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Equilibrium Unemployment with Outsourcing and
Wage Solidarity under Labour Market Imperfections

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EQUILIBRIUM UNEMPLOYMENT WITH OUTSOURCING AND WAGE SOLIDARITY UNDER LABOUR MARKET IMPERFECTIONS

Abstract

We evaluate the effects of outsourcing and wage solidarity on wage formation and equilibrium unemployment in a heterogeneous labour market, where wages are determined by a monopoly labour union. We find that outsourcing promotes the wage dispersion between the high-skilled and low-skilled workers. When the labour union adopts a solidaristic wage policy, it will magnify, and not dampen, this tendency. Further, higher outsourcing will increase equilibrium unemployment among the high-skilled workers, whereas it will reduce it among the low-skilled workers. Overall, outsourcing will reduce economy-wide equilibrium unemployment under the reasonable condition that the proportion of high-skilled workers is sufficiently low.

JEL Code: E23, E24, J31, J51.

Keywords: outsourcing, wage solidarity, labour market imperfections, equilibrium unemployment.

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I. Introduction

On a global scale wage differences are enormous across countries ranging from, for example, 1,10 €per hour in China to above 27 €per hour in Denmark, Germany or Norway (see, e.g. Sinn (2007)). These wage differences constitute a central explanation for the increasingly significant business practice of international outsourcing. In countries with strong labour market imperfections large-scale outsourcing is often considered to pose a significant threat for employment, in particular for the low-skilled labour force segment. These concerns are often expressed by labour unions, and unions often accommodate the particular concern for the low-skilled labour force segment by advocating solidaristic wage policies.¹

In this study we analyze the effects of international outsourcing to low-wage countries on equilibrium unemployment in high-wage countries characterized by strong labour market imperfections. More precisely, we focus on a heterogeneous labour market where wages are determined by a monopoly labour union endowed with solidaristic objectives. We address the following questions: How does outsourcing affect wage formation, and in particular wage dispersion, in a heterogeneous labour market, where the labour union operates with some degree of wage solidarity? What are the effects of outsourcing on equilibrium unemployment among high-skilled and low-skilled workers? How are these effects related to the degree of wage solidarity? How can we characterize the aggregate effects of outsourcing on equilibrium unemployment in the presence of solidaristic wage policies? What is the optimal production mode under imperfectly competitive and segmented labour markets?

We find that the own wage elasticity and the cross wage elasticity of the low-skilled labor demand depend positively on the amount of outsourcing, whereas all these elasticities are independent of the amount of outsourcing for the demand of the high-skilled labour. A higher share of outsourced production will decrease the wage set by a monopoly union for the low-skilled labour, and increase wage for the high-skilled

¹ See also Stefanova (2006) concerning the East-West dichotomy of outsourcing in the European union in the context of its 2004 eastward enlargement.

labour. Consequently, outsourcing promotes the wage dispersion between the two labour force segments. The labour union will magnify, and not dampen, this tendency by adopting a solidaristic wage policy.

Outsourcing and wage solidarity have opposite employment effects among the high-skilled and low-skilled workers. Increased outsourcing increases equilibrium unemployment among the high-skilled workers, whereas it reduces it among the low-skilled workers. By combining these effects we draw the general conclusion that outsourcing will reduce economy-wide equilibrium unemployment under the reasonable condition that the proportion of the high-skilled workers is sufficiently low. Furthermore, increased wage solidarity reduces equilibrium unemployment for the high-skilled workers, whereas it increases equilibrium unemployment for the low-skilled workers. Finally, we characterize the optimal production mode from the firm's point of view. We find that when the firm faces a labour union with a higher degree of wage solidarity this will increase the positive returns from outsourcing through the effects of solidarity on the wage formation of the low-skilled workers. Overall our paper adds to the existing literature by analyzing the effects of outsourcing and wage solidarity between the high-skilled and the low-skilled workers on wage formation and equilibrium unemployment within the framework of imperfectly competitive labour markets.

We are not aware of any existing study which would have evaluated the employment consequences of outsourcing in an imperfectly competitive labour market with a heterogeneous labour force represented by a labour union with solidaristic preferences. A number of studies have, however, explored some related effects of outsourcing. Danthine and Hunt (1994) have both theoretically and empirically studied the effects of international outsourcing and foreign direct investment on wage formation in the home country. They showed that higher product market integration implies intensified product market competition, which moderates wage increases in unionized and homogeneous labour markets. Glass and Saggi (2001) have theoretically studied the causes of outsourcing and its effects, finding that higher international outsourcing lowers the relative wage of domestic workers and increases the profits, creating greater incentives for innovation. Egger and Egger (2003) have empirically

studied the impact of a decline in trade barriers on outsourcing of low-skilled labour and argued that outsourcing raises the relative wages of high-skilled labour in the home country, if the low-skilled labour is unionized in the home country. In terms of empirics Feenstra and Hanson (1999) have studied the impact of foreign outsourcing and technology on wages using U.S. data over the period 1979-1990. According to their findings, wages of low-skilled workers have fallen relative to those of high-skilled workers. Yan (2006) has used Canadian data to show that both foreign outsourcing and ICT (information and communication technologies) play important roles to increase the demand for skills independently of whether it is measured by the wage-bill share or employment share of non-production workers.

Recently, Senses (2006) has argued that an increased probability of outsourcing associated with a decline in foreign intermediate input prices and an increase in the elasticity of substitution between foreign and domestic inputs might increase the wage elasticity of labour demand. He has provided relevant empirical evidence, according to which a production mode with more outsourcing increases the wage elasticity of labour demand. As mentioned earlier, in our model we show that both the own wage elasticity and cross wage elasticity of low-skilled labour depends positively on outsourcing.

Our study proceeds as follows. Section II presents the basic structure of the model as well as the time sequence of the decisions regarding outsourcing, wage setting and labour demand for the separate segments of high-skilled and low-skilled workers. We study the segmented labour demand for the heterogeneous labour force in section III, whereas we focus on wage determination by a monopoly labour union in Section IV. Section V explores how the production mode and the union's degree of wage solidarity affect equilibrium unemployment. In section VI we characterize the optimal production mode in the presence of the imperfectly competitive and segmented labour market. Finally, we present concluding comments in Section VII.

II. Basic Framework

We design on a model with heterogeneous workers in an imperfectly competitive domestic labour market. At stage 1, in the long run, firms commit themselves to the production mode. Under outsourced production firms acquire the low-skilled labour input at the factor price c , which is lower than the wage of the domestic low-skilled workers. Moreover, there is a sunk cost of establishing capacity for foreign outsourced production. In order to exploit M units of the outsourced low-skilled labour input firms have to make the irreversible investment $g(M)$ with the properties that $g'(M) > 0$ and $g''(M) > 0$. This captures the idea the exploitation of the marginal cost advantages offered by production in low-wage countries typically also requires that the firms make irreversible investments into the establishment of networks of suppliers in the relevant low-wage countries.

At stage 2, conditional on the firm's commitment to a production mode, the labour union determines the wages for the high-skilled and low-skilled workers subject to the labour demands for each type of labour by the firms. At stage 3 firms make domestic employment decisions with respect to both the high-skilled and low-skilled workers by taking wage rates and outsourcing as given.

The time sequence of decisions is summarized in Figure 1 and the decisions at each stage are analyzed by using backward induction.

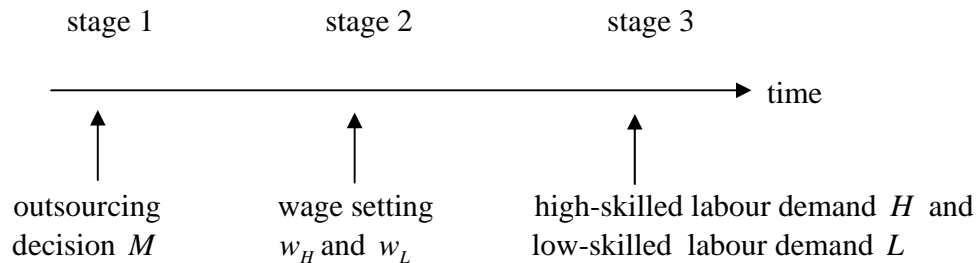


Figure 1: Time sequence of decisions

This timing structure seems plausible when the implementation of a production mode with outsourcing requires irreversible investments concerning the establishment of a network of foreign suppliers. The relative timing of wage formation and outsourcing could also be reversed. Such a reversed timing structure would be relevant if the firms could flexibly adjust their production mode, and decide whether to initiate foreign outsourcing, once the domestic wages are determined. Skaksen (2004) has analyzed this case using a Cobb-Douglas production function applied to a homogeneous labour force.

III. High-Skilled and Low-Skilled Labour Demand

At stage 3 the firm decides about the high-skilled labour demand H and the low-skilled labour demand L in order to maximize the profit function

$$\underbrace{\text{Max}}_{(H,L)} \pi(H, L, M) = F(H, L, M) - w_H H - w_L L - cM - g(M) \quad (1)$$

by taking the wage for high-skilled labour, w_H , the wage for low-skilled labour, w_L , and the outsourced low-skilled labour input M as given. We assume a Cobb-Douglas-type production function² with decreasing returns to scale according to $F(H, L, M) = [H^a (L + \gamma M)^{1-a}]^\rho$, where $0 < \rho < 1$ and $0 < a < 1$. The parameter $\gamma > 0$ captures the productivity of the outsourced low-skilled labour input relative to the domestic low-skilled labour input. The marginal products of the high-skilled labour and the low-skilled labour are $F_H = \rho X^{\rho-1} a H^{a-1} (L + \gamma M)^{1-a}$ and $F_L = \rho X^{\rho-1} H^a (1-a) (L + \gamma M)^{-a}$, respectively, where $X = H^a (L + \gamma M)^{1-a}$.

² Koskela and Stenbacka (2007) have adopted a CES production function to analyze equilibrium unemployment and optimal outsourcing under labour market imperfections with a homogeneous labour force.

Concerning the impact of the outsourced low-skilled labour input on the marginal products of domestic labour inputs one can show that

$$F_{HM} = \rho X^{\rho-1} H^{a-1} (L + \gamma M)^{-1} a(1-a)\gamma\rho > 0 \quad (2a)$$

and

$$F_{LM} = -\rho X^{\rho-1} H^a (L + \gamma M)^{-a-1} (1-a)\gamma[1-a(1-\rho)] < 0. \quad (2b)$$

Thus, for this production function the domestic high-skilled labour input and the outsourced low-skilled labour input are complements, whereas the low-skilled domestic labour input and the outsourced low-skilled labour input are substitutes. Ethier (2005) has introduced a partly related production function to analyze the decision between international outsourcing and in-house production in his analysis of the effect of globalization on the skill premium.

Given both the outsourcing decision and the wages determined by the monopoly labour union the first-order conditions characterizing the domestic high-skilled and low-skilled labour demands are

$$\pi_H = \rho \left[H^a (L + \gamma M)^{1-a} \right]^{\rho-1} a H^{a-1} (L + \gamma M)^{1-a} - w_H = 0 \quad (3a)$$

$$\pi_L = \rho \left[H^a (L + \lambda M)^{1-a} \right]^{\rho-1} (1-a) H^a (L + \gamma M)^{-a} - w_L = 0 . \quad (3b)$$

These first-order conditions imply the following relationship between the high-skilled labour (H), and the low-skilled labour inclusive of outsourcing ($L + \gamma M$)

$$H = \frac{w_L}{w_H} \frac{a}{1-a} (L + \gamma M) . \quad (4)$$

Substituting (4) into (3b) gives (see Appendix A) the low-skilled labour demand, which can be expressed as follows

$$L^* = Aw_L^{-\varepsilon_L^L} w_H^{-\varepsilon_H^L} - \gamma M \quad , \quad (5)$$

where $A = [\rho a^{a\rho} (1-a)^{1-a\rho}]^{\frac{1}{1-\rho}} > 0$, $\varepsilon_L^L = -\frac{L_{w_L} w_L}{L} = \frac{1-a\rho}{1-\rho} > 1$ denotes the own wage elasticity of the low-skilled labour and $\varepsilon_H^L = -\frac{L_{w_H} w_H}{L} = \frac{a\rho}{1-\rho} > 0$ denotes the cross wage elasticity of the low-skilled labour with respect to the high-skilled wage in the absence of outsourcing, i.e. when $M = 0$. These elasticities are higher with weaker decreasing returns to scale.

According to (5), a more extensive outsourcing activity will decrease the low-skilled labour demand. This feature is consistent with empirical evidence. For instance, Diehl (1999) has presented empirical evidence for German manufacturing industries in support of this hypothesis. Moreover, Görg and Hanley (2005) have used plant-level data of the Irish electronic sector to empirically conclude that international outsourcing reduces plant-level labour demand.

In the presence of outsourcing the wage elasticities of the low-skilled labour can be written as follows

$$\hat{\varepsilon}_L^L = \varepsilon_L^L \left(1 + \frac{\gamma M}{L^*} \right) \quad (6a)$$

and

$$\hat{\varepsilon}_H^L = \varepsilon_H^L \left(1 + \frac{\gamma M}{L^*} \right) \quad . \quad (6b)$$

Hence, outsourcing raises both wage elasticities, i.e. $\frac{\partial}{\partial M} \hat{\varepsilon}_L^L > 0$ and $\frac{\partial}{\partial M} \hat{\varepsilon}_H^L > 0$. As we mentioned earlier, Senses (2006) has recently presented empirical evidence according to which higher outsourcing increases the wage elasticity of labour demand, which lies in conformity with our analysis of the demand for low-skilled labour. Moreover, and importantly, the elasticity of low-skilled labour with respect to

outsourcing is $\varepsilon_M^L = -\frac{L_M M}{L} = \left[\frac{\gamma M}{Aw_L^{-\varepsilon_L^L} w_H^{-\varepsilon_H^L} - \gamma M} \right] > 0$ meaning that the outsourcing elasticity of low-skilled labour demand is positive. Differentiating this with respect to M gives

$$\frac{\partial}{\partial M} \varepsilon_M^L = \frac{Aw_L^{-\varepsilon_L^L} w_H^{-\varepsilon_H^L} \gamma}{\left[Aw_L^{-\varepsilon_L^L} w_H^{-\varepsilon_H^L} - \gamma M \right]^2} > 0. \quad (7)$$

This means that higher outsourcing, *ceteris paribus*, will increase the outsourcing elasticity of the low-skilled labour.

Substituting (5) into (4) gives the following demand for high-skilled labour

$$H^* = A \frac{a}{1-a} w_H^{-\varepsilon_H^H} w_L^{-\varepsilon_L^H}, \quad (8)$$

where $\varepsilon_H^H = -\frac{H_{w_H} w_H}{H} = \frac{1-\rho(1-a)}{1-\rho} > 1$, $\varepsilon_L^H = -\frac{H_{w_L} w_L}{H} = \frac{\rho(1-a)}{1-\rho} > 0$ and

$\varepsilon_M^H = -\frac{H_M M}{H} = 0$. These elasticities are also higher with weaker decreasing returns to scale, but unlike the case with low-skilled labour both the own wage and cross wage labor demand elasticities for high-skilled labour are independent of outsourcing.

We can now summarize our findings regarding the properties for heterogeneous labour demand in the presence of outsourcing as follows.

Proposition 1 *In the presence of outsourcing*

(a) *the own wage elasticity, the cross wage elasticity and the outsourcing elasticity for the low-skilled labour demand depend positively on the amount of outsourcing, whereas*

(b) *the own wage elasticity and the cross wage elasticity for the high-skilled labour demand are independent of the amount of outsourcing.*

IV. Wage Formation by Monopoly Labour Union for High-Skilled and Low-Skilled Workers

We now proceed to investigate the wage formation and continue to consider the acquired outsourcing M as given. The monopoly union determines the wages in anticipation of optimal in-house employment decisions by the firm.

The objective function of the labour union with heterogenous workers as members is assumed to be $U = \alpha(w_L - b_L)L + (1 - \alpha)(w_H - b_H)H$, where $b_L(b_H)$ is the (exogenous) outside option available to the low-skilled (high-skilled) workers and $\alpha(1 - \alpha)$ describes the trade union's relative preference for the low-skilled (high-skilled) workers. In the presence of wage solidarity we have $\alpha > 1/2$, whereas $\alpha = 1/2$ captures that the labour union has no relative preferences differentiation across the two labour force segments.³ Ceteris paribus, a solidaristic (egalitarian) wage policy entails a balanced wage structure which implies restraint on wage increases for high-paid groups of employees with above-average productivity with larger percentage rises for low-paid groups with below-average productivity.⁴ In general, the tradition of solidaristic wage policy is stronger in Europe than in the USA and consistent with that the wage dispersion in the USA is clearly greater than in the European countries (for empirics, see e.g. Schulten (2002)).

Kreickemeier and Nelson (2006) have analyzed the effects of global and national technological change on employment and relative wages under "fair" wage constraints. But they assume that the firms are wage setters, but they also emphasize that a fruitful avenue for further research is to allow for imperfectly competitive labour markets.

³ See also Cahuc and Zylberberg (2004), p. 401-403 concerning the monopoly labour union specification.

⁴ Agell and Lommerud (1992) have developed and explored the alternative rationales for egalitarian wage objectives of the labour union. One explanation for egalitarian wage patterns is simply that the labour union has redistributive preferences. A less formalized way of picturing the same phenomenon is to rely on arguments concerning union solidarity and ideology. By narrowing wage differentials between labour union members, it may increase the welfare of risk-averse workers by providing social insurance from a long-run perspective. See also Horn and Svensson (1986) and Rees (1993).

Egger and Kreickemeier (2005) have used the “fairness” approach to efficiency wages, decided by firms when the efficiency wage is derived based on a “fairness” constraint (see e.g. Akerlof and Yellen (1990)), in a model of international outsourcing where the wage inequality and unemployment rate are determined simultaneously. In such a framework they argue that the fairness constraint is binding for the low-skilled workers, giving rise to unemployment of this group, while high-skilled workers face no unemployment in equilibrium.

Given the amount of outsourcing, the monopoly labour union sets wages both for the high-skilled and low-skilled workers so as to maximize the weighted surplus to its heterogeneous members according to

$$\begin{aligned} \max_{(w_H, w_L)} U &= \alpha(w_L - b_L)L + (1 - \alpha)(w_H - b_H)H & (9) \\ \text{s.t. } \pi_H &= 0 \text{ and } \pi_L = 0 \quad . \end{aligned}$$

The first-order conditions associated with (9) can be written as

$$U_{w_H} = (1 - \alpha) \left[w_H (1 - \varepsilon_H^H) + b_H \varepsilon_H^H \right] - \alpha (w_L - b_L) \hat{\varepsilon}_H^L \left(\frac{L}{H} \right) = 0 \quad (10a)$$

$$U_{w_L} = \alpha \left[w_L (1 - \hat{\varepsilon}_L^L) + b_L \hat{\varepsilon}_L^L \right] - (1 - \alpha) (w_H - b_H) \varepsilon_L^H \left(\frac{H}{L} \right) = 0 \quad (10b)$$

Using the first-order conditions characterizing the high-skilled and low-skilled labour demand we have the following relationships between the high-skilled and low-

skilled labour: $\frac{L}{H} = \frac{(1-a)}{a} \frac{w_H}{w_L} (1 + \gamma m)^{-1}$ and $\frac{H}{L} = \frac{a}{(1-a)} \frac{w_L}{w_H} (1 + \gamma m)$, where

$m \equiv M/L$. Substituting these into equations (10a) and (10b) gives, after some rearrangements, the following optimal wage set by the monopoly labour union for the high-skilled labour (see Appendix B)

$$w_H^*(m, \alpha) = \frac{(1-\alpha)(1+\gamma m)}{[\rho\alpha(1-\alpha)(1+\gamma m) + \rho\alpha(1-a)]} b_H . \quad (11)$$

The comparative statics in terms of m (the ratio between outsourcing and low-skilled labour) and α (the labour union's relative preference for the low-skilled workers) can be expressed as

$$\frac{\partial w_H^*}{\partial m} = \frac{\left[\frac{\alpha\rho(1-a)\gamma}{(1-\alpha)(1+\gamma m)^2} \right]}{\left[a\rho + \frac{\rho\alpha(1-a)}{(1+\gamma m)} \right]^2} b_H > 0 \quad (12a)$$

and

$$\frac{\partial w_H^*}{\partial \alpha} = \frac{\left[-\frac{\rho(1-a)}{(1-\alpha)^2(1+\gamma m)} \right]}{\left[a\rho + \frac{\rho\alpha(1-a)}{(1+\gamma m)} \right]^2} b_H < 0 . \quad (12b)$$

A higher ratio of outsourcing to low-skilled labour increases the wage for high-skilled workers. In terms of the effect of expanded outsourcing we have the same qualitative finding, i.e. $\frac{\partial w_H^*}{\partial M} = \frac{\partial w_H^*}{\partial m} \frac{1}{L^*} > 0$. Further, from (12b) we see that the wage for the high-skilled workers depends negatively on the degree of wage solidarity of the monopoly labour union.

In a similar way the optimal wage set by the monopoly labour union for the low-skilled labour can be expressed as (see Appendix B)

$$w_L^*(m, \alpha) = \frac{\alpha(1+\gamma m)}{[(\alpha + \rho(1-\alpha)a)(1+\gamma m) - \alpha(1-\rho(1-a))]} b_L . \quad (13)$$

The comparative statics for the low-skilled wage with respect to m and α is found to be

$$\frac{\partial w_L^*}{\partial m} = \frac{\left[-\frac{\gamma(1-\rho(1-a))}{(1+\gamma m)^2} \right]}{\left[1 + \frac{\rho(1-\alpha)a}{\alpha} - \frac{(1-\rho(1-a))}{(1+\gamma m)} \right]^2} b_L < 0 \quad (14a)$$

and

$$\frac{\partial w_L^*}{\partial \alpha} = \frac{\left[\frac{\rho a}{\alpha^2} \right]}{\left[1 + \frac{\rho(1-\alpha)a}{\alpha} - \frac{(1-\rho(1-a))}{(1+\gamma m)} \right]^2} b_L > 0 \quad (14b)$$

A higher ratio of outsourcing to the low-skilled labour will decrease the wage rate of low-skilled workers. In terms of the effect of expanded outsourcing we have the same qualitative finding, i.e. $\frac{\partial w_L^*}{\partial M} = \frac{\partial w_L^*}{\partial m} \frac{1}{L^*} < 0$. Further, from (14b) we see that the wage for the low-skilled workers depends positively on the degree of wage solidarity of the monopoly labour union.

In particular, if the labour union operates with no solidaristic objectives ($\alpha = \frac{1}{2}$)

we find from (11) and (13) that the wages are given by

$$w_H^*\left(m, \frac{1}{2}\right) = \frac{(1+\gamma m)}{\rho(1+a\gamma m)} b_H \quad (11')$$

and

$$w_L^*\left(m, \frac{1}{2}\right) = \frac{(1+\gamma m)}{\rho(1+a\gamma m) + \gamma m} b_L \quad (13')$$

Under the plausible assumption $b_H \geq b_L$ we can directly see that $w_H^*\left(m, \frac{1}{2}\right) > w_L^*\left(m, \frac{1}{2}\right)$.

By combination of (12a) and (14a) we can infer that outsourcing induces an increase in the wage dispersion between the high-skilled and low-skilled workers. Similarly, comparing (12b) with (14b) verifies the natural property that increased wage solidarity will reduce the wage dispersion between the two labour market segments. These predictions both seem to theoretically confirm common views. Interestingly, by investigating the derivative of the wage dispersion with respect to the parameter capturing wage solidarity we find that

$$\frac{\partial}{\partial \alpha} \left[\left(\frac{\partial w_H^*}{\partial m} \right) - \left(\frac{\partial w_L^*}{\partial m} \right) \right] = \frac{\partial}{\partial m} \left[\left(\frac{\partial w_H^*}{\partial \alpha} \right) - \left(\frac{\partial w_L^*}{\partial \alpha} \right) \right] > 0.$$

This means that wage solidarity serves as an instrument with the effect of increasing, and not decreasing, the tendency of outsourcing to increase wage dispersion. In this respect wage solidarity tends to magnify the dispersion-increasing effect of outsourcing. This feature can intuitively be explained as follows. A higher degree of wage solidarity raises the wage for the low-skilled workers. But, under such circumstances the strengthened discipline imposed **by** increased outsourcing will have a stronger wage-reducing effect.

We now summarize our analysis of the wage formation as follows.

Proposition 2 *In the presence of outsourcing*

- (a) *a higher share of outsourced production will decrease the wage for the low-skilled labour and increase it for the high-skilled labour, thereby inducing increased wage dispersion, whereas*
- (b) *a higher degree of wage solidarity will increase the wage for the low-skilled labour and decrease it for the high-skilled labour, thereby reducing the wage dispersion.*
- (c) *a higher degree of wage solidarity magnifies the dispersion-enhancing effects of outsourcing.*

Proposition 2 (c) has interesting implications for labour unions concerned with threats imposed by outsourcing. From Proposition 2 (c) we can conclude that the labour union would actually promote, not dampen, the wage dispersion induced by outsourcing if it increased the degree of wage solidarity in face of this threat.

A large spectrum of empirical studies offers evidence in support of the hypothesis that outsourcing increases wage dispersion. Feenstra and Hanson (1999, 2001) have empirically studied the impact of foreign outsourcing on wages. According to their findings, based on data from U.S. and other countries, wages of the low-skilled workers have fallen relative to those of the high-skilled workers as a consequence of foreign outsourcing. Also Wood's (1998) review about developed countries argues that the evidence is in fact mostly consistent with the hypothesis that the main cause of the rise in labour market inequality is globalization. Hijzen et.al (2005) have provided evidence from UK data that international outsourcing is an important component in explaining changes in the skill structure of manufacturing industries. Geishecker and Görg (2004) have found evidence that outsourcing has reduced real wages for workers in the lowest skill categories, while it has increased real wages for the high-skilled workers by using data from Germany. Hijzen et al (2003) have also found evidence, using data from UK, that outsourcing plays an important role in explaining UK wage inequality. They argue that outsourcing accounts for approximately half of the increase in domestic wage inequality. Munch and Skaksen (2005) have used data from Denmark to provide evidence that foreign outsourcing tends to reduce wages for the low and medium-skilled workers, while it raises wages for the high-skilled workers. Recently, Dreher and Gaston (2006) have used panel data over the period 1970-2000 to study, for example, the effects of globalization on wage inequality. They have found that the economic dimension has exacerbated industrial wage inequality in developed countries, but the impact of globalization on inequality in less-developed countries has been quite small.

V. Effects of Outsourcing and Wage Solidarity on Equilibrium Unemployment

So far we have studied wage formation within a partial equilibrium framework. We now extend our analysis to a general equilibrium setting, where the labour force is mobile across industries, in order to characterize the effects of outsourcing and wage solidarity across labour market segments on equilibrium unemployment.

Consider a representative industry. According to (11) and (13) the labour union sets the wages according to

$$w_i = A_i b_i \quad (15)$$

for labour market segment i ($i=H,L$), where the mark-up factors are

$$A_H = \frac{(1-\alpha)(1+\gamma m)}{[\rho\alpha(1-\alpha)(1+\gamma m) + \rho\alpha(1-a)]}$$

and

$$A_L = \frac{\alpha(1+\gamma m)}{[(\alpha + \rho(1-\alpha)a)(1+\gamma m) - \alpha(1-\rho(1-a))]},$$

respectively. We assume that all industries are identical and for that reason neglect industry-specific indices. In a general equilibrium context with labour mobility across identical industries, but no mobility across different labour market segments, the endogenous outside option for the labour union representing segment i , b_i , is now interpreted to be

$$b_i = (1-u_i) w_i + u_i B_i, \quad (16)$$

where u_i denotes the unemployment rate in segment i , B_i denotes the unemployment

benefit for workers of type i and w_i denotes the wage determined by the union for workers of type i .⁵

From (16) we can immediately infer that outsourcing and wage solidarity will impact on the outside option available to the labour union in a general equilibrium context through several mechanisms. In the subsequent analysis we will analyze these effects in order to evaluate the overall employment consequences.

In line with the literature we restrict ourselves to a benefit-replacement ratio $q \equiv B_i/w_i$, which is constant across the two labour market segments. Combining (15) and (16) the equilibrium unemployment u_i in labour market segment i can be found to be given by

$$u_i = \frac{1 - \frac{1}{A_i}}{1 - q} . \quad (17)$$

According to (17) the equilibrium unemployment in each segment depends positively both on the benefit-replacement ratio (q) and on the wage mark-up in the labour market.⁶ By substituting the wage mark-ups from (11) and (13) into (17) we can explicitly characterize the equilibrium unemployment in each of the segments, given outsourcing.⁷

For the high-skilled labour force we find that the equilibrium unemployment is given by

⁵ For a standard justification of this interpretation with a homogeneous labour force, see e.g. Nickell and Layard (1999) p. 3048-3049 for a further discussion.

⁶ The unemployment rate satisfies $0 < u_i < 1$ if and only if $q < \frac{1}{A_i}$, which we assume to hold throughout the analysis.

⁷ Egger and Egger (2006) have presented first insights on the role of international outsourcing (international fragmentation of the value-added chain) for the productivity of low-skilled workers in EU manufacturing. Their short-run evidence exerts a negative marginal effect on real value added per low-skilled worker, while their long-run parameter estimates reveal a positive impact of outsourcing on real value added per low-skilled worker.

$$u_H(m, \alpha) = \frac{1}{1-q} \left[1 - \rho a - \frac{\rho \alpha (1-a)}{(1-\alpha)(1+\gamma m)} \right]. \quad (18)$$

From (18) we can directly conclude that outsourcing the low-skilled tasks tends to increase equilibrium unemployment ($\frac{\partial u_H}{\partial m} > 0$) in the segment of high-skilled workers.

Intuitively, this follows from the wage-increasing effect of outsourcing for the high-skilled workers, which was established in (12a). Moreover, straightforward calculations establish that increased wage solidarity reduces equilibrium unemployment for high-skilled workers ($\frac{\partial u_H}{\partial \alpha} < 0$). This follows from the wage-decreasing effect on high-skilled workers of a higher degree of wage solidarity, which was established in (12b).

For the low-skilled labour force we can calculate the equilibrium unemployment to be

$$u_L(m, \alpha) = \frac{1}{1-q} \left[\frac{1 - \rho(1-a)}{1+\gamma m} - \frac{\rho a (1-\alpha)}{\alpha} \right]. \quad (19)$$

From (19) we can directly characterize the effects of outsourcing and wage solidarity on equilibrium unemployment among the low-skilled workers. By (14a) outsourcing was found to impose wage discipline and thereby to have a wage-moderating effect for low-skilled workers. Consistent with this argument, (19) formally verifies that outsourcing reduces equilibrium unemployment in the segment for low-skilled workers

($\frac{\partial u_L}{\partial m} < 0$). Further, increased wage solidarity, and thereby a higher relative preference

for the wages of low-skilled workers, increases the equilibrium unemployment among low-skilled workers ($\frac{\partial u_L}{\partial \alpha} > 0$). This holds true because an increased degree of wage

solidarity induces an increase in the wage for the low-skilled workers, which was established in (14b). Thus, we can see that outsourcing and wage-solidarity affect

employment among low-skilled workers in a way which is completely opposite to the effects on high-skilled workers.

We summarize these findings in the following Proposition.

Proposition 3 *Outsourcing and wage solidarity have opposite employment effects among the high-skilled and low-skilled workers.*

(a) Higher outsourcing increases equilibrium unemployment among the high-skilled workers, whereas it reduces it among the low-skilled workers.

(b) Higher wage solidarity reduces equilibrium unemployment for the high-skilled workers, whereas it increases equilibrium unemployment for the low-skilled workers.

In Proposition 3 we formulate conclusions which seem to be contrary to common views regarding the effects of outsourcing. Namely, in the public debate outsourcing is often seen to impose a particular threat for the low-skilled workers. As our analysis establishes, such a view fail to take account of how a rational labour union with bargaining power would respond to a firm's commitment to outsourcing. Since outsourced production and in-house production with domestic low-skilled workers are substitutes outsourcing induces a wage-moderating effect on the wage for low-skilled workers, which promotes employment in this segment of the labour force. The opposite employment effect of outsourcing on high-skilled workers can be explained by the fact that outsourcing has an opposite effect on the wage formation for the high-skilled workers.

Union leaders often justify policies with wage solidarity by reference to particular concerns for the low-skilled workers. In light of our analysis it seems highly questionable whether low-skilled workers would benefit from wage solidarity, at least in the presence of outsourcing. As we have demonstrated, an increased degree of wage solidarity would tend to burden the employment opportunities for low-skilled workers by increasing the equilibrium unemployment in this labour force segment.

Our model is designed in such a way that the equilibrium unemployment would be equal in the two labour force segments in the absence of outsourcing ($m=0$) and

under circumstances with no relative labour union preferences across the two labour force segments ($\alpha = \frac{1}{2}$). More precisely, by substituting $m=0$ and $\alpha = \frac{1}{2}$ into (18) and (19) we find that

$$u_H(0, \frac{1}{2}) = u_L(0, \frac{1}{2}) = \frac{1-\rho}{1-q}. \quad (20)$$

We next separate both the effects of wage solidarity in the absence of outsourcing and the effects of outsourcing with no wage solidarity. For that reason we initially focus on a configuration with wage solidarity but no outsourcing, i.e. where $m=0$. Substitution of $m=0$ into (18) and (19) shows that

$$u_H(0, \alpha) - u_L(0, \alpha) = \frac{\rho}{1-q} \left[1 - 2a + \frac{a(1-\alpha)}{\alpha} - \frac{\alpha(1-a)}{(1-\alpha)} \right], \quad (21)$$

which is strictly decreasing as a function of α for $\alpha \geq \frac{1}{2}$. Thus, in combination with (20) we can conclude

Corollary 1 *The equilibrium unemployment is higher among the low-skilled workers than among the high-skilled workers in the absence of outsourcing. Furthermore, this effect is stronger the stronger is the union's relative preference in favour of the low-skilled workers.*

Essentially, in the absence of outsourcing wage solidarity leads the labour union to increase the wage for the low-skilled workers to such an extent that employment in this category of workers suffers. However, the presence of outsourcing imposes discipline on wage formation for low-skilled workers. For the case with no wage solidarity, i.e. with $\alpha = \frac{1}{2}$, we find that

$$u_H(m, \frac{1}{2}) - u_L(m, \frac{1}{2}) = \frac{1}{1-q} \frac{\gamma m}{1 + \gamma m}, \quad (22)$$

which is a strictly increasing function of m . Thus, we can conclude

Corollary 2 *The presence of outsourcing without wage solidarity imposes so much negative pressure on the wages of the low-skilled workers that the equilibrium unemployment is higher for the high-skilled workers. This effect is stronger the higher is the amount of outsourcing.*

So far we have explored separately the effects of outsourcing and wage solidarity on equilibrium unemployment in the two labour force segments. In particular, we have found that these effects are opposite in the two segments. We will next evaluate the total effects of outsourcing and wage solidarity on equilibrium unemployment in an economy consisting of both labour force segments.

Assume that the proportion v_H of the labour force belong to the high-skilled segment, whereas the complementary proportion $v_L = 1 - v_H$ are low-skilled workers. In such an economy the equilibrium unemployment for the economy with heterogeneous workers is the weighted average of the unemployment rates in the two different labour force segments according to

$$u(m, \alpha) = v_H u_H(m, \alpha) + (1 - v_H) u_L(m, \alpha) . \quad (23)$$

In the next proposition we establish that the total effects of outsourcing and wage solidarity are crucially determined by the relative proportions of the two labour force segments.

Proposition 4

(a) *Increased outsourcing reduces equilibrium unemployment if and only if the proportion of the high-skilled workers is sufficiently low. Formally,*

$$\frac{\partial u}{\partial m} < 0 \text{ if and only if } v_H < \hat{v}_H = \frac{(1 - \alpha)(1 - \rho(1 - a))}{\rho(1 - a)(2\alpha - 1) + (1 - \alpha)}$$

The threshold \hat{v}_H is a decreasing function of the degree of wage solidarity.

(b) A higher degree of wage solidarity raises equilibrium unemployment if and only if the proportion of the high-skilled workers is sufficiently low. Formally,

$$\frac{\partial u}{\partial \alpha} > 0 \text{ if and only if } v_H < \tilde{v}_H = \frac{1}{1 + \frac{\alpha^2 (1-a)(1-\alpha(1-\rho))}{a(1-\alpha)^2 (1+\gamma m)}}.$$

The threshold \tilde{v}_H is a decreasing function of the degree of outsourcing.

Proof: See Appendix C.

Proposition 4(a) essentially states that outsourcing will reduce equilibrium unemployment under the reasonable condition that the proportion of high-skilled workers is sufficiently low. The threshold $\hat{v}_H = \frac{(1-\alpha)(1-\rho(1-a))}{\rho(1-a)(2\alpha-1) + (1-\alpha)}$, below which this conclusion holds true, depends on the degree of wage solidarity in important ways. Based on straightforward calculations it can be verified that this threshold is strictly decreasing as a function of the degree of wage solidarity. Consequently, the effect of outsourcing on equilibrium unemployment depends monotonically on the degree of wage solidarity. For outsourcing to promote employment the upper threshold for the proportion of high-skilled workers is reduced if the degree of wage solidarity is increased.

From Proposition 4(b) we can conclude that a higher degree of wage solidarity burdens employment when the proportion of the high-skilled workers is sufficiently low. For this to happen the threshold is given by

$$\tilde{v}_H = \frac{1}{1 + \frac{\alpha^2 (1-a)(1-\alpha(1-\rho))}{a(1-\alpha)^2 (1+\gamma m)}}. \text{ The effects on equilibrium unemployment of}$$

an increasing degree of wage solidarity exhibit a systematic relationship with outsourcing. More precisely, increased outsourcing lowers the threshold below which an increased degree of wage solidarity raises equilibrium unemployment.

VI. Optimal Committed Outsourcing: The Long-run Perspective

So far we have restricted ourselves to a medium- or short-run perspective, where the firms have committed to the magnitude of their outsourcing activities. We now turn to explore the initial stage, where the firm commits itself to the outsourcing activity. We characterize how the labour market imperfections affect the equilibrium production mode. It is assumed that the long-run production modes decision internalizes the effects of the share of outsourced production on the wages of the high-skilled and low-skilled workers.

In the long run the firm determines the magnitude of outsourcing so as to maximize profit. The firm has rational expectations regarding the subsequent outcomes with respect to the high-skilled and low-skilled wages and employment so that the production mode internalizes the effects of the share of outsourced production on wages and employments. The long-run production mode is determined by the following optimization problem

$$\begin{aligned} \underset{(M)}{\text{Max}} \quad \pi = \pi(H, L, M) = F(H, L, M) - w_H H - w_L L - cM - g(M) \quad (24) \\ \text{s.t. } U_{w_H} = 0, U_{w_L} = 0, \pi_H = 0 \text{ and } \pi_L = 0, \end{aligned}$$

where the constraints capture that the production mode is set in anticipation of subsequent wage formation and employment in terms of both the high-skilled and low-skilled workers.

By applying the envelope theorem we get the following first order condition for the optimal amount of committed outsourcing associated with the optimization problem (24)

$$\frac{\partial \pi}{\partial M} = \rho(1-a)\gamma \left[H^{*a} (L^* + \gamma M)^{1-a} \right]^{\rho-1} (L^* + \gamma M)^{-a} - \underbrace{\frac{\partial w_L^*}{\partial M} L^*}_{(+)} - \underbrace{\frac{\partial w_H^*}{\partial M} H^*}_{(-)} - (c + g'(M)) = 0 \quad (25)$$

where $-\frac{\partial w_H^*}{\partial M} H^* = -\frac{\partial w_H^*}{\partial m} \frac{H^*}{L^*} < 0$ and $-\frac{\partial w_L^*}{\partial M} L^* = -\frac{\partial w_L^*}{\partial m} > 0$. Hence, in addition to the direct marginal cost $c + g'(M)$, and the direct marginal profit $\rho(1-a)\gamma \left[H^{*a} (L^* + \gamma M)^{1-a} \right]^{\rho-1} (L^* + \gamma M)^{-a} = \rho(1-a)\gamma H^{*-(1-\rho)a} (L^* + \gamma M)^{-(1-\rho(1-a))}$ introducing outsourcing will increase the wage cost of the high-skilled labour, while it will decrease the wage cost of the low-skilled labour. These findings lie in conformity with empirics, as we have mentioned earlier. If the ratio between the optimal high-skilled labour and the optimal low-skilled labour is small enough (large enough), then the presence of labour market imperfections increases (decreases) the returns from M because outsourcing has wage cost-moderating (wage cost-raising) effect, i.e. $-\frac{\partial w_L^*}{\partial m} - \frac{\partial w_H^*}{\partial m} \frac{H^*}{L^*} > 0 (< 0)$.

We can now characterize how the labour union's relative focus on low-skilled workers affects optimal outsourcing by reporting the following comparative statics result.

Proposition 5

A higher relative focus by the monopoly labour union on low-skilled workers will

- (a) increase the returns from outsourcing via the wage-moderating effect for low-skilled workers, and*
- (b) decrease the returns from outsourcing via the wage-increasing effect for high-skilled workers.*

Proof: See Appendix D.

VII. Conclusions

We have studied the consequences of outsourcing and wage solidarity on labour demand, wage dispersion, equilibrium unemployment as well as the incentives

associated with the introduction of outsourcing. We have shown that both the own wage elasticity and the cross wage elasticity as well as the outsourcing elasticity of the low-skilled labour demand depend positively on the amount of outsourcing, while both the own wage elasticity and the cross wage elasticity as well as the outsourcing elasticity of the high-skilled labour demand are independent of the amount of outsourcing. In terms of wage formation by the monopoly labour union a higher share of outsourced production will decrease the wage rate by the low-skilled labour, and increase the wage rate by the high-skilled labour so that the home wage difference becomes higher. The monopoly labour union's higher wage solidarity for the low-skilled labour will increase (decrease) the wage rate of the low-skilled (high-skilled) labour.

Higher outsourcing increases equilibrium unemployment among the high-skilled workers, whereas it reduces it among the low-skilled workers. Increased wage solidarity reduces equilibrium unemployment for the high-skilled workers, whereas it increases equilibrium unemployment for the low-skilled workers. Increased wage solidarity reduces equilibrium unemployment for the high-skilled workers, whereas it increases equilibrium unemployment for the low-skilled workers. Increased outsourcing increases equilibrium unemployment among the high-skilled workers, whereas it reduces it among the low-skilled workers. Increased wage solidarity reduces equilibrium unemployment for the high-skilled workers, whereas it increases equilibrium unemployment for the low-skilled workers. Finally, in terms of optimal production mode a higher relative focus by the monopoly labor union on low-skilled workers will decrease the returns from outsourcing via the wage-increasing effects for low-skilled workers.

We have analyzed the effects of outsourcing and wage solidarity on wage formation and equilibrium unemployment. Likewise we have characterized the effect of wage solidarity on the optimal production mode with heterogeneous workers in the encompassing labour union. An important further research topic is to ask: What are the incentives of heterogeneous labour force segments to merge and negotiate the wage agreement as a unified labour union rather than as separate unions if the firms have

access to production though international outsourcing? Horn and Wolinsky (1988) have earlier studied this issue in a different model without outsourcing,

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Appendix A: Optimal low-skilled labour demand

Substituting the RHS of (4) for H in (3b) gives

$$\rho \left\{ \left(\frac{w_L}{w_H} \right)^a \left(\frac{a}{1-a} \right)^a (L + \gamma M)^a (L + \gamma M)^{1-a} \right\}^{\rho-1} (1-a) \left(\frac{w_L}{w_H} \right)^a \left(\frac{a}{1-a} \right)^a (L + \gamma M)^a (L + \gamma M)^{-a}$$

$$= w_L \tag{A1}$$

so that

$$\rho \left\{ \left(\frac{w_L}{w_H} \right)^a \left(\frac{a}{1-a} \right)^a (L + \gamma M) \right\}^{\rho-1} (1-a) \left(\frac{w_L}{w_H} \right)^a \left(\frac{a}{1-a} \right)^a = w_L \Leftrightarrow \quad (\text{A2})$$

$$(L + \gamma M)^{\rho-1} \left(\frac{w_L}{w_H} \right)^{a\rho} (1-a) \left(\frac{a}{1-a} \right)^{a\rho} = \rho^{-1} w_L \quad (\text{A3})$$

which gives (5).

QED.

Appendix B: Wage formation by monopoly labour union

Substituting $\frac{L}{H} = \frac{(1-a)}{a} \frac{w_H}{w_L} (1+\gamma m)^{-1}$ and $\frac{H}{L} = \frac{a}{(1-a)} \frac{w_L}{w_H} (1+\gamma m)$ into equations

(10a) and (10b) gives

$$(1-\alpha)w_H(1-\varepsilon_H^H) + (1-\alpha)b_H\varepsilon_H^H - \frac{\alpha(1-a)}{a}w_H\hat{\varepsilon}_H^L(1+\gamma m)^{-1}\left(1-\frac{b_L}{w_L}\right) = 0 \quad (\text{B1})$$

$$\alpha w_L(1-\hat{\varepsilon}_L^L) + \alpha b_L\hat{\varepsilon}_L^L - \frac{(1-\alpha)a}{1-a}w_L\varepsilon_L^H(1+\gamma m)\left(1-\frac{b_H}{w_H}\right) = 0 \quad (\text{B2})$$

Equation (B2) can be re-expressed as follows

$$\left(1-\frac{b_L}{w_L}\right) = \frac{1}{\hat{\varepsilon}_L^L} \left\{ 1 - \frac{(1-\alpha)a}{\alpha(1-a)} \varepsilon_L^H (1+\gamma m) \left(1-\frac{b_H}{w_H}\right) \right\} \quad (\text{B3})$$

Substituting the right hand side of (B3) for $\left(1-\frac{b_L}{w_L}\right)$ in (B1) gives after some rearrangements the following optimal monopoly labour union wage for the high-skilled labor

$$w_H^* = \left[\frac{\varepsilon_H^H \hat{\varepsilon}_L^L - \varepsilon_L^H \hat{\varepsilon}_H^L}{(\varepsilon_H^H - 1)\hat{\varepsilon}_L^L - \hat{\varepsilon}_H^L \left(\varepsilon_L^H - \frac{\alpha(1-a)}{(1-\alpha)a(1+\gamma m)} \right)} \right] b_H \quad (\text{B4})$$

Using the wage elasticities, presented earlier, we have

$$\varepsilon_H^H \varepsilon_L^L - \varepsilon_L^H \varepsilon_H^L = \frac{1-a\rho}{1-\rho} \frac{(1-\rho(1-a))}{1-\rho} - \frac{a\rho^2(1-a)}{(1-\rho)^2} = \frac{1}{1-\rho} \quad \text{so that}$$

$$\varepsilon_H^H \hat{\varepsilon}_L^L - \varepsilon_L^H \hat{\varepsilon}_H^L = \frac{(1+\gamma m)}{1-\rho} > 0. \text{ Now equation (B4) can be expressed in equation (11) of}$$

the text.

Equation (B1) can be re-expressed as follows

$$\left(1 - \frac{b_H}{w_H} \right) = \frac{1}{\varepsilon_H^H} \left\{ 1 - \frac{\alpha(1-a)}{a(1-\alpha)} \hat{\varepsilon}_H^L (1+\gamma m)^{-1} \left(1 - \frac{b_L}{w_L} \right) \right\} \quad (\text{B5})$$

Substituting the right hand side of (B3) for $\left(1 - \frac{b_H}{w_H} \right)$ into (B2) gives after some

rearrangements the following optimal wage for the low-skilled labour

$$w_L^* = \left[\frac{\hat{\varepsilon}_L^L \varepsilon_H^H - \hat{\varepsilon}_H^L \varepsilon_L^H}{(\hat{\varepsilon}_L^L - 1)\varepsilon_H^H - \varepsilon_L^H \left(\hat{\varepsilon}_H^L - \frac{(1-\alpha)a(1+\gamma m)}{\alpha(1-a)} \right)} \right] b_L \quad (\text{B6})$$

Using the wage elasticities, presented earlier, (B6) it can be also expressed in equation (13) of the text. QED.

Appendix C: Proof of Proposition 4

In order to explore the effects of outsourcing on the economy-wide unemployment rate we make use of straightforward calculations to form the derivative

$$\frac{\partial u(m, \alpha)}{\partial m} = \frac{\gamma}{(1-q)(1+\gamma m)^2(1-\alpha)} \left[v_H \rho \alpha (1-a) + (1-v_H)(1-\alpha)(\rho(1-a)-1) \right]$$

from (23). Thus, we find that

$$\frac{\partial u}{\partial m} < 0 \text{ if and only if } v_H < \hat{v}_H = \frac{(1-\alpha)(1-\rho(1-a))}{\rho(1-a)(2\alpha-1) + (1-\alpha)}. \quad (C1)$$

It should be emphasized that the threshold $\hat{v}_H \in]0,1[$.

Further, in order to characterize the effects of an increased degree of wage solidarity on economy-wide unemployment we observe that

$$\frac{\partial u(m, \alpha)}{\partial \alpha} = v_H \left[\frac{\partial u_H(m, \alpha)}{\partial \alpha} - \frac{\partial u_L(m, \alpha)}{\partial \alpha} \right] + \frac{\partial u_L(m, \alpha)}{\partial \alpha}, \quad (C2)$$

where

$$\frac{\partial u_H(m, \alpha)}{\partial \alpha} = - \frac{\rho(1-a)(1+\gamma m)(1-\alpha(1-\rho))}{(1-\alpha)^2(1+\gamma m)^2(1-q)} \quad (C3)$$

and

$$\frac{\partial u_L(m, \alpha)}{\partial \alpha} = \frac{\rho a}{(1-q)\alpha^2}. \quad (C4)$$

Substituting (C3) and (C4) into (C2) we can conclude that

$$\frac{\partial u}{\partial \alpha} > 0 \text{ if and only if } v_H < \tilde{v}_H = \frac{1}{1 + \frac{\alpha^2(1-a)(1-\alpha(1-\rho))}{a(1-\alpha)^2(1+\gamma m)}}. \quad (C5)$$

Again it can directly be seen from (C5) that $\tilde{v}_H \in]0,1[$. QED.

Appendix D: Proof of Proposition 5

The first-order condition (25) for the optimal production mode can be characterized by

$$\frac{\partial \pi}{\partial M} = \rho(1-a)\gamma H^{*(1-\rho a)} (L^* + \gamma M)^{-(1-\rho(1-a))} - \underbrace{\frac{\partial w_L^*}{\partial m}}_{(+)} - \underbrace{\frac{\partial w_H^*}{\partial m} \frac{H^*}{L^*}}_{(-)} - (c + g'(M)) = 0 \quad (D1)$$

What is the effect of the labour union's relative preference for the low-skilled workers on the firm's optimal outsourcing? Differentiating (14a) with respect to α gives

$$\frac{\partial}{\partial \alpha} \left(\frac{\partial w_L^*}{\partial m} \right) = \frac{\left[\frac{\gamma(1-\rho(1-a))}{(1+\gamma m)^2 \alpha^2} \right]}{\left[1 + \frac{\rho(1-\alpha)a}{\alpha} - \frac{(1-\rho(1-a))}{(1+\gamma m)} \right]^3} b_L > 0 \quad (D2)$$

Hence, $\frac{\partial}{\partial \alpha} \left(-\frac{\partial w_L^*}{\partial m} \right) < 0$ so that higher α will decrease the returns from outsourcing via

the wage formation of low-skilled workers. Differentiating (12a) with respect to α and

denoting $X = a\rho + \frac{\rho\alpha(1-a)}{(1+\gamma m)}$ gives

$$\frac{\partial}{\partial \alpha} \left(\frac{\partial w_H^*}{\partial m} \right) = \frac{\left[\frac{\alpha\rho(1-a)\gamma}{(1-\alpha)^2(1+\gamma m)^2} X - \frac{2(\rho(1-a))^2 \alpha\gamma}{(1+\lambda m)^3(1-\alpha)} \right]}{X^3} b_H \quad (D3)$$

After some rearrangements (D3) can be written as

$$\frac{\partial}{\partial \alpha} \left(\frac{\partial w_H^*}{\partial m} \right) = \frac{\rho^2(1-a)\gamma}{(1+\gamma m)^2(1-\alpha)} \left[\frac{a}{(1-\alpha)} + \frac{\alpha(1-a)}{(1+\lambda m)(1-\alpha)} - \frac{2\alpha(1-a)}{(1+\gamma m)} \right] b_H \quad (D4)$$

The expression $\frac{a}{(1-\alpha)} + \frac{\alpha(1-a)}{(1+\lambda m)(1-\alpha)} - \frac{2\alpha(1-a)}{(1+\gamma m)}$ can be written as

$$\frac{a}{(1-\alpha)} + \frac{\alpha(1-a)}{(1+\lambda m)(1-\alpha)} - \frac{2\alpha(1-a)}{(1+\gamma m)} = \frac{a(1+\lambda m) + \alpha(1-a)[2a-1]}{(1+\gamma m)(1-\alpha)} \quad (D5)$$

A sufficient, but not necessary condition for $\frac{\partial}{\partial \alpha} \left(\frac{\partial w_H^*}{\partial m} \right) > 0$ is $a \geq 1/2$. In this case

$\frac{\partial}{\partial \alpha} \left(-\frac{\partial w_H^*}{\partial m} \right) < 0$ so that higher α will increase the cost from outsourcing via the wage

formation of high-skilled workers. QED.

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