Supplement to Unionised oligopoly, trade liberalisation and location choice

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In this supplement we provide some additional details concerning the analysis reported in our paper. In Section 1 we show that a particular wage effect of trade liberalisation - lower trade cost leads to higher wages - would be the outcome also with a more general demand system than linear demands. In Section 2 we report wages and utility in regime II, which supplements the last paragraph of Section 3 in the paper. In Section 3 we report profits in the non-union case, which supplements Section 4.1 in the paper. We also provide proofs for propositions 1 and 2. In Section 4 we report profits in the unionised case, which supplements Section 4.2 (*Profits*) in the paper. Section 5 provides calculus and discussion of consumer surplus, which is a part of national welfare that is discussed in Section 5 in the paper. In Section 6 the explicit expressions for national welfare are reported, which supplements Section 5 in the paper, and we provide a proof of Proposition 5. In addition, we analyse the welfare effect of a move from partial to full FDI, which is referred to in footnote 22 in the paper.

1 The wage effect of trade liberalisation

In the main paper we argued that in regime I and for $t \leq (3\sqrt{2}-4)(a-\overline{w})$, a trade cost reduction would increase wages (see Section 3, point 4 in the paper). When setting the wage, the union will balance an increase in wages against the employment reduction that follows from such a wage increase. If the elasticity of labour demand to wages becomes less negative, the union will face a less negative trade off between wages and employment, and consequently increase wage claims. This is exactly what happens when trade costs fall for $t \leq (3\sqrt{2}-4)(a-\overline{w})$, which is easily checked.

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This kind of wage effect from trade liberalisation would apply to a much larger set of demand systems than the linear ones discussed in the paper. Following the above argument, a downward-sloping wage schedule would be present whenever the elasticity of total labour demand, $L \triangleq x + y$, to w, $\frac{\partial L}{\partial w}\frac{w}{L}$, becomes less negative when trade costs fall. That is, if $\frac{\partial}{\partial t}[\frac{\partial L}{\partial w}\frac{w}{L}] < 0$, or equivalently:

$$-\frac{w}{L^2}\frac{\partial L}{\partial w}\frac{\partial L}{\partial t} + \frac{w}{L}\frac{\partial^2 L}{\partial w \partial t} < 0. \tag{1}$$

Production will normally be negatively related to own wages, thus $\frac{\partial x}{\partial w}, \frac{\partial y}{\partial w} < 0$. Consequently, $\frac{\partial L}{\partial w} < 0$. $\frac{\partial L}{\partial t} = \frac{\partial x}{\partial t} + \frac{\partial y}{\partial t}$ is negative whenever a trade cost reduction leads to higher production by the unionised firm. This is the case in our model for equally large markets, but will generally hold if the foreign market is sufficiently large relative to the home market: A trade cost reduction may decrease the home firm's production for the home market through a worsened competitive position. However, with a sufficiently large foreign market, this effect will be more than compensated for by the increased production for the foreign market, where the competitive position is improved (with linear demand, this argument is valid as long as the foreign market is more than *half* the size of the home market, measured in terms of the parameter b).

Thus for a wide range of demand functions, assuming some restrictions on the difference in market sizes, $-\frac{w}{L^2}\frac{\partial L}{\partial w}\frac{\partial L}{\partial t}$ is negative. Accordingly, this analysis restricts attention to demand systems where $\frac{\partial^2 L}{\partial w \partial t}$ is negative, or positive to a limited degree (with linear demand, $\frac{\partial^2 L}{\partial w \partial t} = 0$).

2 Wages and union utility in regime II

It is easily verified that the wages and union utility in regime 2 are given by

$$w^{II} = \begin{cases} \frac{1}{4}a + \frac{1}{4}t + \frac{3}{4}\overline{w} & if \quad t < \frac{5}{7}(a - \overline{w}) \\ 2t + 2\overline{w} - a & if \quad \frac{5}{7}(a-\overline{w}) \leq t \leq \frac{3}{4}(a - \overline{w}) \\ \frac{a+\overline{w}}{2} & if \quad t > \frac{3}{4}(a - \overline{w}) \end{cases} \tag{2}$$

$$U^{II} = \begin{cases} \frac{1}{24}\frac{(a+t-\overline{w})^2}{b} & if \quad t < \frac{5}{7}(a - \overline{w}) \\ \frac{(a-t-\overline{w})(2t+\overline{w}-a)}{b} & if \quad \frac{5}{7}(a-\overline{w}) \leq t \leq \frac{3}{4}(a - \overline{w}) \\ \frac{1}{8}\frac{(a-\overline{w})^2}{b} & if \quad t > \frac{3}{4}(a - \overline{w}) \end{cases} \tag{3}$$

This supplements the discussion in the last paragraph of Section 3 in the paper.

3 Profits in the non-union case

The expressions for profits in the non-union case is not reported in the paper, but only plotted in Fig. 2 in Section 4.1. The profits (denoted Π_{NU}) can be derived from the equilibrium production quantities from section 2 of the paper (eqs. (11) and (12), fixed costs excluded):

$$\Pi^I_{NU} = \begin{cases} \frac{1}{9b}[2(a-\overline{w})^2 - 2t(a-\overline{w}) + 5t^2] & if \quad t < \frac{a-\overline{w}}{2} \\ \frac{(a-\overline{w})^2}{4b} & if \quad t \geq \frac{a-\overline{w}}{2} \end{cases} \tag{4}$$

$$\Pi^{II}_{NU} = \begin{cases} \frac{2(a-\overline{w})^2+2t(a-\overline{w})+t^2}{9b} & if \quad t < \frac{a-\overline{w}}{2} \\ \frac{13(a-\overline{w})^2}{36b} & if \quad t \geq \frac{a-\overline{w}}{2} \end{cases} \tag{5}$$

$$\Pi^{III}_{NU} = \begin{cases} \frac{1}{9}\frac{(a-\overline{w})^2}{b} & if \quad t > a - \overline{w} \\ \frac{1}{9b}[(a-\overline{w})^2 + (a - \overline{w} - t)^2] & if \quad t \leq a - \overline{w}. \end{cases} \tag{6}$$

Proof of Proposition 1: Using the above expressions, the proof of the two first parts of Proposition 1 is straightforward. For a regime II investment when the starting point is not double autarky, we have $\frac{d}{dt}(\Pi^{II}_{NU} - \Pi^I_{NU}) = \frac{4(a-\overline{w})-8t}{9b}$. This is positive for $t < \frac{a-\overline{w}}{2}$, which proves the last part of the proposition. *QED*

Proof of Proposition 2: Since a regime III investment is never profitable, part 3 of Proposition 1 proves this conclusively. *QED*

4 Profits in the unionised case

Profits in the unionised case are plotted in Fig. 3 in Section 4.2 (*Profits*) in the paper. The explicit expressions for profits in regime I (for firm A), gross of any fixed investment cost, are:

$$\Pi^I = \begin{cases} \frac{1}{72b}\left(4(a-\overline{w})^2 - 4(a-\overline{w})t + 37t^2\right) & if \quad t \leq (3\sqrt{2}-4)\,(a-\overline{w}) \\ \frac{1}{36b}\left(a+t-\overline{w}\right)^2 & if \quad (3\sqrt{2}-4)\,(a-\overline{w}) < t < \frac{5}{7}(a-\overline{w}) \\ \frac{1}{b}\left(-a+t+\overline{w}\right)^2 & if \quad \frac{5}{7}(a-\overline{w}) \leq t \leq \frac{3}{4}(a-\overline{w}) \\ \frac{1}{16b}\left(a-\overline{w}\right)^2 & if \quad t > \frac{3}{4}(a-\overline{w}). \end{cases} \tag{7}$$

Profits gross of investment costs in regime II are similarly given by:

$$\Pi^{II} = \begin{cases} \frac{1}{36b}\left(5(a-\overline{w})^2 + 2(a-\overline{w})t + t^2\right) & if \quad t < \frac{5}{7}(a-\overline{w}) \\ \frac{1}{9b}(10(a-\overline{w})^2 - 18(a-\overline{w})t + 9t^2) & if \quad \frac{5}{7}(a-\overline{w}) \leq t \leq \frac{3}{4}(a-\overline{w}) \\ \frac{25}{144b}\left(a-\overline{w}\right)^2 & if \quad t > \frac{3}{4}(a-\overline{w}). \end{cases} \tag{8}$$

The simplest case concerns regime III, where gross profits are as for the non-unionised case:

$$\Pi^{III} = \begin{cases} \frac{1}{9b}[(a-\overline{w})^2 + (a-\overline{w}-t)^2] & if \quad t \leq a-\overline{w} \\ \frac{1}{9b}\left(a-\overline{w}\right)^2 & if \quad t > a-\overline{w}. \end{cases} \tag{9}$$

5 Consumer surplus

In Section 5 of the paper we study national welfare, which is defined as the sum of consumer surplus in country H, union utility and profits for firm A. Let us here report some calculus and discussion concerning the consumer surplus. We assume consumer surplus to be approximated by the usual triangle under the demand curve given by

$$CS^i = \frac{b}{2}(x^i + u^i)^2 \tag{10}$$

where i denotes the regime in question. Using the previous results, we can readily calculate consumer surplus in regime I:

$$CS^I = \begin{cases} \frac{49}{1152b}\left(2(a-\overline{w})-t\right)^2 & if \quad t \leq (3\sqrt{2}-4)\,(a-\overline{w}) \\ \frac{1}{288b}\left(7(a-\overline{w})-5t\right)^2 & if \quad (3\sqrt{2}-4)\,(a-\overline{w}) < t < \frac{5}{7}(a-\overline{w}) \\ \frac{1}{2b}\left(a-\overline{w}-t\right)^2 & if \quad \frac{5}{7}(a-\overline{w}) \leq t \leq \frac{3}{4}(a-\overline{w}) \\ \frac{1}{32b}\left(a-\overline{w}\right)^2 & if \quad t > \frac{3}{4}(a-\overline{w}). \end{cases} \tag{11}$$

The above expression also depicts consumer surplus in regime II for $t > (3\sqrt{2} - 4)(a - \overline{w})$. However, the regime II consumer surplus is given by $\frac{1}{288b}(7(a - \overline{w}) - 5t)^2$ for $t \leq (3\sqrt{2} - 4)(a - \overline{w})$. For regime III, consumer surplus is given by:

$$CS^{III} = \frac{2}{9b}(a - \overline{w} - t)^2 . \tag{12}$$

These expressions are plotted against trade costs in Fig. 1:

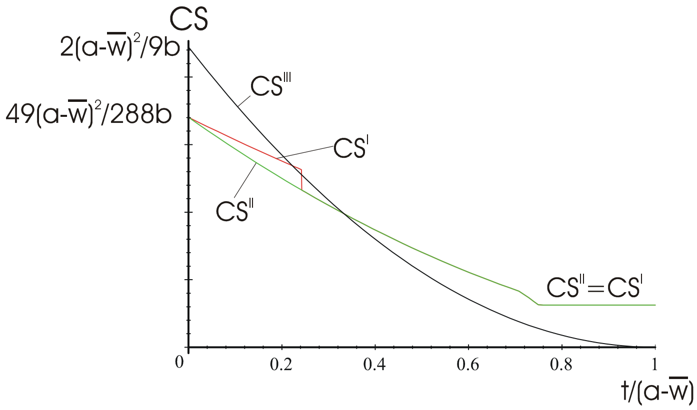

Fig. 1. Consumer surplus in the three regimes

As we would expect, consumer surplus is everywhere non-increasing in trade costs, no matter the investment strategy chosen by firm A. When we compare regimes I and II, consumers are only affected by this type of investment for low trade costs (when there is two-way trade). FDI then eliminates the home workers' incentive to moderate wage claims, so prices go up and output down, and consumers lose. As we can observe from the figure, for low trade costs consumer surplus in regime III is larger than in either of the two other regimes. Competition is harsher after a complete outward move of production. For low trade costs the extra cost of transport back into the home market is of little significance, so in sum consumers benefit.

6 National welfare

National welfare is plotted in Fig. 6 in Section 5 in the paper. It is easily verifiable that national welfare in the three regimes is given by the following expressions (investment costs excluded):

$$NW^I = \begin{cases} \frac{356(a-\overline{w})^2-356t(a-\overline{w})+665t^2}{1152b} & if \quad t \leq (3\sqrt{2}-4)(a-\overline{w}) \\ \frac{23(a-\overline{w})^2-10t(a-\overline{w})+15t^2}{96b} & if \quad (3\sqrt{2}-4)(a-\overline{w}) < t < \frac{5}{7}(a-\overline{w}) \\ \frac{1}{2}(a-\overline{w}-t)\frac{a-\overline{w}+t}{b} & if \quad \frac{5}{7}(a-\overline{w}) \leq t \leq \frac{3}{4}(a-\overline{w}) \\ \frac{7}{32}\frac{(a-\overline{w})^2}{b} & if \quad t > \frac{3}{4}(a-\overline{w}) \end{cases} \tag{13}$$

$$NW^{II} = \begin{cases} \frac{1}{288}\frac{101(a-\overline{w})^2-30t(a-\overline{w})+45t^2}{b} & if \quad t < \frac{5}{7}(a-\overline{w}) \\ \frac{1}{18}\frac{11(a-\overline{w})^2-9t^2}{b} & if \quad \frac{5}{7}(a-\overline{w}) \leq t \leq \frac{3}{4}(a-\overline{w}) \\ \frac{95}{288}\frac{(a-\overline{w})^2}{b} & if \quad t > \frac{3}{4}(a-\overline{w}) \end{cases} \tag{14}$$

$$NW^{III} = \begin{cases} \frac{1}{9}\frac{(a-\overline{w})^2}{b} & if \quad t > a-\overline{w} \\ \frac{1}{9}\frac{4(a-\overline{w})^2-6t(a-\overline{w})+3t^2}{b} & if \quad t \leq a-\overline{w}. \end{cases} \tag{15}$$

Proof of Proposition 5: For $t < (3\sqrt{2}-4)(a-\overline{w})$, the following identities are readily calculated:

$$\Delta NW^{III-I} = NW^{III} - NW^I = \frac{1}{1152}\frac{156(a-\overline{w})^2 - 412t(a-\overline{w}) - 281t^2}{b} \tag{16}$$

$$\Delta\Pi^{III-I} = \Pi^{III} - \Pi^I = \frac{1}{72}\frac{12(a-\overline{w})^2 - 12t(a-\overline{w}) - 29t^2}{b} \tag{17}$$

$$\Delta NW^{II-I} = NW^{II} - NW^I = \frac{1}{1152}\frac{48(a-\overline{w})^2 + 236t(a-\overline{w}) - 485t^2}{b} \tag{18}$$

$$\Delta\Pi^{II-I} = \Pi^{II} - \Pi^I = \frac{1}{72}\frac{6(a-\overline{w})^2 + 8t(a-\overline{w}) - 35t^2}{b}. \tag{19}$$

Now,

$$\Delta NW^{III-I} - \Delta\Pi^{III-I} = -\frac{1}{1152}\frac{36(a-\overline{w})^2 + 220t(a-\overline{w}) - 183t^2}{b} \tag{20}$$

$$\Delta NW^{II-I} - \Delta\Pi^{II-I} = -\frac{1}{384}\frac{16(a-\overline{w})^2 - 36t(a-\overline{w}) - 25t^2}{b}. \tag{21}$$

It is easily shown that $\Delta NW^{K-I} - \Delta\Pi^{K-I} < 0$ in the relevant interval $t < (3\sqrt{2}-4)(a-\overline{w})$ for both $K = II$ and $K = III$. Thus if the firm is initially a regime I producer, for costs C ($= G$ or J) of moving production abroad such that $\Delta NW < C < \Delta\Pi$ (superscripts excluded), the firm will invest and this will lead to decline in national welfare. *QED*

A transition from regime II to regime III

For a regime II to regime III transition, the following identity can be calculated (again superscripts excluded):

$$\Delta NW - \Delta\Pi = \frac{1}{288}\frac{3(a-\overline{w})^2 - 82t(a-\overline{w}) + 27t^2}{b}.$$

The expression is positive for $t < \frac{1}{27}(a-\overline{w})$, and negative otherwise. A transition from regime II to regime III involves a larger gain in consumer surplus and a smaller drop in union utility than a transition from regime I to regime III. For low trade costs ($t < \frac{1}{27}(a-\overline{w})$), the rise in consumer surplus from moving abroad outweighs the fall in union utility (it drops as trade costs fall in regime II). If t is below such a threshold level, the national welfare gain from a regime III investment is larger than the increase in profits. For t above such a threshold level, the opposite is true. This verifies the claim in footnote 22 in the paper at the end of Section 5.