4	Clerks	-0.044	-19.6	-0.043	-0.054	-0.108	1	3
5	Service workers and shop and market sales workers	-0.045	-19.2	-0.044	0.000	0.000	1	1
6	Skilled agricultural and fishery workers	-0.041	-16.6					
7	Craft and related trades workers	-0.042	-19.0	-0.040	-0.144	-0.556	1	11
8	Plant and machine operators and assemblers	-0.046	-21.2	-0.043	-0.194	-0.789	1	17
9	Elementary occupations	-0.043	-19.4	-0.043	-0.023	-0.045	1	3

Table 8 Occupations with the Highest and Lowest Wage Effects by Outsourcing

Smallest Wage Declines				Largest Wage Declines			
Occup. Code	Occupation Titles	Wage Effects	Wage t-stat	Occup. Code	Occupation Titles	Wage Effects	Wage t-stat
2451	Authors, journalists and other writers	-0.020	-3.4	8290	Other machine operators and assemblers	-0.045	-15.8
1210	Directors and chief executives	-0.023	-5.1	4115	Secretaries	-0.045	-15.6
8253	Paper-products machine operators	-0.025	-6.6	8284	Metal-, rubber- and plastic-products assemblers	-0.045	-15.6
7341	Compositors, typesetters and related workers	-0.028	-6.3	7214	Structural-metal preparers and erectors	-0.046	-15.3
8251	Printing-machine operators	-0.031	-7.6	8271	Meat- and fish-processing-machine operators	-0.048	-16.7
3433	Bookkeepers	-0.032	-9.1	8272	Dairy-products machine operators	-0.049	-13.3
3211	Life science technicians	-0.034	-10.3	7222	Tool-makers and related workers	-0.050	-17.2
8324	Heavy truck and lorry drivers	-0.035	-9.8	8240	Wood-products machine operators	-0.051	-17.0
7124	Carpenters and joiners	-0.036	-11.9	8282	Electrical-equipment assemblers	-0.056	-14.1
7213	Sheet metal workers	-0.037	-11.9	8274	Baked-goods, cereal and chocolate-products machine operators	-0.059	-13.3

Table 9 Occupational Characteristics with the Largest Positive and Negative Correlations with the Wage Effects of Outsourcing

Positive Correlations				Negative Correlations			
Characteristics Name	Metric	R2	t_stat	Characteristics Name	Metric	R2	t_stat
Native Language	Importance	0.352	5.4	Trunk Strength	Level	0.210	-3.8
Writing	Level	0.321	5.0	Manual Dexterity	Importance	0.194	-3.6
Critical Thinking	Importance	0.316	5.0	Handling and Moving Objects	Importance	0.188	-3.5
Communicating with Persons Outside Organization	Level	0.314	4.9	Arm-Hand Steadiness	Level	0.177	-3.4
Organizing, Planning, and Prioritizing Work	Level	0.311	4.9	Wrist-Finger Speed	Importance	0.175	-3.4
Achievement/Effort	Importance	0.308	4.9	Performing General Physical Activities	Importance	0.155	-3.1
Social Perceptiveness	Level	0.285	4.6	Wear Common Protective or Safety Equipment such as Safety Shoes, Glasses …	Frequency	0.146	-3.0
Reading Comprehension	Level	0.284	4.6	Exposed to Minor Burns, Cuts, Bites, or Stings	Frequency	0.146	-3.0
Persistence	Importance	0.282	4.6	Controlling Machines and Processes	Importance	0.143	-3.0
Developing Objectives and Strategies	Importance	0.280	4.5	Spend Time Using Your Hands to Handle, Control, or Feel Objects, Tools, or Controls	Frequency	0.139	-2.9
Persuasion	Importance	0.259	4.3	Extent Flexibility	Importance	0.134	-2.9
Initiative	Importance	0.255	4.3	Physical Proximity	Frequency	0.133	-2.9
Communications and Media	Level	0.252	4.2	Spend Time Bending or Twisting the Body	Frequency	0.127	-2.8
Originality	Importance	0.251	4.2	Gross Body Coordination	Level	0.121	-2.7
Time Management	Level	0.248	4.2	Static Strength	Importance	0.112	-2.6

Table 10 Interpretations for Levels of Knowledge

Characteristics Name	Level	Interpretation
Economics and Accounting	29	Answer billing questions from credit card customers
Economics and Accounting	57	Develop financial investment programs for individual clients
Economics and Accounting	86	Keep a major corporation's financial records
Engineering and Technology	29	Install a door lock
Engineering and Technology	57	Design a more stable grocery cart
Engineering and Technology	86	Plan for the impact of weather in designing a bridge
Mathematics	14	Add two numbers
Mathematics	57	Analyze data to determine areas with the highest sales
Mathematics	86	Derive a complex mathematical equation
Biology	14	Feed domestic animals
Biology	71	Investigate the effects of pollution on marine plants and animals
Biology	100	Isolate and identify a new virus
Native Language	29	Write a thank you note
Native Language	57	Edit a feature article in a local newspaper
Native Language	86	Teach a college Native language class

Table 11 Correlation of Knowledge Levels with Wage Effects of Outsourcing

Social Science and Language			Natural Science and Engineering		
Characteristic name	R2	t-stat	Characteristic name	R2	t-stat
Administration and Management	0.156	3.1	Transportation	0.020	1.0
Clerical	0.044	1.6	Production and Processing	0.025	-1.2
Economics and Accounting	0.147	3.0	Food Production	0.018	-1.0
Sales and Marketing	0.106	2.5	Computers and Electronics	0.095	2.4
Customer and Personal Service	0.089	2.3	Engineering and Technology	0.012	-0.8
Personnel and Human Resources	0.069	2.0	Building and Construction	0.001	0.2
Design	0.000	0.0	Mechanical	0.017	-0.9
Psychology	0.105	2.5	Mathematics	0.023	1.1
Sociology and Anthropology	0.110	2.6	Physics	0.001	-0.3
Therapy and Counseling	0.090	2.3	Chemistry	0.011	-0.8
Education and Training	0.060	1.8	Biology	0.010	0.7
English Language	0.305	4.8	Geography	0.124	2.7
Foreign Language	0.000	-0.1	Medicine and Dentistry	0.114	2.6
Fine Arts	0.162	3.2	Telecommunications	0.028	1.2
History and Archeology	0.186	3.5			
Philosophy and Theology	0.164	3.2			
Public Safety and Security	0.008	0.6			
Law and Government	0.144	3.0			
Communications and Media	0.252	4.2			

Table 12: Worker-Level Separation Regressions

	Dependent variable: worker-level separation indicator			
			FE-IV	
	OLS	Worker Fixed Effects	Pre-Sample Weights	Sample Average Weights
Firm-level variables:				
Log(outsourcing)	0.0071***	0.0020***	0.1011***	0.0577***
	[31.94]	[5.44]	[25.54]	[15.82]
Log(exports)	-0.0059***	-0.0088***	-0.0042***	-0.0128***
	[-42.53]	[-41.93]	[-9.57]	[-31.84]
Log(Output)	0.0096***	0.0008	-0.0240***	-0.0110***
	[12.93]	[0.74]	[-16.87]	[-7.97]
Log(Employment)	-0.0164***	-0.0210***	-0.0809***	-0.0497***
	[-21.85]	[-17.99]	[-32.81]	[-21.38]
Log(Value-added per worker)	-0.0503***	-0.0384***	-0.0362***	-0.0378***
	[-58.90]	[-35.59]	[-32.60]	[-34.12]
Log capital per worker	-0.0023***	-0.0012**	-0.0093***	-0.0034***
	[-6.51]	[-1.99]	[-11.89]	[-4.41]
Share of high-skilled workers	-0.0717***	-0.1376***	-0.1473***	-0.1527***
	[-21.65]	[-17.12]	[-17.54]	[-18.29]
Share of medium-skilled workers	-0.0766***	-0.1624***	-0.0628***	-0.1139***
	[-23.48]	[-21.49]	[-7.44]	[-13.69]
Worker-level variables:				
High-skilled worker	-0.0260***	-0.0412***	-0.0435***	-0.0438***
	[-31.01]	[-8.32]	[-8.62]	[-8.68]
Medium-skilled worker	-0.0110***	0.0405***	0.0407***	0.0410***
	[-18.14]	[12.13]	[11.96]	[12.06]
Age	-0.0196***	-0.0309***	-0.0295***	-0.0285***
	[-69.62]	[-37.02]	[-34.58]	[-33.49]
Age2	0.0002***	0.0003***	0.0004***	0.0003***
	[70.74]	[38.38]	[39.07]	[38.04]
Experience	-0.0061***	0.0256***	0.0266***	0.0260***
	[-38.33]	[40.66]	[41.27]	[40.41]
Experience2	0.0001***	-0.0003***	-0.0003***	-0.0003***
	[17.84]	[-24.45]	[-26.68]	[-25.30]
Tenure	-0.0221***	0.0292***	0.0290***	0.0291***
	[-152.69]	[142.14]	[138.91]	[139.61]
Tenure2	0.0008***	-0.0007***	-0.0008***	-0.0008***
	[107.37]	[-67.56]	[-67.53]	[-68.19]
Union member	-0.0080***	0.0133***	0.0144***	0.0145***
	[-9.81]	[8.61]	[9.19]	[9.27]
Married	-0.0123***	-0.0027**	-0.0019	-0.0021*
	[-20.85]	[-2.15]	[-1.45]	[-1.65]
Observations	2,061,902	2,061,902	1,980,470	1,986,415
No. job spells		470,100	450,177	451,665
R2	0.0639	0.0428	0.0442	0.0445

Note: *** p<0.01, ** p<0.05, * p<0.1. All specifications include industry, time and regional fixed effects.

Table 13: Worker-Level Separation Regressions

	Dependent variable: worker-level separation indicator			
			FE-IV	
	OLS	Worker Fixed Effects	Pre-Sample Weights	Sample Average Weights
Firm-level variables:				
Log(outsourcing) x low-skilled	0.0061***	0.0030***	0.0751***	0.0458***
	[25.29]	[5.83]	[22.47]	[14.63]
Log(outsourcing) x medium-skilled	0.0067***	0.0017***	0.0718***	0.0429***
	[24.20]	[3.40]	[21.12]	[13.44]
Log(outsourcing) x high-skilled	0.0001	0.0002	0.0637***	0.0344***
	[0.23]	[0.29]	[18.03]	[10.28]
Log(exports)	-0.0058***	-0.0088***	-0.0042***	-0.0128***
	[-41.51]	[-41.98]	[-9.58]	[-31.95]
Log(Output)	0.0103***	0.0008	-0.0172***	-0.0074***
	[13.91]	[0.77]	[-12.89]	[-5.72]
Log(Employment)	-0.0159***	-0.0210***	-0.0646***	-0.0411***
	[-21.15]	[-17.92]	[-29.73]	[-19.74]
Log(Value-added per worker)	-0.0500***	-0.0385***	-0.0373***	-0.0383***
	[-58.56]	[-35.62]	[-33.75]	[-34.69]
Log capital per worker	-0.0017***	-0.0012*	-0.0060***	-0.0016**
	[-4.73]	[-1.87]	[-8.01]	[-2.12]
Share of high-skilled workers	-0.0760***	-0.1388***	-0.1458***	-0.1534***
	[-22.89]	[-17.24]	[-17.37]	[-18.37]
Share of medium-skilled workers	-0.0774***	-0.1629***	-0.0856***	-0.1263***
	[-23.64]	[-21.54]	[-10.27]	[-15.33]
Worker-level variables:				
High-skilled worker	0.0760***	0.0066	0.1494***	0.1517***
	[10.39]	[0.42]	[5.53]	[5.63]
Medium-skilled worker	-0.0208***	0.0637***	0.0954***	0.0900***
	[-3.82]	[5.49]	[4.60]	[4.36]
Age	-0.0194***	-0.0309***	-0.0298***	-0.0287***
	[-69.07]	[-37.03]	[-34.94]	[-33.67]
Age2	0.0002***	0.0003***	0.0004***	0.0003***
	[70.26]	[38.39]	[38.92]	[37.97]
Experience	-0.0062***	0.0256***	0.0264***	0.0259***
	[-39.03]	[40.67]	[40.98]	[40.29]
Experience2	0.0001***	-0.0003***	-0.0003***	-0.0003***
	[18.36]	[-24.46]	[-26.46]	[-25.21]
Tenure	-0.0221***	0.0292***	0.0290***	0.0291***
	[-152.79]	[142.12]	[138.90]	[139.57]
Tenure2	0.0008***	-0.0007***	-0.0008***	-0.0008***
	[107.47]	[-67.54]	[-67.57]	[-68.19]
Union member	-0.0085***	0.0133***	0.0143***	0.0144***
	[-10.38]	[8.60]	[9.12]	[9.21]
Married	-0.0122***	-0.0027**	-0.0020	-0.0022*
	[-20.73]	[-2.14]	[-1.57]	[-1.70]
Observations	2,061,902	2,061,902	1,980,470	1,986,415
No. job spells		470,100	450,177	451,665
R2	0.0639	0.0428	0.0441	0.0445

Note: *** p<0.01, ** p<0.05, * p<0.1. All specifications include industry, time and regional fixed effects.