Globalisation and union opposition to technological change

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Abstract

We find that trade unions have a rational incentive to oppose the adaption of labour-saving technology when labour demand is inelastic and unions care much for employment relative to wages. Trade liberalisation typically increases trade union technology opposition. These conclusions are reached in a model of international duopoly with monopoly wage setting in one of the countries, and two-way trade. An important stepping stone for the result is to note that even though trade liberalisation means a tougher competitive environment for firms, labour demand tends to increase. We also find that the incentive for technology opposition is stronger in the more technologically advanced country and in the country with the larger home market, complementing earlier explanations for technoogical catch-up and leapfrogging.

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1 Introduction

Is technological progress friend or foe of ordinary workers? If one adopts a long-term perspective, the answer should be obvious. However, with a shorter time horizon the question becomes trickier. Better technology

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could make possible higher wages and better work conditions, but the labour-saving potential of technological improvement could also spell job losses and wage cuts. The final outcome for workers will depend crucially on the particularities of the situation. In history, the perhaps most famous example of technology resistance is the Luddite revolts in England 1811-1812.[1] Framework knitters and weavers broke the new labour-saving machinery in their industries until harsh use of capital punishment subdued the riots. Even though the Luddite campaign and similar incidents during early British industrialisation were largely futile, the Luddite position appears rational enough. To quote Duvall (1969): "Most people in 1811 and 1812 found it difficult to appreciate the value of new machinery economizing labour at a time when goods were a glut upon the market and when there was, in any case a surplus of labour available."

Questions about technology and the labour market are obviously not only of historical interest. A prominent example of modern Luddism is the way printers' unions in many countries managed to postpone the introduction of new technology for quite a long time. Today many ask if the IT revolution will threaten the livelihood of blue-collar workers while highly skilled workers and capital owners profit? Further, should newly industrialised countries choose technologies that are labour-intensive or adopt the same technologies as more advanced countries?[2] The economic literature on these questions is enormous, much recent contributions centre on the question if the widening wage dispersion especially in the US and the UK can be traced back to new technology. Acemoglu (2002) offers an interesting overview. The narrower question about the relationship between organised labour and technology has also received much attention, see Menezes-Filho and Van Reenen (2003) for a survey both of theoretical positions and empirical evidence. The theoretical literature on unions and innovation often focuses on hold-up problems: the fact that unions are powerful may discourage investments both in

[1] The movement was named after 'General' Ned Ludd, but it is historically unclear if this was the instigator of the revolt, an alias used by several of the leaders, or simply an imaginary hero.

[2] Lansbury, Lee and Woo (2002) couple the bankruptcy of Kia Motors with slow adaption of new technology, and hint that union resistance might have played a role. The Korean auto industry was built up using relatively labour-intensive Fordist mass production in a time when military rule kept wages down. When Kia tried to switch to Toyota-style lean production, unions had become more powerful, and the attempts had mixed success. In the economic slump during the Asian financial crisis in 1997, Kia went bankrupt and was in the end taken over by Hyundai.

productive capacity and in technology.[3,4]

The opposite question, how technological change affects the bargaining position of workers, is analysed less frequently. Dowrick and Spencer (1994) is the theoretical economics paper that tackle the Luddite question most directly: they ask when the introduction of labour-saving technology hurts unionised workers, so that Luddite technology opposition would be rational? They study a situation where, at the same time, firms have market power in output markets and workers have market power in the labour market. Rational Luddism occurs in their model when labour demand is relatively inelastic. Also, the more a union value jobs rather than wage increases, the more likely becomes rational opposition to technology changes.[5]

The Dowrick-Spencer paper is an important building block for the present analysis. The purpose of our paper is to provide a theoretical analysis of rational Luddism under globalisation. It is probably no coincidence that the original Luddite movement arose when it did. The years 1811-12 were miserable ones for British industry, one chief reason being that Napoleon blockaded British exports to the continent.[6] Blockades of this type are surely less likely now than under Napoleon, but harsher competition from abroad could perhaps trigger union opposition to technological change in much the same way? Or would workers be eager to give their companies a head start in international competition, so that union resistance to change is weakened? Attempting to disentangle questions as these, we employ a model very much like the Dowrick-Spencer model, but where the oligopoly is an international one

[3] Grout (1983) and Manning (1987) were seminal contributions. Ulph and Ulph (2001) explicitly introduce innovation in a unionised context, and compare bargaining structures that to different degrees open up for hold-ups by workers after technological investment is sunk.

[4] Some authors point out that unions can be beneficial for technology adoption. For example, Agell and Lommerud (1993) and Moene and Wallerstein (1997) show how some unions' taste for wage compression can 'push' the economy towards structural change and modernisation.

[5] The Dowrick-Spencer model analyses technology and wage and employment changes within various given structures of labour market institutions. Acemoglu, Aghion and Violante (2001) develop a model where skill-biased technical change leads to deunionisation, because the coalition among skilled and unskilled workers is undermined. Deunionisation removes the wage compresion imposed by unions and therefore amplifies the direct effect that skill-biased technical change has on wage inequality.

[6] As an aside, it is noteworthy that times were harsh not only for workers, but for many industrialists, too. When Prime Minister Spencer Perceval, who introduced capital punishment for machine-breaking in the Frame-breaking Act, was shot dead in the lobby of the House of Commons in 1812, the assassin was not a Luddite rebel, but a bankrupt businessman.

– where trade costs of various sorts occur when goods are shipped from one market to the other. Globalisation is taken to mean that these trade costs are reduced, so that each national market is more exposed to foreign competition, but at the same time it is easier also for domestic firms to sell goods abroad.

Our work is also related to theoretical research on the consequences of globalisation for unionised oligopolies. Key references are Naylor (1998, 1999).[7] Naylor uses a framework that has many similarities to our model, most importantly the combination of international unionised oligopoly and monopoly union wage setting. Naylor stresses that globalisation need not be hurtful for organised labour. Harsher competition can in fact imply that both employment rises and wages go up. Firms exercise their market power in output markets by restricting output. More competition can imply more demand for labour – and a union can take advantage of such a situation by enjoying *both* increased employment *and* higher wages. True, profits suffer, but the situation for workers in a Naylor-type framework is tied to the elasticity of labour demand rather than to the profits of firms, which explains the apparent paradox that workers can benefit from harsher competition.[8]

The present model shares many traits with Naylor's framework, with the added feature that we study workers' incentives to sabotage the application of new technology. Such incentives are present if the fear of job losses outweigh the prospect of higher wages. Our main finding is that globalisation tends to *increase* the likelihood that workers oppose new technology, provided that the industry in question is characterised by intra-industry trade, and given some fairly mild restrictions on relative market sizes. Under these circumstances, increased competition from abroad – due to globalisation – is counteracted by easier access to foreign markets, causing total labour demand to increase. This contributes to making labour demand more inelastic, which can be shown to increase the amount of job losses if new labour-saving technology is introduced. Consequently, the likelihood that a trade union will oppose the implementation of such technology increases. If technology opposition hurts the interests of future generations of workers, this problem is aggravated by globalisation. We also briefly study the case of one-way trade, something that occurs for relatively high trade costs. In this case,

[7] See also, for example, Lommerud, Meland and Sørgard (2003), Meland (2002), Straume (2003), Neary (2002), Andersen and Sørensen (2003), Piperakis and Wright (2003) and Munch and Skaksen (2003). Staiger (1988) shares Naylor's prediction that the union wage premium may rise with intensified international competition, but in a different model framwork.

[8] Naylor assumes products to be homogenous and discusses Cournot competition. Gürtzgen (2002) obtain similar results for the Bertrand differentiated products case.

globalisation tends to reduce technology opposition.

It should be underlined that the results from this kind of unionised oligopoly model fits rather poorly with historical Luddism. Our model shares with Naylor the prediction that harsher competition in an international oligopoly under fairly mild assumptions will imply *increased* labour demand. Globalisation can lead to more technology opposition precisely because labour demand goes up. As already underlined, the original Luddite revolts broke out in a period of very low labour demand, which does not tally well with this aspect of the model. The models of Dowrick-Spencer and ourselves investigate when a union representing all workers will oppose technology. A revolt, on the other hand, can be instigated by a subset of workers, for example by the frustrated workers who have already lost their jobs, so the question of when the introduction of new technology leads to massive protests from some of the workers, is a slightly different one from the one we attempt to answer here.[9]

We also ask what market size and relative technological position imply for technology opposition. We find that technology opposition is larger in a country with a large home market and with a technological advantage. This points to an explanation why technological laggards sometimes catch-up with more advanced countries or even overtake them, to complement other explanations that has been offered for this phenomenon.

2 Model

There are two firms, each producing a differentiated product. Firm 1 is located in country 1 and firm 2 in country 2. Competition is assumed to be Cournot, but in the appendix it is shown that the qualitative results do not change if we instead analysed the case of Bertrand competition. We adopt the segmented market hypothesis, where firms maximise profits by choosing sales in each market (country) separately.[10] Output produced in country i (by firm i) and sold in market j is denoted q_{ij}, so that total sales for firm i – denoted q_i – is given by $q_i = \sum_{j=1}^{2} q_{ij}$.

[9] Moreover, workers in Britain 200 years ago were living close to subsistence level: then, in a downswing, workers might give extreme priority not to lose their job. The present study uses a Stone-Geary union utility function, which is convienient for tractability reasons and very often used in this type of analysis. However, it is not fully general, and the possibility that the employment priority in union utility rises very sharply in a downturn is therfore ruled out by assumption.

[10] The segmented markets oligopoly model was made popular by Brander and Krugman (1983). Neary (2003) presents a general equilibrium picture of international oligopoly with segmented markets.

Demand is assumed to be linear[11], with the inverse demand functions for goods 1 and 2 in market j given by

$$p_{1j} = a - \frac{1}{s_j}(q_{1j} + bq_{2j}) \tag{1}$$

and

$$p_{2j} = a - \frac{1}{s_j}(q_{2j} + bq_{1j}), \tag{2}$$

where $s_j > 0$ is a measure of the size of market j, and $b \in (0,1)$ is a measure of product differentiation.

Both firms operate under constant returns to scale with labour as the only input. Let n_i denote the amount of labour employed in the production of good i. The following technology applies:

$$q_i = \phi_i n_i, \tag{3}$$

where $\phi_i > 0$ is a firm-specific technology parameter.

There are two cost components: each unit of labour employed by firm i is paid a wage rate w_i. In addition, there is a trade cost, t, associated with shipping one unit of a good between the two countries. In principle, these trade costs can include both tariff and non-tariff cost components. We further assume that the labour market in country 1 is unionised, whereas the firm located in country 2 can recruit workers from a competitive labour market at a wage rate $w_2 = \overline{w}$.[12,13] For simplicity, we assume that the outside wage (that can be earned outside the oligopoly industry) for workers in country 1 also equals $\overline{w}$. To save notation, we set $w_1 = w$.

We adopt the monopoly union model, where the trade union in country 1 freely chooses the wage at a stage prior to the Cournot subgame.[14]

[11] This assumption can be considerably loosened while the main results are still maintained. See footnote 22 for a further discussion.

[12] Early contributions to unionised oligopoly models include Brander and Spencer (1988), Dowrick (1989) and De Fraja (1993).

[13] Lommerud, Meland and Sørgard (2003) and Lommerud, Straume and Sørgard (2003, 2004) are other examples of international oligopoly models with asymmetric union power across countries. Naylor (1998, 1999) and Haaland and Wooton (2003) study situations where unions are equally powerful in all countries.

[14] The monopoly union can be seen as that special case of the right-to-manage model where unions have all the bargaining power. We use this model as a simple representation of a situation where wage bargaining is inefficient because workers have a larger degree of control over wage setting than over how employment is determined. When one wants to study unionised wage bargaining and international oligopolistic rivalry at the same time one is typically forced to use somewhat more simplifying assumptions than when studying only one of the phenomena, for tractability reasons. The combination of linear Cournot oligopoly and monopoly unions is commonplace in this literature.

Union preferences are characterised by the following Stone-Geary-type utility function:

$$U = (w - \overline{w})^{\theta} n_1, \tag{4}$$

where $\theta > 0$ represents the relative importance of wages over employment for the trade union. Note that $\theta = 1$ corresponds to a rent-maximising union.

The source of the labour-saving technological change is taken to be exogenous, and we follow Dowrick and Spencer (1994) by analysing the effect of a marginal increase in the technology parameter ϕ_i. We consider the following three-stage game:

- Stage 1: The union determines whether or not it will accept the implementation of a labour saving innovation.
- Stage 2: The wage rate in country 1 is unilaterally set by the trade union
- Stage 3: Employment in each firm is determined by the firms' simultaneous and independent choices of optimal output levels for each market.

Stage 1 is not chosen for its realism. Rather, we want to study what the union would have decided about technology if it had been given the chance. The domestic union may well be in a position where it can sabotage introduction of labour saving innovations. Firms may anticipate that unions will not necessarily concede to the changes in manning rules, remuneration systems and the like that new technology requires. Firms may then in various ways be able to bribe workers to facilitate the introduction of innovations, but technological change will nevertheless be more costly and we should expect to see less of it. In other cases, unions and workers have no influence over technology choice, for example when an upstart firm builds a new plant ahead of hiring any workers. The present analysis is then not a positive analysis of technology adoption, but simply asks if workers benefit or not from the technological changes that do take place, something that in turn could constitute an important part of a normative analysis of technology policy.

We solve by backwards induction. The next section discusses the production game at stage 3.

3 Product market equilibrium

For given wages and technologies, each firm maximises profits by choosing the optimal level of sales for each market. The optimization problem facing firm 1 is thus

$$\max_{q_{11},q_{12}}[\pi_1 = (p_{11} - \frac{w}{\phi_1})q_{11} + (p_{12} - \frac{w}{\phi_1} - t)q_{12}]. \tag{5}$$

The first-order conditions are given by

$$q_{11} = \frac{as_1 - bq_{21} - s_1\frac{w}{\phi_1}}{2} \tag{6}$$

and

$$q_{12} = \frac{(a-t)\,s_2 - bq_{22} - s_2\frac{w}{\phi_1}}{2}. \tag{7}$$

Making similar calculations for firm 2 and assuming that all quantities are positive, we get the following equilibrium quantities:

$$q_{11} = s_1\frac{a\,(2-b) + bt + b\frac{\overline{w}}{\phi_2} - 2\frac{w}{\phi_1}}{4-b^2} \tag{8}$$

and

$$q_{12} = s_2\frac{a\,(2-b) - 2t + b\frac{\overline{w}}{\phi_2} - 2\frac{w}{\phi_1}}{4-b^2}. \tag{9}$$

Obviously, the problem facing firm 2 is similar, so that the equilibrium quantities q_{21} and q_{22} are of a similar structure as the expressions given above.

In an international duopoly, three different trade regimes are logically possible: two-way trade, one-way trade or autarky. Two-way trade means that both duopolists export into the neighbouring market, so this is intra-industry or cross-hauling trade of the same good. One-way trade means that one of the duopolists export, but not the other. Arguing slightly outside the model, if there are several oligopolies in an economy, we will expect a country to export the goods from some oligopolies, but import the goods from others, so the result is inter-industry trade.

Our focus here, however, will mainly be two-way (or intra-industry) trade. Lommerud, Meland and Sørgard (2003) discuss in detail, in a related set-up, under what trade costs what regime will arise in equilibrium.[15,16] Two-way trade generally occurs for relatively 'low' trade costs. When we study trade liberalisation with two-way trade, this means that

[15]Note that even though labour costs will be higher in the unionised country, there may be one-way trade from the unionised to the non-unionised country if the technology of the unionised firm is sufficiently better than that of the non-unionised firm.

[16]See also Naylor (1999) and Straume (2002) for discussions of trade patterns in unionised international oligopolies.

what we have in mind are economies that are rather well integrated to begin with but where trade costs are lowered even more. There always exists a range of the model parameters for which the equilibrium entails intra-industry trade. To see this, note that as the trade costs approach zero, the firms *either* produce for *both* or *none* of the markets (the effective production costs for the two markets are the same). Consequently, the union will – for such very low trade costs – never want to set a wage so high that the unionised firm does not export. Similarly, the foreign firm cannot be induced to stop shipping goods into the union home country either. It could be that the unionised economy had a large technological lead, but if it is not profitable for the laggard to export at almost zero trade cost, it is not profitable to operate in the laggard's home country either, so we would not have an operative duopoly. In general, a sufficiently low level of trade costs is sufficient to induce intra-industry trade in equilibrium. Even though two-way trade is our main assumption, we will discuss the case of one-way trade in Section 6.

Assuming two-way trade in equilibrium, labour demand by firm 1 is given by

$$n_1 = \frac{[s_1 + s_2][a\,(2-b) + b\frac{\overline{w}}{\phi_2} - 2\frac{w}{\phi_1}] - t\,(2s_2 - s_1 b)}{\phi_1\,(4-b^2)}. \tag{10}$$

4 Union wage setting

The union's wage setting is governed by a trade off between wages and employment. The first-order condition for optimal wage setting, on a general form, is given by

$$\varepsilon_1\,(w;\phi_1,\phi_2,s_1,s_2,t,b,\overline{w}) = \frac{\theta w}{w-\overline{w}}, \tag{11}$$

where $\varepsilon_1\,(w;\cdot) := -\frac{\partial n_1(w;\cdot)}{\partial w}\frac{w}{n_1(w;\cdot)}$ is the wage elasticity of labour demand for the unionised firm. More inelastic labour demand (lower ε_1) increases the equilibrium wage. Obviously, the wage will be higher the stronger the union values wages over employment, as represented by θ. Using (10), the equilibrium wage in the intra-industry trade regime is found to be

$$w = \frac{[s_1 + s_2][\phi_1\theta a\,(2-b) + \overline{w}(2 + \theta b\frac{\phi_1}{\phi_2})] - \phi_1\theta t\,(2s_2 - s_1 b)}{2\,(1+\theta)\,(s_1+s_2)}. \tag{12}$$

Some comparative statics properties of (12) can be immediately established. Less differentiated products (higher b) will intensify competition and reduce the union wage level. A contraction (expansion) of demand from the home (export) market will have the same effect, provided that there are positive trade costs. Likewise, an increase in productivity for the foreign firm will also have a negative impact on the union wage. This is all quite intuitive. Our main concern, however, is the effect of a change in the technology parameter of the unionised firm, ϕ_1. This is explored in great detail below.

5 Union opposition to technological change

We consider an incremental labour-saving innovation in the unionised firm, i.e., a marginal increase in the technology parameter ϕ_1. Let us first check the effect on the union wage level. A labour-saving innovation will cause a wage response from the union insofar as the innovation changes the own-wage elasticity of labour demand. It is useful to decompose the total effect into a *slope-of-demand* effect and a *demand-shifting* effect: in general, an increase in ϕ_1 changes both the slope of the labour demand curve *and* the demand for labour at the pre-innovation wage. Labour demand elasticity is affected through both channels. Starting with the first effect, from (10) we can easily calculate

$$\frac{\partial}{\partial \phi_1}\left(-\frac{\partial n_1}{\partial w}\right) = -4\frac{s_1 + s_2}{\phi_1^3\,(4 - b^2)} < 0, \tag{13}$$

implying that increased labour productivity reduces the wage responsiveness of labour demand. This is very intuitive: if workers are highly productive, an increase in the wage level will have only a moderate impact on the *effective* wage rate (w/ϕ_1). *Ceteris paribus*, this effect makes labour demand less elastic and pulls in the direction of higher wage claims by the union.

A labour-saving innovation also affects labour demand directly, in two different ways. On the one hand, it reduces the marginal cost of production, w/ϕ_1, which tends to increase the demand for labour. This again provides an incentive for the union to increase wage claims. On the other hand, a labour-saving innovation increases the productivity of each worker, which has the opposite effect on labour demand, since the same production quantity can now be produced using fewer workers. Thus, the overall *demand-shifting* effect is generally ambiguous. From (10) we can derive

$$\frac{\partial n_1}{\partial \phi_1} = \frac{2\,(s_1 + s_2)\,w(1 - \frac{1}{\varepsilon_1})}{\phi_1^3\,(4 - b^2)}, \tag{14}$$

implying that increased labour productivity causes a reduction (increase) in labour demand if the wage elasticity of labour demand – at the pre-innovation level – is below (above) unity.[17] If labour demand is inelastic, a small reduction in the marginal cost of production (w/ϕ_1) leads to a less than proportionate increase in the demand for effective labour ($\phi_1 n_1$).[18] Consequently, the firm does not need the entire existing labour force – which is now more efficient – to meet the new demand for effective labour, causing labour demand to fall. Obviously, the opposite result holds true for elastic labour demand.

Although the *slope-of-demand* effect and the *demand-shifting* effect may work in opposite directions, the net impact on labour demand is that it becomes *less elastic*. Consequently, the union will respond to the implementation of a labour-saving innovation by increasing the wage level. From (12) we find that

$$\frac{\partial w}{\partial \phi_1} = \theta \frac{[a(2-b) + b\frac{\overline{w}}{\phi_2}][s_1 + s_2] - t(2s_2 - s_1 b)}{2(1+\theta)(s_1+s_2)}. \qquad (15)$$

A closer inspection of (15) reveals that $\partial w/\partial \phi_1 > 0$ for all permissible values of the model parameters.[19]

If a labour-saving innovation yields higher wages and higher employment, the trade union would obviously benefit, irrespective of union preferences. If, like in most cases, a labour-saving innovations causes higher wages and lower employment,[20] the effect on union utility depends on how the union evaluates the trade-off between wages and employment. Trading lower employment for higher wages is more likely to increase union utility if the union is more wage oriented (implying a higher value of θ). Inserting equilibrium wages and employment into the union utility function, we find that $\partial U/\partial \phi_1 > 0$ if θ is above a threshold level, θ^*, given by

$$\theta^* = 1 - \frac{4\frac{\overline{w}}{\phi_1}(s_1+s_2)}{[a(2-b) + b\frac{\overline{w}}{\phi_2}][s_1+s_2] - t(2s_2 - s_1 b)}. \qquad (16)$$

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[17] See also Dowrick and Spencer (1994).

[18] Using (3), it is easily shown that the elasticity of labour demand with respect to the wage level is equal to the elasticity of effective labour demand with respect to the effective wage, i.e., $\varepsilon_1 = -\frac{\partial(\phi_1 n_1)}{\partial(w/\phi_1)}\frac{(w/\phi_1)}{(\phi_1 n_1)}$.

[19] Rewriting (15), we get

$$\frac{\partial w}{\partial \phi_1} = \frac{1}{2}\frac{\theta}{(1+\theta)}\frac{[a(2-b) + b\frac{\overline{w}}{\phi_2} + tb]s_1 + [a(2-b) + b\frac{\overline{w}}{\phi_2} - 2t]s_2}{s_1+s_2}.$$

>From (9), it is easily shown that a *necessary* condition for $q_{12} > 0$ is that $a(2-b) + b\frac{\overline{w}}{\phi_2} - 2t > 0$. Thus, $\frac{\partial w}{\partial \phi_1}$ is positive under intra-industry trade.

[20] In the present model, it can be shown that a labour-saving innovation yields lower employment for a substantial subset of the valid parameter values.

Thus, the trade union will accept the implementation of a labour-saving innovation only if the union is sufficiently wage oriented, i.e., if $\theta > \theta^*$. Since $\theta^* < 1$, it follows that a rent-maximising union would never oppose technological change.

In the remainder of the analysis we will see how changes in the key parameters of the model affect union attitudes towards technological change. For the union not to try to sabotage productivity-enhancing technological change, the union must be sufficiently wage oriented. In line with this, we adopt the following interpretation of the model: any structural change that increases (reduces) the critical value θ^* is said to increase (reduce) the likelihood of union opposition to technological change. Note that some unions may oppose technological change both before and after some parameter changes, and some unions may be in favour before and after. But if we picture the economy as consisting of many international unionised oligopolies, where the various unions have different preferences over wages and employment, an increase in θ^* will induce more unions to go against labour-saving innovation.

5.1 Globalisation

The main aim of the paper is to analyse how globalisation – interpreted as a reduction of trade costs between countries – affects union attitude towards labour-saving technological change in oligopolistic industries.[21] The following result is obtained:

Proposition 1 *Globalisation increases the probability of union opposition to technological change if (i) the industry is characterised by intra-industry trade, and (ii) the domestic market is not too large relative to the foreign market.*

Proof. >From (16) we find that

$$\frac{\partial \theta^*}{\partial t} = -\frac{4\left(2s_2 - s_1 b\right)\frac{\overline{w}}{\phi_1}\left(s_1 + s_2\right)}{\left\{\left[a\left(2-b\right) + b\frac{\overline{w}}{\phi_2}\right]\left[s_1 + s_2\right] - t\left(2s_2 - s_1 b\right)\right\}^2} < (>)\, 0$$

iff

$$s_1 < (>)\, \frac{2}{b} s_2.$$

■

The size-difference between markets referred to in Proposition 1 depends crucially on how differentiated the two products are. For very

[21] In line with our broad interpretation of trade costs, globalisation should be thought of as any measures taken to reduce the costs of trade, including reduced tariffs, improved quality of infrastructure and reduced bureaucratic barriers to trade.

close substitutes, the home market must be less than twice the size of the foreign market. However, for unrelated products ($b \to 0$), the above result essentially applies regardless of market sizes.

The intuition behind Proposition 1 can ultimately be traced to the effect of trade liberalisation on labour demand, but first we have to do a preliminary round of explanation. Trade liberalisation affects the critical value of θ^* insofar as the effect of technological change on the labour demand elasticity – and thus the union's optimal trade-off between wages and employment – is influenced by a reduction of trade costs. Obviously, the trade-off between wages and employment is only relevant if a labour-saving innovation *reduces* the demand for labour, implying $\theta^* > 0$. Consequently, if trade liberalisation causes a *larger reduction* in labour demand due to a technological improvement, then the union must be *less* concerned about employment in order to gain from the technology-induced wage increase, i.e., $\frac{\partial \theta^*}{\partial t} < 0$. From (10) we find that

$$\frac{\partial}{\partial t}\left(\frac{\partial n_1}{\partial \phi_1}\right) = \frac{2s_2 - s_1 b}{\phi_1^2(4-b^2)},$$

implying that a reduction of trade costs amplifies a negative labour demand effect if $s_1 < \frac{2s_2}{b}$.

This result is explained by the relationship between labour demand elasticity and the labour demand effect of a technological change: the less elastic labour demand is, the larger the reduction of labour demand in response to a labour-saving innovation. As we have previously shown – see (14) – the less elastic labour demand is, the smaller is the increase in demand for effective labour due to a technological improvement. It follows that more worker will become redundant when productivity increases. Thus, trade liberalisation increases $\left|\frac{\partial n_1}{\partial \phi_1}\right|$ if it makes labour demand less elastic. Since t does not affect the slope of the labour demand curve, trade liberalisation makes labour demand less elastic if it simply increases the total demand for labour. From (10) it is easily found that

$$\frac{\partial n_1}{\partial t} = -\frac{2s_2 - s_1 b}{\phi_1(4-b^2)} < (>)\, 0$$

if

$$s_1 < (>)\, \frac{2s_2}{b},$$

which confirms the intuition. It is important to note that this effect of trade cost reductions on the elasticity of labour demand applies to a much larger class of demand systems than the linear one.[22]

[22] Writing the labour demand function for the unionised firm on general form, $n_1(w,t)$, with $\varepsilon_1(w,t) := \frac{\partial n_1(w,t)}{\partial w}\frac{w}{n_1(w,t)}$ being the corresponding own-wage elastic-

It is less strenuous to understand why trade liberalisation increases labour demand. A reduction of trade costs implies that both firms improve their competitive positions in their respective export markets. Thus, total labour demand will increase if the gain of market share in the export market more than outweighs the loss of market share domestically. Since reduced trade costs increase the degree of competition, and thus total sales, in both markets, total labour demand from the unionised firm will increase unless the domestic market is very large relative to the foreign market. If products are homogeneous, the domestic market must be more than twice as large as the foreign market in order for the unionised firm to reduce its labour demand in response to a reduction of trade costs.[23]

Perhaps the most interesting implication of this result regards social welfare. Proposition 1 suggests that the traditional welfare gains of globalisation – increased competition and lower consumer prices – may be modified by increased union opposition to technological change in oligopolistic industries, which may reduce the rate at which new labour-saving innovations are implemented.

5.2 Relative market sizes and technological advantage

Maintaining the assumption of intra-industry trade, we will also investigate how union attitude towards labour-saving innovations depends on the relative size of the domestic market, and the degree of technological (dis)advantage. These relations are established by the following two propositions:

Proposition 2 *Union opposition to technological change is more likely the larger the domestic market is relative to the foreign market.*

Proof. >From (16) we have that

$$\frac{\partial \theta^*}{\partial s_1} = \frac{4\frac{\overline{w}}{\phi_1} t s_2 (2+b)}{\{[a(2-b) + b\frac{\overline{w}}{\phi_2}][s_1+s_2] - t(2s_2 - s_1 b)\}^2} > 0$$

---

ity, it is easily shown that trade cost reductions make labour demand less elastic if

$$-\frac{w}{n_1(w,t)}(\varepsilon_1(w,t)\frac{\partial n_1(w,t)}{\partial t} + \frac{\partial^2 n_1(w,t)}{\partial w \partial t}) < 0.$$

For a linear demand system we have that $\frac{\partial^2 n_1(w,t)}{\partial w \partial t} = 0$, so in this case the inequality is satisfied if $\frac{\partial n_1(w,t)}{\partial t} < 0$. Thus, in general, the analysis applies to demand systems where $\frac{\partial^2 n_1(w,t)}{\partial w \partial t}$ is negative or not 'too positive'.

[23] If products are independent ($b = 0$), there is no deterioration of the firms' competitive position in their respective home markets, and consequently – in this case – labour demand always increases when t decreases.

and

$$\frac{\partial\theta^*}{\partial s_2} = -\frac{4\overline{w}ts_1\left(2+b\right)}{\{[a\left(2-b\right)+b\frac{\overline{w}}{\phi_2}][s_1+s_2]-t\left(2s_2-s_1b\right)\}^2} < 0.$$

■

Proposition 3 *Union opposition to technological change is more (less) likely if the unionised firm has a technological (dis)advantage.*

Proof. >From (16) it follows that

$$\frac{\partial\theta^*}{\partial\phi_1} = \frac{2\frac{\overline{w}}{\phi_1}\left(s_1+s_2\right)}{[a\left(2-b\right)+b\frac{\overline{w}}{\phi_2}][s_1+s_2]-t\left(2s_2-s_1b\right)} > 0$$

(the denominator in the expression for $\frac{\partial\theta^*}{\partial\phi_1}$ is positive by assumption; see footnote 19) and

$$\frac{\partial\theta^*}{\partial\phi_2} = -\frac{2(\frac{\overline{w}}{\phi_2})^2b\left(s_1+s_2\right)^2}{\phi_1\{[a\left(2-b\right)+b\frac{\overline{w}}{\phi_2}][s_1+s_2]-t\left(2s_2-s_1b\right)\}^2} < 0.$$

■

Both results are explained by the effect of the relevant parameters on labour demand elasticity, in line with the intuition given for Proposition 1. If a parametric change makes labour demand less elastic, a labour-saving technological change is more likely to reduce the demand for labour (or to make a negative labour demand response larger). This, in turn, increases the critical value of θ, above which the union will benefit from such a technological change.

So how does an increase in market size – which is equivalent to an increase in the number of consumers residing in the market in question – affect labour demand elasticity for the unionised firm? Once more, it is useful to decompose the total effect into a *slope-of-demand* effect and a *demand-shifting* effect. It is easily shown that an expansion of either market makes labour demand more wage responsive. Since sales increase, a given increase in wages now results in a larger reduction of labour demand.[24] Ceteris paribus, this makes labour demand more elastic. However, the increase in sales due to a market expansion implies

[24] >From (10) we find that

$$\frac{\partial}{\partial s_1}\left(-\frac{\partial n_1}{\partial w}\right) = \frac{\partial}{\partial s_2}\left(-\frac{\partial n_1}{\partial w}\right) = \frac{2}{\phi_1^2\left(4-b^2\right)} > 0.$$

that the *demand-shifting* effect works in the opposite direction, making labour demand less elastic. The size of this effect depends on which market expands. As long as $t > 0$, the increase in sales – and thus labour demand – is larger if the domestic market expands. It turns out that the *demand-shifting* effect dominates the *slope-of-demand* effect if the market expansion occurs in the domestic market, making labour demand less elastic. Consequently, union opposition to technological change increases. If the foreign market expands, the opposite result applies. Finally, if $t = 0$ the two effects exactly cancel, leaving labour demand elasticity unchanged.

Consider then an increase in labour productivity for firm 1 – interpreted here as a 'technological advantage' for firm 1. We know from the previous discussion that this will make labour demand less elastic, due to the reduced wage responsiveness of labour demand. Obtaining a technological advantage will thus increase the likelihood of union opposition towards the introduction of further labour-saving innovations, and make it more difficult to increase the technological advantage. The opposite result applies if the foreign firm gets a technological advantage. An increase in labour productivity for this firm will unambiguously reduce labour demand from the unionized firm, making labour demand from this firm more elastic.

The result in Proposition 3 suggests the presence of a 'catch-up' effect in the introduction of new technology. Due to union opposition to technological change, it may be more difficult to increase, or even sustain, a technological advantage. Both in industrial organisation (for example, Fudenberg *et al.*, 1983 and Reinganum, 1983) and in the trade literature (for example, Brezis, Krugman and Tsiddon, 1993 and Desmet, 2002) researchers have studied models of technology leaders that rationally adopt new technology so late that newcomers overtake them. The present model, with its focus on harder union resistance to technology in the technologically leading nation, complements this line of work.

6 One-way trade

In order to check the robustness of our results with respect to different trade patterns, we briefly study the situation where there is one-way trade into the domestic (unionised) market. In general, this trade regime would emerge for some intermediate range of t.[25] Since, in this model, the sales in the two markets are independent variables as seen from the firms, labour demand by the unionised firm is in this case given by

[25] See Lommerud, Meland and Sørgard (2003) for further discussion of such a possibility.

$n_1 = \frac{q_{11}}{\phi_1}$, where q_{11} is given by (8). Thus,

$$n_1 = s_1 \frac{a\,(2-b) + bt + b\frac{\overline{w}}{\phi_2} - 2\frac{w}{\phi_1}}{\phi_1\,(4-b^2)}. \tag{17}$$

It is then straightforward to derive the optimal wage:

$$w = \frac{\phi_1 \theta [a\,(2-b) + bt] + \frac{\overline{w}}{\phi_2}\,(\theta b \phi_1 + 2\phi_2)}{2\,(1+\theta)}. \tag{18}$$

Inserting the equilibrium values of wages and employment into the utility function, (4), we find that the critical level of θ, denoted by θ^{**}, below which the trade union will oppose a labour-saving technological change, is given by

$$\theta^{**} = 1 - \frac{4\frac{\overline{w}}{\phi_1}}{a\,(2-b) + bt + b\frac{\overline{w}}{\phi_2}}. \tag{19}$$

As can easily be shown, the qualitative effect of a technological (dis)advantage on union opposition to technological change is not affected by trade patterns, so Proposition 3 still holds. However, the effect of relative market size is now modified. Relating to the previous intuition given for Proposition 2, it can easily be shown that the slope-of-demand effect and the demand-shifting effect exactly cancel, implying that the size of the domestic market has no effect on union attitudes towards labour-saving innovations.

More interesting, though, is the question of whether the main result of the paper – given in Proposition 1 – is crucially dependent on trade patterns. Keeping the intuition for Proposition 1 in mind, it is not surprising that this is indeed the case:

Proposition 4 *Trade liberalisation reduces the probability of union opposition to technological change if the industry is characterised by one-way trade into the unionised country.*

Proof. >From (19) we find that

$$\frac{\partial \theta^{**}}{\partial t} = \frac{4b\overline{w}}{\phi_1 [a\,(2-b) + bt + b\frac{\overline{w}}{\phi_2}]^2} > 0.$$

■

>From the previous analysis we know that whether or not trade liberalisation increases the probability of union hostility towards technological change ultimately relies on whether or not a reduction of trade

costs increases demand for labour from the unionised firm. When the unionised firm competes in the domestic market only, a marginal reduction of trade costs implies that the (domestic) unionised firm aggravates its competitive position vis-à-vis the foreign firm. Consequently, labour demand from the unionised firm will be reduced. It follows that the likelihood of union opposition to labour-saving innovations is also reduced.

7 Concluding remarks

Globalisation can make technology opposition from unions more likely. Increased international integration is often seen as a force that drive economies towards efficiency and modernisation, but we have here pinpointed an effect that works in the opposite direction.

If unions sabotage technology adoption, this should be traceable in the many empirical studies on unions, R&D, technology adoption, productivity, and the like. Menezes-Filho and Van Reenen (2003) summarise this body of work as follows: "North American results find consistently strong and negative impacts of unions on R&D. By contrast, European studies (mainly in the UK) generally do not uncover negative effects of unions on R&D. There is no consensus of the effects of unions on our other main measures: technological diffusion, innovation or productivity growth even in the North American studies. These cross-country differences in the R&D impact of unions could represent either unsolved econometrics problems or genuine institutional differences between nations in union attitudes and ability to bargain. We suspect the latter is the main reason."

Unions hurt technology adoption in some circumstances and not in others. Theoretical studies like this one hopefully can help pinpoint when what happens, to the aid both of empirical studies and of policy. One should be careful to draw strong policy conclusions from a model of any one specified institutional set-up. This said, the central problem is – as in many other models of trade unionism – that the union has too much power over certain decision variables relative to others. Here, this means too much power over technology and wages relative to employment decisions. This can in general be solved either by increasing union power over some variables, or decreasing union power over others. A nationwide corporativist union might take the long-term consequences for most of the population into account, so that the outcome resembles that achieved under efficient bargaining. Taking away a union's power to sabotage technology would of course also eliminate the problem that globalisation fosters technology opposition.

Given the assumed structure – a strong union in an oligopolist firm that does not take into account the long-term effect of its own actions on the wider economy – it is actually beneficial for technology adoption that the union is wage-oriented rather than employment-oriented. A wage-oriented union could be seen as a union where the preferences of the 'insiders' in the union dominate over the 'outsiders' with less secure jobs. Job protection that increases with seniority and other measures that strengthen insider power will here in fact have the surprising side-effect of making the union more prone to accept technological change. Such changes typically increases the wages of insiders – job losses will have to be carried by the marginal 'outsiders', which is of no concern to an insider dominated union.

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Appendix

A The Bertrand case

In this supplement, we show that the qualitative results for the Cournot set-up also applies to the Bertrand case.

A.1 Labour demand

Solving (1) and (2) for quantities, we get ($j = 1, 2$)

$$q_{1j} = s_j \frac{a(1-b) - p_{1j} + bp_{2j}}{1-b^2}, \tag{A1}$$

$$q_{2j} = s_j \frac{a(1-b) - p_{2j} + bp_{1j}}{1-b^2}. \tag{A2}$$

Profit maximisation for the home firm then implies

$$\max_{p_{11},p_{12}} [\pi_1 = (p_{11} - \frac{w}{\phi_1}) s_1 \frac{a(1-b) - p_{11} + bp_{21}}{1-b^2} \tag{A3}$$
$$+(p_{12} - \frac{w}{\phi_1} - t) s_2 \frac{a(1-b) - p_{12} + bp_{22}}{1-b^2}].$$

For the two way trade case, the first order conditions are

$$p_{11} = \frac{1}{2}[bp_{21} + a(1-b) + \frac{w}{\phi_1}], \tag{A4}$$

$$p_{12} = \frac{1}{2}[bp_{22} + a(1-b) + t + \frac{w}{\phi_1}]. \tag{A5}$$

The first order conditions for the foreign firm are similar, and solving for equilibrium prices, we obtain

$$p_{21} = \frac{a(2-b-b^2) + 2t + b\frac{w}{\phi_1} + 2\frac{\overline{w}}{\phi_2}}{4-b^2}, \tag{A6}$$

$$p_{11} = \frac{a(2-b-b^2) + bt + b\frac{\overline{w}}{\phi_2} + 2\frac{w}{\phi_1}}{4-b^2}, \tag{A7}$$

$$p_{22} = \frac{a(2-b-b^2) + bt + b\frac{w}{\phi_1} + 2\frac{\overline{w}}{\phi_2}}{4-b^2}, \tag{A8}$$

$$p_{12} = \frac{a(2-b-b^2) + 2t + b\frac{\overline{w}}{\phi_2} + 2\frac{w}{\phi_1}}{4-b^2}. \tag{A9}$$

This yields production quantities q_{11} and q_{12}, given by

$$q_{11} = s_1 \frac{a(2-b-b^2) + bt - (2-b^2)\frac{w}{\phi_1} + b\frac{\overline{w}}{\phi_2}}{(4-b^2)(1-b^2)}, \quad \text{(A10)}$$

$$q_{12} = s_2 \frac{a(2-b-b^2) + b\frac{\overline{w}}{\phi_2} - (2-b^2)(\frac{w}{\phi_1} + t)}{(4-b^2)(1-b^2)}. \quad \text{(A11)}$$

Labour demand by the unionised firm is then given by $n_1 = \frac{q_{11}+q_{12}}{\phi_1}$, or

$$n_1 = \frac{[a(2-b-b^2) - (2-b^2)\frac{w}{\phi_1} + b\frac{\overline{w}}{\phi_2}](s_1+s_2) - [(2-b^2)s_2 - bs_1]t}{\phi_1(4-b^2)(1-b^2)}. \quad \text{(A12)}$$

A.2 Wages and the impact of a change in technology

Union wages are again obtained by solving (11) from the main paper:

$$w = \frac{[\theta\phi_1 a(2-b-b^2) + \overline{w}(2-b^2+\theta b\frac{\phi_1}{\phi_2})](s_1+s_2) - \theta\phi_1[(2-b^2)s_2 - bs_1]t}{(2-b^2)(s_1+s_2)(1+\theta)}. \quad \text{(A13)}$$

The discussion in the beginning of section 5 is valid in the Bertrand case also. (13) and (14) from the main text becomes

$$\frac{\partial}{\partial\phi_1}\left(-\frac{\partial n_1}{\partial w}\right) = -2\frac{2-b^2}{1-b^2}\frac{s_1+s_2}{\phi_1^3(4-b^2)} < 0, \quad \text{(A14)}$$

$$\frac{\partial n_1}{\partial\phi_1} = \frac{2-b^2}{1-b^2}\frac{(s_1+s_2)w(1-\frac{1}{\varepsilon_1})}{\phi_1^3(4-b^2)}. \quad \text{(A15)}$$

Again, the *slope-of-demand* effect is negative, while the *demand-shifting* effect depends on the initial elasticity of labour demand.

The wage response of a technology improvement in the Bertrand case is given by

$$\frac{\partial w}{\partial\phi_1} = \theta\frac{[a(2-b-b^2) + b\frac{\overline{w}}{\phi_2}](s_1+s_2) - t[(2-b^2)s_2 - s_1 b]}{(2-b^2)(1+\theta)(s_1+s_2)}. \quad \text{(A16)}$$

Rewriting , we can again show that $\frac{\partial w}{\partial\phi_1}$ is positive for all permissible parameter values:

$$\frac{\partial w}{\partial\phi_1} = \theta\frac{[a(2-b-b^2) + b\frac{\overline{w}}{\phi_2} + tb]s_1 + [a(2-b-b^2) + b\frac{\overline{w}}{\phi_2} - (2-b^2)t]s_2}{(2-b^2)(1+\theta)(s_1+s_2)}. \quad \text{(A17)}$$

>From (A11), it is clear that a *necessary* condition for two way trade is that $\frac{\partial w}{\partial \phi_1}$ is positive.

Solving for θ^* in the Bertrand case, we get

$$\theta^* = 1 - \frac{2(2-b^2)\frac{\overline{w}}{\phi_1}(s_1+s_2)}{[a\,(2-b-b^2)+b\frac{\overline{w}}{\phi_2}](s_1+s_2)-t[(2-b^2)s_2-s_1b]}. \qquad \text{(A18)}$$

A.3 Proofs

It is now easy to show that all the propositions of the main text hold for the Bertrand case also:

Proof of Proposition 1:

$$\frac{\partial \theta^*}{\partial t} = -\frac{2(2-b^2)[(2-b^2)s_2-s_1b]\frac{\overline{w}}{\phi_1}\,(s_1+s_2)}{\{[a\,(2-b-b^2)+b\frac{\overline{w}}{\phi_2}](s_1+s_2)-t[(2-b^2)s_2-s_1b]\}^2} < (>)\,0 \qquad \text{(A19)}$$

iff

$$s_1 < (>)\,\frac{2-b^2}{b}s_2. \qquad \text{(A20)}$$

Thus the qualitative result remains, although the exact relative market sizes that ensures the result, are different.■

Proof of Proposition 2:

$$\frac{\partial \theta^*}{\partial s_1} = \frac{2(2-b^2)\frac{\overline{w}}{\phi_1}ts_2(2-b)(1+b)}{\{[a\,(2-b-b^2)+b\frac{\overline{w}}{\phi_2}](s_1+s_2)-t[(2-b^2)s_2-s_1b]\}^2} \geq 0 \qquad \text{(A21)}$$

and

$$\frac{\partial \theta^*}{\partial s_2} = -\frac{2(2-b^2)\frac{\overline{w}}{\phi_1}ts_1(2-b)(1+b)}{\{[a\,(2-b-b^2)+b\frac{\overline{w}}{\phi_2}](s_1+s_2)-t[(2-b^2)s_2-s_1b]\}^2} \leq 0. \qquad \text{(A22)}$$

■

Proof of Proposition 3:

$$\frac{\partial\theta^*}{\partial\phi_1} = \frac{2(2-b^2)\overline{w}\,(s_1+s_2)}{\phi_1^2\{[a\,(2-b-b^2)+b\frac{\overline{w}}{\phi_2}](s_1+s_2)-t[(2-b^2)s_2-s_1b]\}} > 0 \tag{A23}$$

(the numerator in the expression for $\frac{\partial\theta^*}{\partial\phi_1}$ is again positive in the two-way-trade regime) and

$$\frac{\partial\theta^*}{\partial\phi_2} = -\frac{2(2-b^2)(\frac{\overline{w}}{\phi_2})^2 b\,(s_1+s_2)^2}{\phi_1^2\{[a\,(2-b-b^2)+b\frac{\overline{w}}{\phi_2}](s_1+s_2)-t[(2-b^2)s_2-s_1b]\}^2} \leq 0. \tag{A24}$$

■

A.4 One-way trade

Labour demand is in this case given by $n_1 = \frac{q_{11}}{\phi_1}$, or

$$n_1 = \frac{a(2-b-b^2)+bt-(2-b^2)\frac{w}{\phi_1}+b\frac{\overline{w}}{\phi_2}}{\phi_1\,(4-b^2)\,(1-b^2)}s_1. \tag{A25}$$

It is straightforward to derive the optimal wage:

$$w = \frac{\phi_1\theta[a\,(2-b-b^2)+bt]+\frac{\overline{w}}{\phi_2}[\theta b\phi_1+(2-b^2)\phi_2]}{(2-b^2)\,(1+\theta)}. \tag{A26}$$

θ^{**} is in the Bertrand case given by

$$\theta^{**} = 1-\frac{2(2-b^2)\frac{\overline{w}}{\phi_1}}{a\,(2-b-b^2)+bt+b\frac{\overline{w}}{\phi_2}}. \tag{A27}$$

Proof of Proposition 4:

$$\frac{\partial\theta^{**}}{\partial t} = \frac{2(2-b^2)b\frac{\overline{w}}{\phi_1}}{\{[a\,(2-b-b^2)+bt]+b\frac{\overline{w}}{\phi_2}\}^2} > 0. \tag{A28}$$

■