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Specialization, Outsourcing and Wages*

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Abstract

This paper studies the impact of outsourcing on individual wages. In contrast to the standard approach in the literature, we focus on domestic outsourcing as well as foreign outsourcing. By using a simple theoretical model, we argue that, if outsourcing is associated with specialization gains arising from an increase in the division of labor, domestic outsourcing tends to increase wages for both unskilled and skilled labor. We use a panel data set of workers in Danish manufacturing industries to show that domestic and foreign outsurcing affect wages as predicted by the theory.

Keywords: Outsourcing, Comparative advantage, Specialization, Wages.

JEL Classification: F16, J31, C23.

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1 Introduction

The labor market implications of outsourcing of activities to countries abundant in unskilled labor – such as countries in Eastern Europe and Asia – is a topical issue, and the hypothesis seems to be that unskilled workers in Western Europe and the US have been the losers while skilled workers have gained. This view is supported by much empirical evidence showing that the relative demand of unskilled workers in Western Europe and the US has declined through international specialization (see Feenstra & Hanson (2003) for a survey). This literature is mostly considering how outsourcing affects the relative demand and, in turn, the relative wage of skilled and unskilled labor. The dominating view is that outsourcing is biased towards activities intensive in the use of unskilled labor.

In this paper, we want to divert attention towards another effect of outsourcing, namely specialization gains that may arise as a result of an increase in the division of labor across firms. By using a simple theoretical model, we argue that outsourcing has two different effects; a *comparative advantage effect* and a *division of labor effect.* The comparative advantage effect is due to specialization gains resulting from exploitation of factor endowment differences across countries, and this corresponds to the traditional effect investigated in the literature cited above. The division of labor effect arises if the level of outsourcing within an industry affects the division of labor across firms. This is in line with Duranton & Jayet (2005) who argue that the opportunities to reap gains from the division of labor is limited by the extent of the market, and the extent of the market is, in turn, determined by transportation efficiency. As far as outsourcing is limited by transportation efficiency, the level of outsourcing will to some extent reflect the division of labor. An important difference between the comparative advantage effect and the division of labor effect is that the comparative advantage effect will be skill biased, and primarily benefit the abundant factor in a country, whereas there is no reason to expect the division of labor effect to be skill biased.

Empirically, it is not straightforward to distinguish between the two effects, since foreign outsourcing typically gives rise to a mixture of the two effects. This would be the case if, for example, foreign outsourcing in part is composed of activities shifted out to countries with different skill endowments and in part activities outsourced to countries with similar skill endowments. Domestic outsourcing, on the other hand, is presumably not skill biased and should, as a result, only affect productivity and wages to the extent that it affects the division of labor. Therefore, in contrast to the usual approach in the literature, we focus on the consequences of foreign as well as domestic outsourcing. In our empirical analysis, we consider the Danish labor market, and since Denmark is a skilled

labor abundant country, foreign outsourcing is expected to result in comparative advantage effects which benefit skilled labor and hurt unskilled labor. Domestic outsourcing primarily affects wages if there is a division of labor effect. Hence, domestic outsourcing is expected to be more beneficial for unskilled labor than foreign outsourcing, and domestic outsourcing may raise wages for all workers.

Our empirical results turns out to be surprisingly supportive for the hypothesis that outsourcing has comparative advantage effects as well as division of labor effects. Foreign outsourcing tends to reduce wages for low and medium-skilled workers, while wages of high-skilled workers rise. In contrast, domestic outsourcing tends to increase wages for low and medium-skilled workers, while there is no significant effect on high-skilled wages.

Two different lines of the literature have considered the labor market implications of specialization on the one hand and international outsourcing on the other. In *The Wealth of Nations,* Adam Smith famously argued that specialization gains are realized in larger markets by increasing the division of labor, and an immediate consequence is that workers should be able to command higher wages in larger markets. This key insight was later formalized by Ethier (1982), who showed that intra industry trade in differentiated intermediate goods can arise because firms find it profitable to split up their production processes. That is, a larger number of intermediate goods become available from opening up for trade, and this increases the productivity of final goods producers.[1] This insight is theoretically well understood, but as noted by Duranton & Jayet (2005) there is remarkably little empirical work on the division of labor.[2] In their empirical analysis they focus on the link between the extent of the market and the division of labor, and they find a positive relationship between division of labor and the size of French cities. In contrast, the link between the division of labor and wages, which is the subject of our paper, is still an empirically unexplored issue. That international outsourcing, on the other hand, may reduce the relative wages of unskilled workers has e.g. been documented in a series of papers by Feenstra and Hanson (see e.g. Feenstra & Hanson (2003)). However even in the case where unskilled intensive production activities are moved abroad it is also possible that unskilled labor may benefit because outsourcing entails cost savings for domestic industries as illustrated by e.g. Arndt (1997) and Kohler (2004). The theoretical part of this paper combines elements from these two branches of literature in a simple model that focuses on the impacts on absolute wage levels.

[1] Ethier's division of labor model has since found numerous applications in eg. international trade, growth theory and development. For a recent coherent exposition of this model and its variants, see Francois & Nelson (2002). Becker & Murphy (1992) argue that the level of specialization also depends on other considerations such as various coordination costs.

[2] Duranton & Jayet (2005) cite two case studies that focus on particular industries.

The empirical part of our paper is most closely related to Geishecker & Görg (2004). They study the implications of foreign outsourcing on individual wages in a human capital framework by using data on a large German household panel combined with industry level data for the period 1991 to 2000. They find that foreign outsourcing generally reduces wages of low-skilled workers and increases wages of high-skilled workers. We use a panel data set of workers in Danish manufacturing industries combined with industry level data for the period 1993 to 2000, and we find similar results as Geishecker & Görg (2004) with respect to the effects of foreign outsourcing. However, by using information on domestic outsourcing, we find that outsourcing also entails a division of labor effect, and this effect may be very different from the comparative advantage effect usually focused on in the literature.

The paper is structured as follows. In the following section we set up a simple theoretical model of specialization, outsourcing and wages. In section 3 we present our empirical analysis, and in section 4 we conclude.

2 A simple model of outsourcing and wages

The purpose of this section is to set up a model that encompasses the two effects of outsourcing, i.e., the comparative advantage effect and the division of labor effect. The model distinguishes between outsourcing of activities intensive in unskilled labor and outsourcing intensive in skilled labor, and by doing so it illustrates how outsourcing with and without skill bias affect wages. The model is set up in two steps – first, we show how wages of skilled and unskilled workers depend on the level of outsourcing of either type of labor, and second we show how the level of outsourcing is determined by globalization. Increased globalization here corresponds to firms getting access to new labor markets such that the "effective" supply of labor rises.

We assume that a final good is produced by using inputs of capital, unskilled labor and skilled labor. To allow for the possibility of outsourcing in the firm it is assumed that the inputs of services from skilled and unskilled labor can be achieved in two ways: either by employing labor in the firm or through outsourcing by purchasing intermediate goods from other firms.[3] More specifically, we assume that the production function is Cobb-Douglas and given as:

$$Y = A\left(Y_s^{\alpha} Y_u^{1-\alpha}\right)^{\rho} K^{1-\rho}, \tag{1}$$

[3]In practice, services from capital can also be achieved through outsourcing, but to simplify we focus on labor.

where $A > 0$ and α, $\rho \in (0,1)$. Y_s is a measure of the input of services produced by skilled labor, Y_u is a measure of the input of services produced by unskilled labor, and K is capital. The inputs of services produced by skilled and unskilled labor are given as:

$$Y_s = \left[L_s^\gamma + M_s^\gamma\right]^{\frac{1}{\gamma}}, \tag{2}$$

$$Y_u = \left[L_u^\gamma + M_u^\gamma\right]^{\frac{1}{\gamma}}, \tag{3}$$

where $\gamma \in (0,1)$, and $L_s(L_u)$ is the employment of skilled (unskilled) labor, while $M_s(M_u)$ is a measure of the input of intermediate goods produced by using skilled (unskilled) labor, i.e. outsourcing. For now the outsourcing measures are simply taken as given, but below we will return to how they may be determined. Also, for simplicity we assume that the "production functions" for Y_s and Y_u are identical and given as constant returns to scale CES functions, where the inputs of labor and intermediates enter symmetrically. Notice that even if an increase in services of a certain type of labor can be achieved either by employing this type of labor in the firm or through outsourcing, the two inputs are not perfect substitutes as long as $\gamma < 1$.

The wages of skilled and unskilled labor can be found as the marginal product of labor, and it turns out that[4]

$$w_s = \alpha\rho A\left[1+\left(\frac{M_s}{L_s}\right)^\gamma\right]^{\frac{\alpha\rho-\gamma}{\gamma}}\left[1+\left(\frac{M_u}{L_u}\right)^\gamma\right]^{\frac{\rho(1-\alpha)}{\gamma}}\left(\frac{L_u}{L_s}\right)^{\rho(1-\alpha)}\left(\frac{K}{L_s}\right)^{1-\rho} \tag{4}$$

$$w_u = (1-\alpha)\rho A\left[1+\left(\frac{M_s}{L_s}\right)^\gamma\right]^{\frac{a\rho}{\gamma}}\left[1+\left(\frac{M_u}{L_u}\right)^\gamma\right]^{\frac{\rho(1-\alpha)-\gamma}{\gamma}}\left(\frac{L_s}{L_u}\right)^{\rho\alpha}\left(\frac{K}{L_u}\right)^{1-\rho} \tag{5}$$

A number of interesting results follows immediately from equations (4) and (5). First, more outsourcing of a certain type of labor (i.e. a higher value of $\frac{M_s}{L_s}$ or $\frac{M_u}{L_u}$) gives rise to an unambiguous increase in the wage of the other type of labor. This is so because the marginal product of the other type of labor increases.

Second, it is ambiguous whether the wage of, say, unskilled labor, increases if there is an increase in the outsourcing of activities intensive in the use of unskilled labor. The wage increases if the elasticity of substitution between unskilled labor and outsourcing is sufficiently low.[5] The intuition is that more outsourcing leads to a higher marginal

[4] When deriving these wage equations, it has been assumed that the capital stock is fixed. If the capital stock is endogenous, we get similar equations except that the cost of capital replaces the capital-labor ratio as an explanatory variable.

[5] The elasticity of substitution is given as $\sigma = \frac{1}{1-\gamma}$, and the exact condition for an increase in the wage of unskilled labor is that $\sigma < \frac{1}{1-\rho(1-\alpha)}$.

product of unskilled labor in production of unskilled services (i.e., Y_u), and this effect is sufficiently strong to "dominate" the fall in the marginal product of unskilled services in the production of final goods.

Third, the equations also show that wages are increasing in the use of capital, and the wages of unskilled (skilled) labor are rising in the relative employment of skilled to unskilled (unskilled to skilled) labor.

Equations (4) and (5) illustrate how wages respond to changes in outsourcing, but they do not explain how $\frac{M_u}{L_u}$ and $\frac{M_s}{L_s}$ are determined, and whether they change as a result of globalization. To illustrate how the level of outsourcing may be determined we borrow from Ethier (1982), who sets up a simple model of specialization in production of intermediate goods. The details of the model is given in the appendix.

One central ingredient of the model is that the demand for labor comes from two sources – the production of final goods (see (2) and (3)) and the production of intermediate goods. The supplies of skilled and unskilled labor are assumed to be exogenous. Inputs of intermediate goods (i.e., outsourcing) in the production of the composite inputs (Y_s and Y_u) are given as:

$$M_s = \left[\sum_{i=1}^{n_s} x_{si}^{\gamma}\right]^{\frac{1}{\gamma}} \tag{6}$$

$$M_u = \left[\sum_{i=1}^{n_u} x_{ui}^{\gamma}\right]^{\frac{1}{\gamma}} \tag{7}$$

where $x_{ui}(x_{si})$ is the input of a specific intermediate good produced by unskilled (skilled) labor, and $n_u(n_s)$ is the number of intermediate goods produced by unskilled (skilled) labor.[6] We note that there is a "return to variety" in the "production" of M_s and M_u. That is, M_s or M_u rises if the number of intermediate goods rises, even if the total production of intermediate goods is unchanged (i.e. for a given value of $\sum_{i=1}^{n_s} x_{si}$ and $\sum_{i=1}^{n_u} x_{ui}$). Hence, an increase in the division of labor increases productivity. One justification of this is that it is easier to find inputs satisfying specific needs in the production of final goods if there are more intermediates to choose from.

We follow Ethier (1982) in assuming that there is monopolistic competition in the market for intermediate goods, and that each firm faces a fixed cost as well as a variable cost of production. These costs are identical for firms producing the same type of inter-

[6]The elasticity of substitution between the input of different intermediate goods in the "production" of M_s and M_u is assumed to be the same as the elasticity of substitution between labor and the input of intermediate goods in the production of Y_s and Y_u. This assumption has no important qualitative implications, but it enables us to get closed form solutions.

mediate goods (i.e., goods intensive in either unskilled or skilled labor), but they may vary over types of intermediate goods.

This specification has some interesting implications concerning outsourcing. First, we find that the level of outsourcing does not depend on wages. Hence, the interdependence between wages and outsourcing is fully determined by (4) and (5).

Second, an increase in the supply of unskilled (skilled) labor leads to more specialization in the sense that the number of varieties of the intermediate goods produced by unskilled (skilled) labor increases. In other words, when the extent of the market increases, more varieties in the supply of intermediate goods are produced, and because of the aforementioned return to variety this makes it more profitable to outsource ($\frac{M_u}{L_u}$ ($\frac{M_s}{L_s}$) rises). This result is particularly interesting with regards to the implications of globalization. One aspect of globalization is that firms get access to new labor markets such that the "effective" supply of labor rises, and this may result in an increase in the division of labor and, in turn, specialization gains as just described. Of course, the globalization process is often associated with easier access to foreign labor markets abundant in unskilled labor, which, in our model, corresponds to a higher supply of unskilled labor, L_u. This would lead to more outsourcing of activities produced by unskilled labor, $\frac{M_u}{L_u}$, and from equations (4) and (5) we know the implications for the wages of both types of labor as discussed earlier. This is the comparative advantage effect.

Third, a proportional increase in the supply of unskilled and skilled labor brings about more outsourcing of both types (i.e. $\frac{M_u}{L_u}$ and $\frac{M_s}{L_s}$), and this improves wages of both types of labor (see the appendix). Hence, a general increase in the extent of the market for intermediate goods increases the division of labor, and the implied increase in outsourcing benefits all workers as long as the increase in the extent of the market is not biased too much towards the use of a certain type of labor.

Fourth, similar to an increase in the labor supply, a reduction in the fixed or variable cost of producing intermediate goods[7] intensive in unskilled (skilled) labor also increases the extent of the market for intermediate goods. This implies that there will be more specialization and outsourcing of activities intensive in unskilled (skilled) labor. Moreover, if there is a proportional decrease in the cost of producing the two types of intermediate goods, there will be more outsourcing and an increase in the division of both types of labor, such that wages rise for both types.

The main conclusion from this theoretical section is that there are two important effects on wages associated with outsourcing: a division of labor effect, and a comparative

[7]A reduction in the variable cost can be interpreted as a reduction in transport cost, which is often seen as another important aspect of globalization.

advantage effect due to skill biased labor demand. The comparative advantage effect arises if outsourcing is biased towards activities which are intensive in, say, unskilled labor. In that case the implication for unskilled wages is ambiguous, but there is an unambiguous increase in wages for skilled workers. Hence, outsourcing may affect the relative wages between different types of labor, and this relative wage effect is what most of the literature has focused on (see e.g. Feenstra & Hanson (2003)). In contrast, the division of labor effect arises because outsourcing gives rise to specialization gains across firms. If there is no skill bias in outsourcing, both types of labor benefit in terms of higher wages.

3 The empirical analysis

In order to assess the wage implications of outsourcing, we should ideally estimate the wage equations given in (4) and (5). However, the theoretical model is simple and stylized, and there is not a perfect match between the variables in the model and our data from the Danish manufacturing sector. First of all, we do not have information on whether outsourced activities are intensive in the use of skilled or unskilled labor in our data. Instead we do have data on two different types of outsourcing, namely domestic and foreign outsourcing. Since Denmark is relatively abundant in skilled labor, our presumption is that foreign outsourcing is relatively intensive in unskilled labor. Then, according to our model, foreign outsourcing should benefit skilled workers, and to the extent that employment of unskilled labor in the firm and foreign outsourcing are close substitutes, foreign outsourcing should hurt unskilled workers. Further, it is likely that there is no skill bias in domestic outsourcing – i.e., the content of skilled and unskilled labor in domestic outsourcing reflects the relative supply of skilled and unskilled labor in the country – and in that case domestic outsourcing is similar to a "pure" division of labor effect, and so it should benefit both types of labor. A less clear-cut situation would arise if domestic outsourcing also is biased but not as much towards unskilled labor as foreign outsourcing. In that case all we can say is that domestic outsourcing benefits unskilled labor more than foreign outsourcing, while foreign outsourcing benefits skilled labor more than unskilled labor.

Another divergence between theory and empirical implementation is that our theoretical model only distinguishes between two types of labor – skilled and unskilled. Since it is likely that there are important differences between workers with basic education, vocational education and further education, we distinguish between these three worker types.

3.1 Data

To test our hypotheses we need information on the absolute wage level of different types of workers. We have access to a panel data set of workers in Danish manufacturing industries for the years 1993-2000, and to this data set we add measures of outsourcing at the industry level.

We measure domestic and foreign outsourcing in terms of intermediate inputs in production at the industry level (55 manufacturing industries based on a Danish industry code which is between the two-digit and three-digit NACE definition). Feenstra & Hanson (1996) and Feenstra & Hanson (1999) consider two different measures for foreign outsourcing – a broad and a narrow measure. The broad measure is defined as the value of all imported intermediate inputs of an industry, while the narrow measure restricts attention to intermediate inputs that are purchased from the same industry as the good being produced. The idea behind the narrow measure is that it only includes imported intermediate goods that could have been produced within the domestic industry, so this measure arguably best captures the idea of specialization within the industry. We restrict attention to the narrow measure of foreign outsourcing, and in a similar way a narrow measure for domestic outsourcing can be defined. This measure of domestic outsourcing is then capturing the degree of division of labor at the industry level, if domestic outsourcing is limited by transportation efficiency (and thus the extent of the market) within the industry.

The domestic and foreign measures are constructed from input-output tables from Statistics Denmark. According to our theoretical model, the input of intermediates should be measured in terms of the input of labor used in production of final goods. However, for simplicity, it was assumed in our theoretical model that there is no outsourcing of capital services, but this is presumably the case in practice. Therefore, we follow Hijzen, Görg & Hine (2005), among others, and define outsourcing as intermediate goods divided by industry output. Figure 1 shows the measures of domestic and foreign outsourcing as a weighted average for all manufacturing industries. As expected foreign outsourcing has become more important during the period while domestic outsourcing declined in the beginning of the period. The decline in domestic outsourcing is not that surprising given that employment in manufacturing has fallen.[8]

The three industries with the highest level of foreign outsourcing in 2000 were manufacture of fertilizers and nitrogen compounds, manufacture of basic precious and non-ferrous

[8]The theoretical model predicts that outsourcing falls with declining employment (see the appendix). From 1992 to 2000 total manufacturing employment fell by 5.2%.

metals, and manufacture of radio, television and communication equipment, all with outsourcing intensities above 20 percent. The three industries that experienced the highest rise in foreign outsourcing from 1993 to 2000 were manufacture of fertilizers and nitrogen compounds, manufacture of basic precious and non-ferrous metals, and manufacture of wearing apparel. The three industries with the highest level of domestic outsourcing in 2000 were printing and service activities related to printing, manufacture of vegetable and animal oils and fat, and publishing of newspapers, all with outsourcing intensities between 10 and 15 percent. The three industries that experienced the highest rise in domestic outsourcing from 1993 to 2000 were publishing of newspapers, publishing of journals and periodicals, and manufacture of basic precious and non-ferrous metals. This indicates that domestic outsourcing is more widespread in service based industries.

Insert Figure 1 about here

Since we use a different measure of outsourcing than the one suggested by the theoretical model, we have also tried two alternative measures of outsourcing. One is outsourcing relative to the number of full-time workers, which is the measure suggested by equations (4) and (5). However, it could be argued that, because of aggregation problems (the composition of the workforce differs across industries), outsourcing should be measured in terms of the wage sum – this is the other alternative measure of outsourcing we apply. It turned out that all three measures had qualitatively similar impacts on wages, so in the following we only report results where outsourcing is measured in terms of production value.

Our theoretical model also predicts that the relative employment of skilled and unskilled labor affects wages. To take this into account we simply include the industry share of workers with vocational education, and the share with further education (the reference is basic education). Also the ratio of capital to skilled labor (unskilled labor) is an explanatory variable in the wage equations of the theoretical model. To accommodate for this, we construct a variable relating the return to capital to the wage sum $\left(\frac{rK}{wL}\right)$ from information about industry output (Y) and industry wages (i.e. $\frac{rK}{wL} = \frac{Y-wL}{wL}$).

We also include industry export and import. The export activity is likely to be correlated with firm productivity (see e.g. Bernard, Eaton, Jensen & Kortum (2003)) and could thus affect wages. A higher level of import penetration is likely to increase competition and reduce rents and wages. To control for other industry performance indicators, a concentration ratio defined as the market share of the four biggest firms of each industry has been included as a measure of domestic competition, and the size of the industry in

terms of the value of production is included to capture other unobserved industry characteristics. A substantial literature documents that skill biased technological changes have had an important effect on the development in relative wages (see e.g. Berman, Bound & Machin (1998)). We have tried to include the industry's R&D intensity to capture such effects, but this variable was only available at a higher industry aggregation level, and it had to be imputed for the year 2000 by a linear time trend. Since its inclusion only had a negligible impact on the estimated coefficients of the other variables, we opted to leave it out. Finally, to capture business cycle effects, local unemployment rates based on 51 local labor markets[9] are included along with a full set of year dummies.

Information about individual characteristics of a 10 % sample of workers in Danish manufacturing is extracted from the Integrated Database of labor Market Research (IDA) and the Income Registers in Statistics Denmark.[10] The hourly wage rate is clearly the most important individual level variable in the analysis, and this wage rate is calculated as total labor income divided by the total number of hours worked in any given year. A few problems are encountered when using this IDA-wage rate. Most importantly, the measure for total labor income does not include mandatory pension fund payments, and these payments have been rising over the 1990s but not in a uniform manner across collective bargaining segments of the labor market. However, since the individual pension fund payments are available in the data, it was straightforward to correct the wage rate.[11] Also, a measurement error could arise as potential overtime work is not included in the registered number of hours worked. Comparison with a presumably more exact individual wage rate measure originating from The Confederation of Danish Employers (which is only available for a limited number of years) shows only very small deviations, so we have confidence in the validity of the (corrected) IDA wage rate.

A long list of individual socio economic characteristics are used as control variables in the analysis. Of particular interest is information about education and occupation. Information about individual occupation is based on the Danish version of the ISCO-88 definition, and we operate with the nine main categories.

Among other socio economic characteristics are self explanatory dummies for gender, the presence of children, the presence of two adults in the household, city size, experience

[9] The local labor markets are socalled commuting areas that are defined such that the internal migration rate is 50 % higher than the external migration rate, cf. Andersen (2000).

[10] For more details on the IDA data see Abowd & Kramarz (1999).

[11] Except for the years 1993 and 1994, where the pension fund payment had to be estimated based on collective bargaining agreements for different sections of the labour market. However in 1993 and 1994 pension fund payment were relatively small, so the measurement error arising from this procedure is minimal.

and tenure[12]. There are also dummies for membership of unemployment insurance funds and trade unions, and there are dummies for the size of the firm (or more precisely workplace) in terms of the workforce.

We restrict the sample to include only full-time manufacturing workers in the age group of 18-65 years. In the final data set there are 287.955 observations coming from 66.377 workers. Descriptive statistics for a selected set of variables are presented in Table 1.

Insert Table 1 about here

3.2 Empirical model

The empirical strategy is to test the predictions from the theoretical model by estimating a simple Mincer human capital wage equation of the form

$$\log w_{ijt} = \alpha + \beta' x_{it} + \gamma' z_{jt} + \alpha_i + \epsilon_{it}, \tag{8}$$

where w_{ijt} is worker is hourly wage in industry j at time t. Individual covariates such as experience, experience squared and tenure are included in x_{it}, and industry specific variables – notably outsourcing variables – are contained in z_{jt}. Individual unobserved heterogeneity is controlled for by estimating a fixed effects version of the wage equation – a random effects model was rejected in a standard Hausman specification test.

Two methodological issues should be considered when estimating the effects of aggregate variables (i.e. outsourcing at the industry level) on micro units. First, as shown by Moulton (1990), the standard errors are biased downward in OLS regressions. We account for such clustering of individuals within industries by adjusting the standard errors along the lines of Moulton (1990). Second, there is the question about endogeneity of our variables of interest (i.e. outsourcing variables). It could be argued that outsourcing not only affects individual wages, but that wages also influence outsourcing decisions. However, according to our theoretical model, there are no endogeneity problems as wages have no effect on the level of outsourcing. Moreover, as also argued in e.g. Geishecker & Görg (2004), potential endogeneity problems are less of a concern when regressing individual wages on industry level variables, since the industry's outsourcing intensity may be largely considered exogenous to the individual worker. Finally, the implications of domestic outsourcing are really the novelty of this paper, and even if a part of individual wages is an industry specific component, it is very unlikely that domestic outsourcing in a

[12]Information about workplace tenure only goes back to 1980, so an indicator variable for left censored tenure is included.

specific industry is driven by the industry wage level, because the domestically outsourced activities are by definition produced within that same domestic industry.

3.3 Results

The results of estimating different versions of the wage equation (8) for the full sample are presented in Table 2. For all three models of the table, most individual covariates have expected signs; i.e. labor market experience, tenure and education are positively related to wages. There appears to be no wage effect of union membership whereas there is a positive wage premium associated with being insured against unemployment. There is also a significant firm size effect, which is consistently found in the literature (see e.g. Oi & Idson (1999)).

Insert Table 2 about here

With the purpose to investigate the importance of controlling for different industry characteristics, model 1 to 3 in the table differ by successively including more industry control variables. In model 3 with the full set of industry variables, it is seen that industries with a high concentration ratio as expected have relatively higher wages, indicating that less domestic product market competition leaves room for higher wages. Foreign competition in the form of the import penetration does not have a significant impact, but there is a wage premium for workers employed in industries that tend to export a high share of their production. The last result is in accordance with Edin, Frederiksson & Lundborg (2004) who study the Swedish labor market, but they also find a negative effect of imports.

Turning to the variables of primary interest, the first model in Table 2 includes only the foreign and domestic outsourcing measures as industry characteristics, and foreign outsourcing has a significantly negative impact on wages while domestic outsourcing has a significant positive effect. This picture is robust to the inclusion of more variables in models 2 and 3, but the size of the coefficient to foreign outsourcing roughly doubles. Thus, in line with our theoretical model, domestic outsourcing raises individual wages, presumably as a result of specialization gains. In contrast, foreign outsourcing reduces wages suggesting that comparative advantage effects are important in industries with high foreign outsourcing intensities. We also note that a change in domestic outsourcing has a numerical effect on wages which is more than three times the effect of a change in foreign outsourcing (model 3). An increase in domestic outsourcing of one percentage point leads to 0.34% higher wages, while a one percentage point increase in foreign outsourcing reduces wages by 0.12%.

One of the main insights of our theoretical model was that outsourcing could have different effects across skill groups. Foreign outsourcing is likely to be biased towards activities intensive in unskilled labor, and in that case our model predicts that foreign outsourcing should benefit skilled labor, while it is ambiguous how wages of unskilled labor are affected. With respect to domestic outsourcing, if it corresponds to a pure division of labor effect in the sense as there is no skill bias, we expect that more domestic outsourcing leads to higher wages for all workers. If instead there is a skill bias in domestic outsourcing then it should clearly be less biased towards activities intensive in unskilled labor than foreign outsourcing since Denmark is a skilled labor abundant country. In that case all we can say is that domestic outsourcing should benefit unskilled workers more than foreign outsourcing, and it should benefit skilled workers less than foreign outsourcing.

To study these questions we have estimated the model for workers with three different levels of education: basic education, vocational education and further education, cf. Table 3. We find that foreign outsourcing harms workers with both basic and vocational education, but workers with further education gain from this type of outsourcing (which is in line with the main result of Geishecker & Görg (2004)). This is consistent with the predictions of the theoretical model if, as presumed, foreign outsourcing is biased towards unskilled labor and the elasticity of substitution between employment of unskilled labor in the firm and outsourcing is relatively high. Moreover, workers with basic and vocational education benefit from domestic outsourcing, while there is a positive but insignificant impact on wages of workers with further education. Again, this is in accordance with our theoretical model. Domestic outsourcing appears not to correspond to a pure division of labor effect. Instead the results suggest that it is slightly biased toward skilled labor as there is no effect on high skilled wages.

Insert Table 3 about here

We recall that these results are robust to changes in the definition of the outsourcing measures. As discussed in section 3.1 we have also measured outsourcing in terms labor input and the wage sum, with the qualitative results of Tables 2 and 3 being essentially unchanged.

4 Conclusion

The standard approach in the literature on wages and outsourcing is to focus entirely on the consequences of foreign outsourcing. In this paper, we have diverted attention

towards the consequences of domestic outsourcing, such that the implications of both types of outsourcing can be analyzed.

By using a simple theoretical model, we have argued that, in general, outsourcing is associated with specialization gains arising from an increase in the division of labor. If domestic outsourcing has no bias towards any type of labor, it corresponds to a pure division of labor effect, and it increases wages for all workers. In contrast, foreign outsourcing is expected to be biased towards activities intensive in unskilled labor. Therefore, foreign outsourcing benefits skilled labor more than unskilled labor, and it is likely that unskilled wages are decreasing in the level of foreign outsourcing.

By using data on the Danish labor market, we show that domestic outsourcing as well as foreign outsourcing do affect wages. As predicted by the theory, we find that international outsourcing tends to raise wages of workers with further education and lower wages of workers with basic and vocational education. In contrast, we find that domestic outsourcing tends to raise wages of workers with basic and vocational education, while domestic outsourcing has no significant impact on wages for workers with further education.

In this paper, we have considered domestic outsourcing and foreign outsourcing. An interesting extension in future research would be to subdivide foreign outsourcing into groups of destination countries according to their relative labor endowment. We would expect that outsourcing to countries having a similar relative factor endowment as the domestic economy mainly affects wages through an increase in the extent of the market for intermediate goods, and therefore benefits all types of labor. The comparative advantage effect is expected to be much more important when considering outsourcing to countries with a very different factor endowment, and outsourcing to these countries may hurt unskilled labor.

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A Appendix: Theory

With respect to the markets of intermediate goods, we assume monopolistic competition, and there is only one firm producing each variety. In the following, we focus on intermediate goods intensive in the use of unskilled labor, but analogous expressions can be derived with respect to intermediate goods intensive in the use of skilled labor.

Using that the marginal product of a certain variety in the production of the final good is equal to the price of this variety, we find that the relative demand of variety ui and variety uj $(i \neq j)$ is

$$\frac{x_{ui}}{x_{uj}} = \left(\frac{p_{ui}}{p_{uj}}\right)^{\frac{1}{\gamma-1}} \tag{9}$$

where p_{ui} is the price of variety ui. Standard assumptions of monopolistic competition implies that the firm producing variety ui has no impact on quantity and price of other intermediate goods, and, therefore, the price elasticity is $\frac{1}{\gamma-1}$.

The cost of producing variety i of unskilled inputs is:

$$C_{ui} = w_u \left(a_u x_{ui} + b_u\right) \tag{10}$$

where w_u is the wage of unskilled labor. The fixed cost of production is $w_u b_u$, and the marginal cost of producing and transporting variety ui is $a_u w_u$. Hence, a change in a_u may be a result of a change in production technology as well as transport costs.

By maximizing the profit of the firm producing variety ui, and using the zero profit condition, and that the firms producing different varieties are symmetric, we find that[13]

$$p_{ui} = p_u = \frac{a_u}{\gamma} w_u \tag{11}$$

$$x_{ui} = x_u = \frac{\gamma b_u}{(1-\gamma)\, a_u} \tag{12}$$

The prices on all varieties become identical and equal to a mark up on the wage of unskilled labor. Moreover, as it is standard in these models, it turns out that all firms produce the same amount which is increasing in the fixed cost of setting up a firm.

The total amount of outsourcing, and the cost or "price" of outsourcing (i.e. the cost of obtaining one unit of M_u) become[14]:

[13] These derivations are standard, and can be found in e.g. Ethier (1982).

[14] This "price" can be found as the Lagrange multiplier in the following cost minimization problem:

$$M_u = \frac{\gamma}{1-\gamma}\frac{b_u}{a_u}n_u^{\frac{1}{\gamma}} \tag{13}$$

$$P_u = \frac{a_u}{\gamma}w_u n_u^{\frac{\gamma-1}{\gamma}} \tag{14}$$

We note that because of the "return to variety", more available varieties leads to a lower P_u and a higher M_u. I.e., if there are more intermediate goods to choose from, it is cheaper to obtain a certain level or "quality" of the total input of intermediate goods. This implies that outsourcing increases.

By maximizing profits in final good production, and using that the use of unskilled labor in producing intermediate goods and final goods add up to the supply of unskilled labor, we find that

$$n_u = \frac{1-\gamma}{b_u}\overline{L}_u - \left(\frac{a_u}{\gamma}\right)^{\frac{\gamma}{1-\gamma}} \tag{15}$$

$$\frac{M_u}{L_u} = \left[\left(\frac{\gamma}{a_u}\right)^{\frac{\gamma}{1-\gamma}}\frac{1-\gamma}{b_u}\overline{L}_u - 1\right]^{\frac{1}{\gamma}} \tag{16}$$

$$\frac{L_u}{L_s} = \frac{b_u}{b_s}\left(\frac{a_u}{a_s}\right)^{\frac{\gamma}{1-\gamma}} \tag{17}$$

A number of conclusions follow from equations (15)-(17). First, an increase in the supply of unskilled labor gives rise to an increase in the number of intermediate goods produced by using unskilled labor (i.e. n_u increases). Hence, when there is an increase in the supply of unskilled labor available for producing the final good, and intermediate goods which can be used to produce the final good, there is an increase in the extent of the market for intermediate goods, which implies that there will be more specialization and more outsourcing (i.e. $\frac{M_u}{L_u}$ increases).

Second, a reduction in the fixed cost (i.e. b_u) or variable cost (i.e. a_u) of producing unskilled labor intensive intermediate goods also gives rise to more specialization (n_u increases) and more outsourcing ($\frac{M_u}{L_u}$ increases).

Third, the symmetry of the model, implies that we get similar results with respect to the supply of skilled labor as well as the cost of producing intermediate goods intensive in the use of skilled labor.

$\min p_{u1}x_{u1} + p_{u2}x_{u2} + ... - P_u\left[\left[\sum_{i=1}^{n_u} x_{ui}^{\gamma}\right]^{\frac{1}{\gamma}} - M_u\right]$.

An increase in the supply of both types of labor may be seen as a "pure" division of labor effect as there will be no skill bias. This leads to more outsourcing of both types, and it can be shown that it gives rise to an unambiguous increase in the wage of both types of labor, i.e.

$$\frac{\Delta \overline{L}_u}{\overline{L}} = \frac{\Delta \overline{L}_s}{\overline{L}} > 0 \ \Rightarrow \Delta w_u > 0 \text{ and } \Delta w_s > 0$$

Similarly, it can be shown that, if there is a proportional decrease in the cost (either fixed cost or variable cost) of producing the two types of intermediate goods, there will be an increase in both types of outsourcing, and there will be an increase in wages of both types of labor. These positive wage effects arise because of specialization gains.

B Appendix: Tables and figures

TABLE 1. SAMPLE MEANS

Variables	Mean	Min.	Max.
Log wage rate (DKR)	5.1412	3.7063	6.7790
Female	0.2817	0.0000	1.0000
Married	0.5563	0.0000	1.0000
Two adults	0.7251	0.0000	1.0000
Children 0-6 years	0.2218	0.0000	1.0000
Experience (years)	16.2593	0.0380	37.0000
Tenure (years)	5.0317	0.0000	20.0000
Censored tenure	0.0869	0.0000	1.0000
Basic education	0.4044	0.0000	1.0000
Vocational education	0.4492	0.0000	1.0000
Further edu.	0.1464	0.0000	1.0000
Union member	0.8264	0.0000	1.0000
UI fund member	0.9295	0.0000	1.0000
Firm size 0-10	0.0658	0.0000	1.0000
Firm size 11-50	0.2241	0.0000	1.0000
Firm size 51-200	0.3083	0.0000	1.0000
Firm size 200+	0.4018	0.0000	1.0000
Copenhagen	0.1305	0.0000	1.0000
Big cities	0.1282	0.0000	1.0000
Rest of country	0.7412	0.0000	1.0000
Local unemployment rate (/10)	0.7441	0.3037	1.9308
Industry characteristics:			
Production value (billion DKK/100)	0.1456	0.0069	0.4898
Concentration ratio	0.5306	0.2492	0.9993
Import ratio	0.6194	0.0000	7.8964
Export ratio	0.5859	0.0000	18.9833
Basic education share	0.3897	0.1250	0.6364
Vocational education share	0.4630	0.1667	0.6557
Further education share	0.1473	0.0044	0.6667
Capital labor ratio	2.9502	0.3338	75.2753
Foreign outsourcing	0.0503	0.0000	0.2828
Domestic outsourcing	0.0507	0.0000	0.1929
# observations		287.955	

TABLE 2. ESTIMATION RESULTS

	Model 1		Model 2		Model 3	
Variables	Coeff.	Std.err.	Coeff.	Std.err.	Coeff.	Std.err.
Married	0.0003	0.0017	0.0003	0.0017	0.0001	0.0017
Two adults	**0.0151**	0.0016	**0.0151**	0.0016	**0.0151**	0.0016
Children 0-6 years	**0.0043**	0.0014	**0.0043**	0.0014	**0.0043**	0.0014
Experience	**0.0286**	0.0009	**0.0286**	0.0009	**0.0285**	0.0009
Experience^2	**-0.0006**	0.0000	**-0.0006**	0.0000	**-0.0006**	0.0000
Tenure	**0.0019**	0.0002	**0.0019**	0.0002	**0.0019**	0.0002
Censored tenure	-0.0005	0.0061	-0.0010	0.0061	-0.0008	0.0060
Vocational education	**0.4819**	0.0084	**0.4827**	0.0084	**0.4829**	0.0084
Further education	**0.5240**	0.0149	**0.5216**	0.0148	**0.5214**	0.0148
Union member	-0.0016	0.0020	-0.0014	0.0020	-0.0014	0.0020
UI fund member	**0.1436**	0.0046	**0.1434**	0.0046	**0.1433**	0.0046
Occ. managers	**0.0498**	0.0035	**0.0495**	0.0035	**0.0497**	0.0035
Occ. professionals	**0.0245**	0.0036	**0.0242**	0.0036	**0.0242**	0.0036
Occ. technicians	**0.0076**	0.0026	**0.0075**	0.0026	**0.0075**	0.0026
Occ. clerks	**-0.0106**	0.0030	**-0.0106**	0.0030	**-0.0105**	0.0030
Occ. service	**-0.0102**	0.0037	**-0.0106**	0.0037	**-0.0106**	0.0037
Occ. agriculture	**0.0418**	0.0052	**0.0417**	0.0052	**0.0415**	0.0052
Occ. craft	-0.0032	0.0021	-0.0026	0.0021	-0.0025	0.0021
Occ. mach. operators	0.0033	0.0017	0.0030	0.0017	0.0029	0.0017
Firm size 1-10	**-0.0365**	0.0031	**-0.0354**	0.0030	**-0.0352**	0.0030
Firm size 51-200	**0.0273**	0.0018	**0.0255**	0.0018	**0.0254**	0.0018
Firm size 200+	**0.0429**	0.0023	**0.0393**	0.0023	**0.0392**	0.0023
Big cities	**-0.0223**	0.0068	**-0.0232**	0.0068	**-0.0236**	0.0068
Rest of country	**-0.0261**	0.0055	**-0.0270**	0.0054	**-0.0273**	0.0054
Local unemployment	-0.0096	0.0064	-0.0069	0.0064	-0.0066	0.0064
Production value			-0.0986	0.0859	-0.1091	0.0863
Concentration ratio			**0.0619**	0.0069	**0.0511**	0.0075
Import ratio			-0.0018	0.0016	-0.0020	0.0016
Export ratio			**0.0039**	0.0011	**0.0040**	0.0011
Voc. edu. share			**-0.0544**	0.0177	**-0.0492**	0.0180
Further edu. share			**0.0460**	0.0159	**0.0496**	0.0159
Capital labor ratio					**0.0025**	0.0006
Foreign outsourcing	**-0.0606**	0.0205	**-0.1250**	0.0232	**-0.1199**	0.0231
Domestic outsourcing	**0.3465**	0.0406	**0.3674**	0.0437	**0.3449**	0.0434
Constant	**4.3828**	0.0147	**4.3718**	0.0183	**4.3693**	0.0183
# observations	287,955		287,955		287,955	
R^2	0.8917		0.8919		0.8919	

Note: Bold numbers indicate significance at the 5% level. Time dummies have been omitted.

TABLE 3. ESTIMATION RESULTS, EDUCATIONAL SUBGROUPS

	Basic education		Vocational edu.		Further edu.	
Variables	Coeff.	Std.err.	Coeff.	Std.err.	Coeff.	Std.err.
Married	**-0.0119**	0.0029	0.0014	0.0023	**0.0217**	0.0040
Two adults	**0.0098**	0.0024	**0.0123**	0.0023	0.0059	0.0038
Children 0-6 years	0.0037	0.0023	0.0035	0.0019	0.0036	0.0030
Experience	**0.0321**	0.0017	**0.0238**	0.0015	**0.0189**	0.0020
Experience^2	**-0.0006**	0.0000	**-0.0004**	0.0000	**-0.0008**	0.0000
Tenure	**0.0026**	0.0004	**0.0025**	0.0003	**0.0024**	0.0006
Censored tenure	**-0.0269**	0.0086	-0.0064	0.0082	-0.0207	0.0146
Union member	**0.0184**	0.0038	**-0.0064**	0.0026	**-0.0118**	0.0036
UI fund member	**0.1465**	0.0062	**0.0320**	0.0068	0.0163	0.0092
Occ. managers	**0.0269**	0.0061	**0.0400**	0.0049	**0.0825**	0.0079
Occ. professionals	**0.0492**	0.0114	**0.0213**	0.0065	**0.0377**	0.0065
Occ. technicians	**0.0163**	0.0053	**0.0145**	0.0036	**0.0237**	0.0061
Occ. clerks	**-0.0240**	0.0056	-0.0038	0.0037	**0.0187**	0.0082
Occ. service	-0.0045	0.0057	**-0.0101**	0.0046	0.0023	0.0144
Occ. agriculture	**0.0348**	0.0067	**0.0428**	0.0078	0.0522	0.0300
Occ. craft	-0.0057	0.0030	0.0053	0.0027	**0.0270**	0.0079
Occ. mach. operators	0.0009	0.0020	0.0049	0.0026	0.0089	0.0086
Firm size 1-10	**-0.0307**	0.0053	**-0.0374**	0.0038	**-0.0553**	0.0110
Firm size 51-200	**0.0386**	0.0031	**0.0208**	0.0024	0.0063	0.0049
Firm size 200+	**0.0590**	0.0039	**0.0324**	0.0031	**0.0124**	0.0056
Big cities	**-0.0277**	0.0122	-0.0213	0.0110	**-0.0358**	0.0112
Rest of country	-0.0122	0.0094	**-0.0215**	0.0089	**-0.0239**	0.0076
Local unemployment	0.0129	0.0093	-0.0081	0.0081	-0.0193	0.0140
Production value	-0.1261	0.1881	-0.0542	0.0888	0.1728	0.1908
Concentration ratio	**0.0510**	0.0117	**0.0587**	0.0094	0.0306	0.0161
Import ratio	-0.0020	0.0025	-0.0014	0.0023	0.0018	0.0032
Export ratio	-0.0013	0.0018	**0.0049**	0.0017	0.0039	0.0024
Voc. edu. share	**-0.1370**	0.0296	0.0415	0.0225	0.0793	0.0389
Further edu. share	-0.0120	0.0257	**0.0856**	0.0216	**0.0703**	0.0327
Capital labor ratio	**0.0025**	0.0009	0.0011	0.0006	0.0016	0.0010
Foreign outsourcing	**-0.1627**	0.0334	**-0.1049**	0.0307	**0.1037**	0.0463
Domestic outsourcing	**0.2968**	0.0540	**0.3107**	0.0482	0.0411	0.0472
Constant	**4.5168**	0.0286	**4.7685**	0.0274	**5.1603**	0.0422
# observations	116,447		129,347		42,161	
R^2	0.8977		0.8426		0.9151	

Note: Bold numbers indicate significance at the 5% level. Time dummies have been omitted.

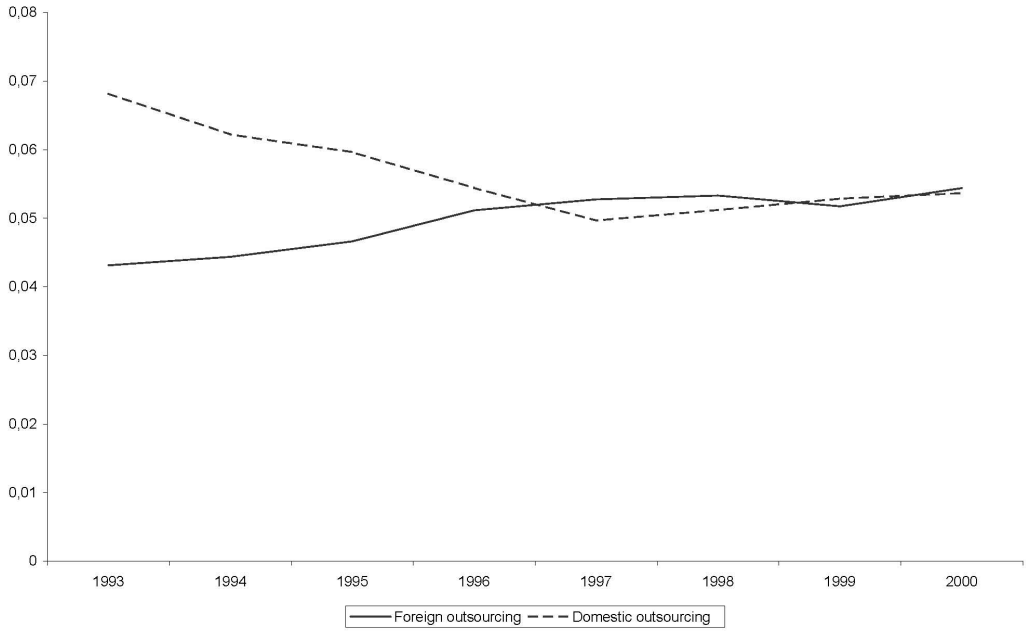

Figure 1: Foreign and domestic outsourcing in Danish manufacturing industries.