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The Labor Market Effects of Outsourcing Parts and Components: Adverse Cournot Competition*

Michael Hübler

Abstract: This paper contributes to Hübler (2008) who analyses a partial equilibrium model of outsourcing with Cournot competition in intermediate good production. Final production is located in Western Europe, whereas the intermediate good can be manufactured by a Western (outsourcing) or Eastern European supplier (offshore outsourcing). The paper asks the question how changes in production costs, in particular wages, affect output and thus labor input in the two regions. The paper proves analytically that under certain conditions higher production costs in one region reduce intermediate good production in both regions.

Keywords: Offshoring, outsourcing, Cournot competition, intermediate goods, high-skilled, low-skilled

JEL classification: D24, D43, F20, J31

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1 Introduction

A main result in Hübler (2008) is the possibility of "adverse Cournot competition". This means, one producer decreases output as a reaction to an output decrease of the other producer. Thus, if the first producer faces a cost increase, he will decrease his output, and the second producer will also do so, however to a smaller extent, so that the second producer will produce more relative to the first producer. While Hübler (2008) derives this result from numerical simulations, this paper derives the necessary conditions for this outcome strictly analytically in section 4. Section 2 repeats the model setup described by Hübler (2008). Section 3 provides the proof that the second order condition for a profit maximum in Hübler (2008) is indeed fulfilled. Section 5 contains corrections of Hübler (2008). Section 6 concludes.

2 Model setup

The partial equilibrium model set up in Hübler (2008)[1] consists of final good Y production, located in the Western European region, and intermediate good X production located in the Western and in the Eastern European region.

$$Y = H^{\alpha}\left(X_W + X_E\right)^{1-\alpha}; \quad 0.5 < \alpha < 1 \tag{1}$$

The final good producer takes demand as given by the market. (The final good market form is not of importance in this case.) H is a high-skilled labor and high-technology intensive input, which is available in the Western area only and cannot be outsourced.

The process of intermediate good X production includes all activities requiring low-skilled labor like manual work and usual capital. X can be manufactured in Western (X_W) or Eastern Europe (X_E). Low-skilled labor is supplied in both regions. Intermediate good production can be moved to the East when production costs or wages are cheaper in the East, afterwards the manufactured intermediates are imported to the West. X_W and X_E are homogeneous goods and perfect substitutes so that they can be summed up to $X = X_W + X_E$. The assumption $\alpha > 0.5$ implies a higher income share for the high-skilled labor and high-technology intensive input located in

[1] This section is partly a citation of Hübler (2008), section 3.

the West (under perfect competition). The Cobb-Douglas function implies the possibility of replacing part of input *X*, produced with a high amount of low-skilled labor and a standard technology, by input *H*, produced by high-skilled workers and modern technologies, and vice versa.

The *Y* producer minimizes production costs for a given output *Y*:

$$\begin{aligned} &min\ \ C = w_H H + p_W X_W + p_E X_E \\ &s.t.\ \ Y = H^{\alpha}\left(X_W + X_E\right)^{1-\alpha} \end{aligned} \tag{2}$$

w_H is the price of high-skilled labor intensive input *H*, p_W and p_E are the prices of *X,* manufactured in the Western or Eastern region. The final good *Y* producer is a price taker, he sets the input factor quantities according to the factor prices w_H, p_W and p_E.

The intermediate good is manufactured by independent rivalling firms located in Western Europe or Eastern Europe, respectively. We call the former case outsourcing, the latter case offshore outsourcing. Intermediate good *X* production is represented by using Cobb-Douglas functions with the inputs capital *K* and low-skilled labor *L* with constant returns to scale:

$$X_i = A_i K_i^{\beta_i} L_i^{1-\beta_i}; \quad 0 < \beta_i < 1,\ i = [W; E] \tag{3}$$

The production processes in West and East differ in technologies A_i and in real wages w_i. Capital is not mobile across boarders. Furthermore, differences in the returns to capital investment r_i and in the elasticities of production β_i and $1 - \beta_i$ are possible.

Cost minimizing *X* manufacturing leads to the following marginal costs c_i:

$$c_i = \beta_i^{-\beta_i}\left(1-\beta_i\right)^{\beta_i - 1} A_i^{-1} r_i^{\beta_i} w_i^{1-\beta_i} \tag{4}$$

Marginal costs c_i are assumed constant and equal to the cost per unit of output. Marginal costs are derived from the exogenous parameters technology A_i, real wage w_i, real return rate on investment r_i and the Cobb-Douglas function exponents β_i and $1-\beta_i$. If the returns on investment and the exponents are similar in the East and West, a cost advantage can be achieved via a more efficient technology or a lower wage level.

X producers maximize their profits and have oligopolistic (monopolistic) power reflected in the price for *X* depending on the quantity of $X = X_W + X_E$:

$$max\ \Pi_i = p_i(X)\cdot X_i - c_i \cdot X_i \tag{5}$$

Without any market power of X producers, prices would be equal to marginal costs. In general a productivity gap between East and West exists, and hence intermediate good production takes place in the area with lower marginal costs only.

In the case of Bertrand competition (price competition) intermediate good manufacturing occurs only in the cheaper region, too. Now the cheaper producer can increase the price for X and reduce the production quantity of X, but if he increases the price for X more than to the marginal costs of the rival X producer, he will loose all the demand for his product.

Cournot competition (competition in quantities) is the interesting case referring to the current tendencies in the European automotive industry as well as analytically. Under the assumption of pure Cournot competition the Eastern and Western company offer the intermediate good X at the same price $p_X = p_W = p_E$. The firms optimize their supply of X taking the rivals reaction and the demand function for X given by the Western final good Y producer into account. The conditional factor demand function can be derived from (2):

$$X(Y, w_H, p_x) = \left(\frac{\alpha p_x}{(1-\alpha)w_H}\right)^{-\alpha} Y \tag{6}$$

Total demand for X falls with the price p_X and increases with w_H, the price of the skilled labor intensive good H. Solving (6) for p_X yields the inverse factor demand function for X:

$$p_X = \frac{1-\alpha}{\alpha} w_H X^{-\frac{1}{\alpha}} Y^{\frac{1}{\alpha}} \tag{7}$$

Obviously, the intermediate good suppliers face a non-linear and downward-sloping inverse factor demand function with respect to total X. Since $\alpha < 1$, expanding the supply of total X leads to a more than proportional fall in the price p_X. Hence, a monopolist would choose the output as small as possible, but in the oligopoly the situation is different. For every given positive quantity of one supplier there is an optimal output of the rival, which results in an equilibrium with positive quantities.

In market equilibrium supply equals demand for X at the price p_X, so that we can insert (7) into (5):

$$max\ \Pi_i = \frac{1-\alpha}{\alpha} w_H X^{-\frac{1}{\alpha}} Y^{\frac{1}{\alpha}} \cdot X_i - c_i \cdot X_i \tag{8}$$

Accordingly, the oligopolists maximize their profits Π_i by choosing their production quantities X_i and by taking the total amount X that includes their own and their rival's quantity into account. This results in the following first order conditions for profit maximization representing the oligopolists reaction functions with $i = [W; E]$:

$$\frac{d\Pi_i}{dX_i} = \frac{1-\alpha}{\alpha} w_H Y^{\frac{1}{\alpha}} \left(-\frac{1}{\alpha} X^{-\frac{1}{\alpha}-1} \cdot X_i + X^{-\frac{1}{\alpha}} \right) - c_i = 0 \tag{9}$$

3 Second order condition for a profit maximum

Now we want to show that the second order condition for the profit maximization problem in equation (8) is indeed fulfilled. We first rewrite the first order condition in equation (9) above using equation (7):

$$\frac{\partial \Pi_i}{\partial X_i} = p_X \left(1 - \frac{1}{\alpha} \frac{X_i}{X} \right) - c_i = 0$$

$$\Leftrightarrow\ 1 - \frac{1}{\alpha} \frac{X_i}{X} = \frac{c_i}{p_X} \tag{10}$$

The second order condition for a profit maximum is the derivative of (9) and can be rewritten using (10):

$$\frac{\partial^2 \Pi_i}{\partial X_i^2} = \frac{\partial p_X}{\partial X_i} \left(1 - \frac{1}{\alpha} \frac{X_i}{X} \right) - \frac{1}{\alpha} \frac{p_X}{X} \left(1 - \frac{X_i}{X} \right) < 0 \tag{11}$$

This condition is obviously fulfilled: $\frac{\partial p_X}{\partial X_i}$ is negative according to equation (7) with

$X = \sum^{i} X_i,\ i = [W; E]$ and in accordance with basic economic intuition. $1 - \frac{1}{\alpha}\frac{X_i}{X}$ is positive according to (10). Herein, equation (7) ensures that p_X is indeed positive, while marginal costs c_i and α are positive per definition. Finally, in the last term in (11), $1 - \frac{X_i}{X}$ is positive, because all output values are positive and X_i cannot exceed X. (X_i never becomes zero as long as marginal production costs c_i are positive.)

4 Condition for adverse Cournot competition

This section proves analytically that a cost increase in a region reduces output in this region as expected. It then shows mathematically that under certain conditions a cost increase in one region not only decreases output in this region, but additionally slightly decreases output in the other region. Such an adverse Cournot behaviour is a main result of the considerations and simulations in Hübler (2008). This surprising result stems from the interconnection of production in the two regions via Cournot competition.

We recall and rewrite equation (11) in Hübler (2008), where c_E denotes marginal production costs in the East, c_W denotes marginal production costs in the West, and $c_{WE} = c_W / c_E$.

$$V_{WE} \equiv \frac{X_W}{X_E} = \frac{(1-\alpha)c_{WE} + \alpha}{(1-\alpha) + \alpha\, c_{WE}} = \frac{(1-\alpha)c_W + \alpha c_E}{(1-\alpha)c_E + \alpha\, c_W} \tag{12}$$

and insert this expression into Hübler (2008), equation (15), second expression:

$$X_W = \left(\alpha' \frac{w_H}{c_W + c_E}\right)^{\alpha} \frac{1}{1 + \frac{(1-\alpha)c_E + \alpha c_W}{(1-\alpha)c_W + \alpha\, c_E}}\ Y$$

$$= \Theta \frac{1}{(c_W + c_E)^{\alpha}} \frac{(1-\alpha)c_W + \alpha\, c_E}{(1-\alpha)c_W + \alpha\, c_E + (1-\alpha)c_E + \alpha c_W} \tag{13}$$

$$= \Theta \frac{1}{(c_W + c_E)^{\alpha}} \frac{(1-\alpha)c_W + \alpha\, c_E}{c_W + c_E} = \Theta \frac{(1-\alpha)c_W + \alpha\, c_E}{(c_W + c_E)^{1+\alpha}}, \qquad \Theta = (\alpha'\, w_H)^{\alpha}\, Y$$

We first calculate a differential that tells us how production in the West (in absolute terms) reacts to marginal production cost changes in the West (in absolute terms), keeping all other variables constant. (Note that calculating the differential dX_E / dc_E leads to analogue results, i. e. the model is symmetric.)

$$\frac{dX_W}{dc_W} = \Theta \frac{(1-\alpha)(c_W + c_E)^{1+\alpha} - [(1-\alpha)c_W + \alpha\, c_E](1+\alpha)(c_W + c_E)^{\alpha}}{(c_W + c_E)^{2(1+\alpha)}}$$

$$= \Theta \frac{(1-\alpha)(c_W + c_E) - [(1-\alpha)c_W + \alpha\, c_E](1+\alpha)}{(c_W + c_E)^{2+\alpha}} \qquad (14)$$

$$= \Theta \frac{-\alpha(1-\alpha)c_W - (\alpha^2 + 2\alpha - 1)\, c_E}{(c_W + c_E)^{2+\alpha}}$$

Is this expression smaller or larger than zero? At first, all variables are positive per economically plausible assumption. At second, we assume α =]0.5; 1[throughout the paper. It follows that the numerator is clearly negative, while the denominator is clearly positive. Therefore, the whole differential is negative. As a consequence, higher production costs in the West, for example due to a rising Western wage level, reduce Western production and hence Western employment in absolute terms as expected.

We now derive a differential from (13) that tells us how production in the West (in absolute terms) reacts to marginal production cost changes in the East (in absolute terms), keeping all other variables constant:

$$\frac{dX_W}{dc_E} = \Theta \frac{\alpha(c_W + c_E)^{1+\alpha} - [(1-\alpha)c_W + \alpha\, c_E](1+\alpha)(c_W + c_E)^{\alpha}}{(c_W + c_E)^{2(1+\alpha)}}$$

$$= \Theta \frac{\alpha(c_W + c_E) - [(1-\alpha)c_W + \alpha\, c_E](1+\alpha)}{(c_W + c_E)^{2+\alpha}} \qquad (15)$$

$$= \Theta \frac{-\alpha^2 c_E + (\alpha^2 + \alpha - 1)c_W}{(c_W + c_E)^{2+\alpha}}$$

The condition for the differential to be smaller than zero is:

$$-\alpha^2 c_E + (\alpha^2 + \alpha - 1)c_W < 0$$

$$\Leftrightarrow \frac{\alpha^2 + \alpha - 1}{\alpha^2} < \frac{c_E}{c_W} =: c_{EW} \qquad (16)$$

If the condition is fulfilled, a cost increase in the East results in an output decrease in the West, this means there is "adverse Cournot competition". We first check in which cases this condition is fulfilled for α =]0.5; 1[as assumed throughout Hübler (2008). If α is slightly below one, the whole expression on the left hand side of (16) is also slightly below one. Then condition (16) is still fulfilled when c_E is at least as large as c_W. This leads to the first result: Rising costs in the high-cost region always reduce output in the low-cost region. (Note that calculating the differential dX_E / dc_W leads to analogue results, i. e. the model is symmetric.)

If α is slightly above 0.5 the left hand side of condition (16) is slightly higher than -1. Solving $\alpha^2 + \alpha - 1 = 0$ yields $\alpha_{1,2} = \frac{-1 \pm \sqrt{5}}{2}$. The positive solution is $\alpha_1 \approx$ 0.618. This leads to the second result: In the interval α =]0.5; 0.618[rising costs in the low-cost region always reduce output in the high-cost region, independent of the production costs in the East and the West. On the contrary, in the interval α = [0.618; 1[rising costs in the low-cost region can decrease or increase output in the high-cost region depending on the cost differential c_{EW}. This leads to the third result: In the interval α = [0.618; 1[rising costs in the low-cost region reduce output in the high-cost region only if the cost difference between the high- and low-cost region is small (so that c_{EW} is high). If the cost difference is large (so that c_{EW} is small), rising costs in the low-cost region increase output in the high-cost region.

In the simulations in Hübler (2008), section 8, we assumed α = 0.66. This leads to a critical cost ratio $c_{EW} \approx 0.219$. If the cost ratio c_{EW} is higher than this critical value within the interval α = [0.618; 1[, the differential in (15) becomes negative, otherwise it becomes positive. The cost ratio with respect to average wage levels between the Czech Republic and Germany, for example, is just in the area of this critical value. Hence, according the model, further rising costs in the Czech Republic would likely have a slightly negative impact on German intermediate output. On the other hand, cost increases in a country like Romania would have a positive effect on

German intermediate output, because the cost ratio is larger than the critical value.[2]

Moreover, α represents the income share of the high-skilled labor and high-tech intensive input factor. This kind of input is used in final production, which is only located in the West. Thus, following the results above, a higher income share of the high-skilled and high-tech intensive factor reduces the likelihood that cost increases in the East are harmful for intermediate production in the West.

However, we need to take into account that in our partial equilibrium analysis the output of the final product is kept constant. Therefore, the analysis does not take into account how cost changes in intermediate production affect the output quantity in final production.

5 Errata

The last sentence in Hübler (2008), page 177 should read: For c_{WE} towards infinity or towards zero the elasticity goes towards zero (Figure 1).

The first equation in (15) in Hübler (2008), page 178 correctly reads:

$$X_E = \left(\alpha' \frac{w_H}{c_W + c_E} \right)^{\alpha} \frac{1}{1+V_{WE}} Y$$

6 Conclusion

The analytic treatment of the model set up in Hübler (2008) has provided some new insights. Naturally, rising costs in one region reduce intermediate good output in the same region. The interesting question is under which conditions rising costs in one region also reduce output in the other region to some (possibly small) extent. This is the case of adverse Cournot competition.

The analysis shows that rising costs in the high-cost region always reduce output in the low-cost region. Furthermore, if the factor demand function is relatively steep, rising costs in the low-cost region always reduce output in the high-cost region, independent of the production costs in the East and the West. On the contrary, if the

[2] Note that according to the model a large cost differential between Romania and Germany implies that the main part of intermediate production is located in Romania.

factor demand function is relatively flat, rising costs in the low-cost region can decrease or increase output in the high-cost region depending on the cost differential between East and West. In this case, rising costs in the low-cost region reduce output in the high-cost region only if the cost difference between the high- and low-cost region is small.

To illustrate the results, suppose the income share of the high-tech and high-skilled labor intensive input factor is relatively high so that the factor demand function is relatively flat. Then according to the model, rising costs in the Czech Republic would likely have a negative impact on German intermediate good output. On the other hand, cost increases in a country like Romania would have a positive effect on German intermediate good output, because the cost ratio is larger than the critical value. Believing this result, policy makers need not be too concerned about reallocation of production to Eastern European countries with very low production costs due to changes in production costs (for example via wage bargaining) within Eastern countries. They should be more concerned about the reallocation effects due to production cost changes in countries where production costs are only slightly lower than in the home country. This is in accordance with the previous outcome of Hübler (2008), stating that changes in relative costs cause larger re-allocations of intermediate production, if the interregional cost difference is smaller.

Finally, following the results, a higher income share of the high-skilled and high-tech intensive factor reduces the likelihood that cost increases in the East are harmful for intermediate production in the West. This implies that a policy that fosters education and innovation as “assets” for production *at home*, makes companies less “vulnerable” to cost changes in other countries when taking offshore outsourcing into account.

However, the analysis says nothing about the magnitude and the economic significance of the results, and the caveats pointed out by Hübler (2008) apply.

References

Hübler, Michael (2008). The Labor Market Effects of Outsourcing Parts and Components: A Simple Model with Cournot Competition. Aussenwirtschaft 63(2), 167-194.