Technology resistance and globalisation with trade unions: the choice between employment protection and flexicurity[*]

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Abstract

We analyse how different labour market institutions – employment protection versus 'flexicurity' – affect technology adoption in unionised firms. The analysis is cast in a setting of corporate globalisation, where domestic unionised labour face the double threat of labour-saving technological innovations and international outsourcing of domestic production. In the main part of the analysis, we analyse trade unions' incentives to oppose or endorse the adoption of new technology. Our main result is that both weaker employment protection and a higher reservation wage for unionsed workers (interpreted as increased 'flexicurity') contribute to make trade unions more willing to accept labour-saving technological change. Furthermore, these effects are reinforced by globalisation. In an extension to the main analysis, we endogenise the technological progress by studying firms' incentives to invest in new technology and find that these incentives are also generally strengthened in a labour market with more 'flexicurity'.

Keywords: Technology adoption; Globalisation, Trade unions, Employment protection, Flexicurity

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1 Introduction

The rich countries of the world are similar in so many respects, but labour market relations differ quite significantly. A dividing line is often drawn between the flexible labour market of the US and the more regulated ones in Europe. Sometimes the lack of European labour market flexibility has been denoted 'eurosclerosis' (see, e.g., Bentolila and Bertola, 1990) and given as a reason why Europe lags behind the US in a time of rapid technological change and globalisation.

However, labour markets can be less than flexible in many ways, and the economic performance of European countries vary considerably. Many countries offer employment protection in various forms. This makes it costly to lay off workers, which is beneficial (at least in the shorter term) for workers who are already hired. But too strong employment protection can reduce the willingness of firms too hire people in the first place, and the work force can get stuck in old ways of production, with too little restructuring and technological and organisational change. 'Flexicurity' is sometimes seen as an alternative to employment protection. Flexicurity purportedly exists in Scandinavia and the Netherlands, and the key elements are low employment protection, good unemployment insurance (and other means of income support for people outside the labour market), and an emphasis on labour market training and skill development to ease (re)entry into paid work.[1]

Flexicurity has become somewhat of a buzzword among policy makers. For example, the 2005 Employment Outlook (OECD, 2005) recommends countries as Germany and France to adopt a labour market model inspired by Denmark. There is also an up-start economics literature that discusses flexicurity and employment protection within formal models, something we shall return to.

The present paper is also one attempt to employ formal economic modelling to get to grips with the flexicurity debate. A salient feature of the model is that workers are unionised. Those countries where authorities try to regulate the income security of work-

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[1]Some claim that the flexicurity concept should be reserved as a description of the Danish labour market only, since Denmark has less employment protection than some other candidate countries with high unemployment insurance and active labour market policies (Andersen and Svarer, 2006).

ers, by employment protection, high unemployment insurance benefits, or the like, are typically countries also with other deviations from free, competitive labour markets, with trade unionism as a prime example. Trade unions are still important in most West-European economies. Membership rates may have fallen in some countries, but coverage – the number of workers covered by a union wage agreement – has fallen much less.[2] The UK is perhaps the prime example of unions markedly losing influence over the last couple of decades, but even for this country it can be asked if unions 'have turned the corner'?[3] Notice also that trade unionism remains strong in those countries that are foremostly associated with flexicurity, as the Scandinavian countries. We therefore think it is interesting to ask how regulations as employment protection and unemployment benefits interact with unionised wage setting.

'Flexibility' in the labour market is a rather vague concept that can be given many interpretations. In our formal model, what we think of as flexibility is the adoption of new labour-saving technologies in firms. We make the reasonable assumption that trade unions have some influence on the use of technology. At first we exaggerate this by assuming that the union can veto the adoption of any technology that is not in the best interest of the union membership. As in Dowrick and Spencer (1994) and Lommerud, Meland and Straume (2006), this is a stylised way to capture that unions – being concerned about job losses among their members – can use their collective power to, if not permanently block, then at least significantly delay, and make more costly, the adoption of labour-saving technology. This is typically done by, e.g., refusing to concede to the changes in manning rules, remuneration systems and the like that new technology requires.[4] In a subsequent version of the model, we use the assumption that technology is endogenous: the firm can install labour-saving technology at a cost, but takes into account the wage response of the trade union. A key question in the paper is if income protection for the unemployed triggers the use of new technology, whereas employment protection is bad for technology

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[2] For documentation, see OECD (1997) and EEAG (2004).

[3] Blanden, Machin and Van Reenen (2006).

[4] See, e.g., Dowrick and Spencer (1994) and Lommerud et al. (2006) for comprehensive analyses and discussions – including many empirical and anectodal examples – of such 'rational Luddism' by trade unions.

adoption – or is it perhaps the other way around?

The model also introduces globalisation in a specific sense. We want to capture the notion that while employment protection can be good for employment in the short-run, it can also spell less employment-generating investments in the long-run. In the second of two periods, the firm can choose to produce its output domestically or abroad. To build capacity abroad is associated with an increasing, convex cost function – so it will never be the case that all production takes place in a foreign location. Everything that drives up the cost of using domestic labour will make the offshoring option more tempting. In our model, then, unionised workers face the potential double threat of labour-saving technological change and offshoring of jobs.

Within this general framework, we investigate how two parameters, an employment protection variable (the cost of laying people off) and a reservation wage variable (the utility of unionised workers outside the firm in question), affect technology adoption. We interpret 'flexicurity' as an increase in the reservation wage and a decrease in employment protection. We are foremostly interested in how flexicurity influences adoption of labour-saving technological advances.

A key result is that flexicurity is good for technology adoption. The increase in reservation wage and the decrease in employment protection will both contribute towards higher union willingness to adopt technology. Furthermore, the magnitude of both these effects increase with 'globalisation', that is, the ease with which a firm can offshore its production. Moving labour markets institution towards the flexicurity ideal therefore becomes more important the more internationalised production becomes.

The result that flexicurity is good for technology adoption is certainly not straightforward, since a first-glance intuition might suggest that stronger employment protection, by reducing job losses due to labour-saving innovations and thereby reducing the downside of technological change, should rather make trade unions *more* willing to accept technological change. This intuition is correct *all else equal*. However, when comparing different labour market institutions, all else is not equal. More specifically, but without going too

much into detail at this stage, a change in the degree of employment protection (resp. 'flexicurity') changes the wage-employment equilibrium and thereby changes the labour market effects of labour-saving innovations.

The flexicurity debate is often presented as a comparison of two European models. Less often is flexicurity compared with a non-interference type labour market as the US one. If one takes the existence of at least some union power as a starting point, our results suggest that non-interference is not a solution that best stimulates technology adoption. On the contrary, introducing minimum wages or social insurance that lifts the reservation wage of workers that lose their jobs – from the non-interference level – encourages technology adoption. A union that contemplates vetoing labour-saving technology, will weigh the wage benefit of the remaining more productive workers against the loss for workers that lose their jobs. Given that labour demand elasticity is increasing in the wage level, we show that the higher union wage level associated with a good reservation utility will tilt the union's trade-off more towards accepting the new technology.

The pre-existing academic economics literature on the flexicurity vs. employment protection debate is small, and little focussed on technology choices. Nevertheless, we would like to mention some related work. First we would want to point out the link to the debate in the Nordic trade union movement, spurred by the two Swedish trade union economists Gösta Rehn and Rudolf Meidner (see Turvey, 1952). They argued that it was important to keep wages up in traditional industry, to increase the rate of structural change and modernization. On the other hand, unemployment insurance and active labour market policies should be used to ease the situation for workers who lost their jobs and to speed up their re-entry into the labour market. (Agell and Lommerud (1993) and Moene and Wallerstein (1997) provide two different attempts at capturing these ideas in neoclassical economics models.)

One important ingredient in the flexicurity debate is unemployment insurance. Acemoglu and Shimer (2000) point out that unemployment insurance can yield productivity gains. In particular, insurance can motivate workers to move to higher productivity jobs

and also motivate firms to create those jobs. Hassler and Rodriguez Mora (2007) characterise optimal unemployment insurance when works can move and/or retrain, and find that the classical result that benefits should fall with unemployment duration no longer necessarily holds. Both of the latter papers picture 'flexibility' to mean structural and geographical mobility in the labour market, in contrast to our emphasis on the installment of labour-saving technology.

The other important ingredient in flexicurity is the reduction of employment protection. Bertola (2004) gives an overview of the debate on labour market institutions in Europe, with one emphasis on the consequences of employment protection. His focus is on structural change, rather than technology adoption.[5]

Blanchard and Tirole (2007) study the optimal design both of unemployment insurance and employment protection. In a first-best version of the model they find that unemployment insurance always should be accompanied by employment protection – and go on to discuss various deviations from this first-best model. We do not study the joint optimality of unemployment insurance and employment protection, but instead focus on the positive question how more unemploymnet insurance and less employment protection influence the adoption of new technology. Blanchard and Tirole do not focus on technology adoption, and trade unions and globalisation are not mentioned. Algan and Cahuc (2006) postulate that the tendency to cheat on unempolyment insurance programmes is larger in some countries than in others. This can make flexicurity the optimal choice for some Northern European countries, while it is not necessarily optimal to copy this policy in countries closer to the Mediterrean.[6]

Lastly, we would like to draw attention to the relatively large literature on how trade unionism influence the technology choices of the firm. See, for example, Tauman and Weiss (1987), Ulph and Ulph (1998), Calabuig and Gonzalez-Maestre (2002) and Haucap and Wey (2004). There is no mention of flexicurity in these papers.

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[5]Ichino and Riphahn (2005) discuss employment protection in the context of absenteeism. Dewit, Leahy and Montagna (2003) and Kessing (2006) discuss the possible strategic advantages from employment protection – building on the key insight that a firm that only costly can get rid of its workers, will fight harder for market shares.

[6]Boeri, Conde-Ruiz and Galasso (2006) bring political economy elements into the flexicurity debate.

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The rest of this paper is organised as follows. The basic model is presented in the next section. In Section 3, we analyse union resistance to an exogenous technological change. In Section 4, we endogenise the technology by analysing firm incentives to invest in better technology. The paper is concluded by Section 5.

2 Model

A unionised firm exists for two periods. In both periods, wages are set by a monopoly trade union, while employment is set by the firm. Two things happen before the start of period 2: the firm is able – due to investment liberalisation – to build up production capacity abroad, in a non-unionised environment. Furthermore, a new labour-saving technology is available in domestic production. However, due to employment protection legislation, it is costly for the firm to downsize domestic employment.

The firm is a monopolist in the product market, where demand is equal in both periods. The inverse demand function is given by the linear form[7]

$$p\left(q_i\right) = \alpha - \beta q_i, \tag{1}$$

where q_i is produced quantity in period i. Labour is the only factor of production in a simple linear technology. Denoting domestic employment in period i by L_i, produced output in the two periods is given by, respectively,

$$q_1 = L_1 \tag{2}$$

and

$$q_2 = \phi L_2 + q_f, \tag{3}$$

where q_f is output from production abroad. The firm can build up capacity abroad –

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[7]A linear demand function is chosen for analytical simplicity, but our results generalise well beoynd the linear specification. As we will show later, the main results depend on the assumption that the wage elasticity of labour demand is increasing in the wage level. This holds for a wide class of demand functions (see Footnote 16).

using foreign contractors and/or establishing greenfield plants – according to a strictly increasing, convex and twice differentiable cost function $K(q_f)$. For simplicity, we assume that all costs of serving the market (including production and trade costs) are included in $K(\cdot)$. Henceforth, we will refer to q_f as the level of offshoring. We also assume $K(\cdot)$ to be sufficiently convex to preclude all production being offshored.

Technological progress from period 1 to period 2 is measured by the technology parameter $\phi > 1$, and we equip the trade union with the power to block the introduction of the new technology in period 2. Thus, technology adoption requires that both the firm and the trade union benefit from it.

With the above assumptions, profits in period 1 and 2, respectively, are given by

$$\pi_1 = p(q_1)q_1 - w_1 L_1, \tag{4}$$

$$\pi_2 = \begin{cases} p(q_2)q_2 - w_2 L_2 - c(L_1 - L_2) - K(q_f) & if \quad L_2 < L_1 \\ p(q_2)q_2 - w_2 L_2 - K(q_f) & if \quad L_2 \geq L_1 \end{cases}. \tag{5}$$

The degree of employment protection is given by the parameter $c > 0$, in the case of second-period downsizing of domestic employment.[8,9] Throughout the analysis, we will focus exclusively on this (most interesting) case, where $L_2 < L_1$.

Trade union objectives are given by the following Stone-Geary-type utility function for period i:

$$U_i = (w_i - b)^\theta L_i, \tag{6}$$

where $\theta > 0$ is a measure of the degree of wage orientation in union preferences[10], while $b > 0$ is the reservation (reference) wage level. It is reasonable, and standard, to assume that b reflects both opportunities outside the firm (e.g., the minimum wage level) and

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[8]We focus on the red tape component of employment protection legislation. As noted by Boeri et al. (2006), both empirical evidence (Bertola et al, 2000) and economic theory (Lazear, 1990) suggest that it is mainly red tape and procedural costs that affect employment flows.

[9]As pointed out by Bentolila and Bertola (1990), the effects of employment protection laws are arguably best approximated by a fixed firing cost per worker, implying linear employment downsizing costs.

[10]The parameter θ can indirectly be interpreted as the degree of 'insider' domination. A trade union that is more dominated by insiders will typically give more importance to wages (all else equal).

outside the labour market (e.g., unemployment benefits). We also make the assumption that $b > c$. This assumption – as we will show later – ensures that the firm has no incentives to enforce a lower productivity on its workforce ex post.

We consider a game of complete and perfect information, with the following sequence of events:

1. **(a)** The union sets the first-period wage w_1.

   (b) The firms sets first-period employment L_1.

2. **(a)** The union decides whether to block the introduction of the new technology.

   (b) The firm decides the level of offshoring q_f.

   (c) The union sets second-period wages w_2.

   (d) The firms sets second-period (domestic) employment L_2.

Notice that the ordering of decisions 2a and 2b is not crucial for the analysis, as long as both decisions are made before wages and employment are determined in period 2. We look for a subgame perfect Nash equilibrium in pure strategies, solving the game by backwards induction.

2.1 Second-period employment and wages

Maximising the second-period profit function with respect to L_2, and assuming that $L_2 < L_1$, domestic labour demand in period 2 is given by

$$L_2 (w_2, q_f) = \frac{\alpha\phi - w_2 + c}{2\beta\phi^2} - \frac{q_f}{\phi}. \tag{7}$$

For a given wage, second-period labour demand is increasing in the degree of employment protection and decreasing in the degree of offshoring, as expected.

The trade union maximises its utility by choosing a wage level that optimally balances the concerns for wages and employment. The first-order condition for the optimal second-

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period wage level is given by

$$\varepsilon_2 \left(w_2, q_f\right) = \frac{\theta w_2}{w_2 - b}, \tag{8}$$

where $\varepsilon_2 \left(\cdot\right) := - \left(\partial L_2/\partial w_2\right)/\left(w_2/L_2\right)$ is the wage elasticity of second-period labour demand, defined for a given level of offshoring. Since the expression on the right-hand side of (8) is decreasing in w_2, we directly obtain the well-known result that the equilibrium wage is decreasing in the degree of labour demand elasticity.[11] From (7) we can derive an explicit expression for the second-period labour demand elasticity:

$$\varepsilon_2 \left(w_2, q_f\right) = \frac{w_2}{\phi \left(\alpha - 2\beta q_f\right) - w_2 + c}. \tag{9}$$

Many of the main results of the paper can be derived from changes in the wage elasticity of labour demand. It is therefore instructive to take a closer look at the determinants of this elasticity. Notice first that, since an increase in ϕ makes labour demand less responsive to wage changes,[12] there is a negative relationship between labour productivity and labour demand elasticity. Consequently, technological progress is accompanied by higher wages.

Consider the effect of employment protection. It follows directly from (9) that stronger employment protection makes second-period labour demand less elastic. Given that the firm wants to downsize domestic employment in the second period, an increase in c makes this more costly for the firm and the fall in second-period labour demand will consequently be smaller. The wage elasticity of labour demand is correspondingly reduced. The degree of offshoring, q_f, has the opposite effect. A higher offshoring level naturally reduces domestic labour demand, with a corresponding increase in labour demand elasticity.

The two remaining key parameters, θ and b, does not affect the wage elasticity of labour demand. Thus, we can see directly from (8), that, for a given level of offshoring, an increase in either of the two parameters will increase the equilibrium second-period wage.

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[11] See Oswald (1985) for an excellent early survey of the classical trade union models and their properties.

[12] This is easily verified by observing, from (7), that the slope of the labour demand function is given by

$$\frac{\partial L_2 \left(\cdot\right)}{\partial w_2} = -\frac{1}{2\beta\phi^2}.$$

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We can summarise the determinants second-period wages as follows:

Proposition 1 *The equilibrium second-period wage is increasing in the degree of employment protection, union wage orientation, labour productivity and the reservation wage level, and decreasing in the degree of offshoring.*

The explicit expressions for equilibrium second-period wages and employment are easily derived. Inserting (9) into (8), second-period union utility is maximised at the wage level

$$w_2^* = \frac{\theta \left(\phi \left(\alpha - 2q_f\beta \right) + c \right) + b}{1 + \theta}. \tag{10}$$

Equilibrium domestic employment is then found by substituting (10) in (7), yielding

$$L_2^* = \frac{\phi \left(\alpha - 2q_f\beta \right) - (b - c)}{2\beta\phi^2 \left(\theta + 1 \right)}. \tag{11}$$

We assume that $L_2^* > 0$, which requires that offshoring is sufficiently costly. For a given level of offshoring, both second-period wages and second-period employment are increasing in the degree of employment protection. Notice that the employment effect of improved technology is *a priori* ambiguous. We will return to a full analysis and discussion of this relationship in Section 3.

2.2 Offshoring

The firm chooses a degree of offshoring that maximises (5), taking into account how the offshoring decision affects second-period wages. Substituting from (10) and (11) into (5), and assuming that $L_1 > L_2$, the first-order condition for the optimal level of offshoring is given by[13]

$$\frac{\theta \left(2 + \theta \right) \phi \left(\alpha - 2q_f\beta \right) + b - c}{\phi \left(\theta + 1 \right)^2} - K' \left(q_f \right) = 0, \tag{12}$$

which implicitly defines a function $q_f^* = q_f \left(\theta, \phi, \alpha, \beta, b, c \right)$. We see that, due to the linearity of employment downsizing costs, q_f^* does not depend on any first-period decisions.

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[13] Non-concavity of $K \left(\cdot \right)$ ensures that the second-order condition is satisfied.

Comparative statics results are obtained by totally differentiating (12), yielding

$$\frac{\partial q_f^*}{\partial \theta} = \frac{4\beta q_2^*}{2\theta\beta(\theta+2) + (\theta+1)^2 K''\left(q_f^*\right)} > 0, \tag{13}$$

$$\frac{\partial q_f^*}{\partial c} = -\frac{\partial q_f^*}{\partial b} = \frac{-1}{\phi\left(2\theta\beta(\theta+2) + (\theta+1)^2 K''\left(q_f^*\right)\right)} < 0, \tag{14}$$

$$\frac{\partial q_f^*}{\partial \phi} = \frac{-(b-c)}{\phi^2\left(2\theta\beta(\theta+2) + (\theta+1)^2 K''\left(q_f^*\right)\right)} < 0. \tag{15}$$

Proposition 2 *The equilibrium level of offshoring is increasing in the degree of union wage orientation and the reservation wage level, and decreasing in the degree of employment protection and domestic technological progress.*

A more wage oriented union implies that domestic production is more costly for the firm, due to higher domestic wages. Consequently, the firm finds it profitable to offshore more production. Notice the importance of the timing of the game for this result: it is, by implicit assumption, not possible for the union to commit to a lower wage level in order to keep a larger share of production at home. The same argument is behind the positive relationship between the domestic reservation wage and the extent of offshoring. A higher reservation wage pushes up the domestic wage level, inducing the firm to offshore more production.

Employment protection, on the other hand, has the opposite effect on offshoring incentives. Although stronger employment protection leads to higher second-period wages, which – in isolation – should lead to more offshoring, the direct cost of offshoring also increases, since it becomes more costly for the firm to downsize production at home. The second effect always dominates, yielding a negative relationship between the degree of employment protection and offshoring incentives. A similar effect is established with respect to domestic technological progress. Although part of any productivity increase is absorbed by higher domestic wages, the profitability of domestic production nevertheless increases (which we will show more rigorously in the next section), making offshoring of production

less attractive to the firm.

2.3 First-period employment and wages

Both the firm and the trade union make their first-period choices by maximising the sum of first- and second-period payoffs. For simplicity, we abstract from discounting. Maximising $\pi_1 + \pi_2$ with respect to L_1, and assuming that $L_2 < L_1$, first-period labour demand is given by

$$L_1\left(w_1\right) = \frac{\alpha - c - w_1}{2\beta}. \tag{16}$$

Due to the linearity of employment downsizing costs, first-period labour demand does not depend on second-period wages. It is only the degree of employment protection that matters.

Optimal first-period wage setting by the trade union is determined by the same mechanisms that were given a thorough treatment in Section 2.1, and the results are – with the exception of the effect of employment protection – qualitatively similar. In this subsection, we focus more on dynamic employment effects. Inserting (16) into (6), the equilibrium first-period wage is given by

$$w_1^* = \frac{\theta\left(\alpha - c\right) + b}{\theta + 1}, \tag{17}$$

which yield equilibrium first-period employment

$$L_1^* = \frac{\alpha - b - c}{2\beta\left(\theta + 1\right)}. \tag{18}$$

Notice that the equilibrium wage and employment in the first-period are independent of second-period decisions.

The effect of employment protection on wages and employment differs diametrically in the first and second period. Stronger employment protection implies that it is more costly for the firm to operate with a large workforce in the first period, given the incentives for second-period downsizing. Thus, stronger employment protection yields lower labour demand in the first period. In other words, the positive effect on employment in the second

period is counteracted by a negative first-period effect. Correspondingly, employment protection causes a wage reduction in the first-period.

What about the overall effect on employment? This is given by

$$\frac{\partial \left(L_1^* (c) + L_2^* \left(c, q_f^* (c) \right) \right)}{\partial c} = \underbrace{\frac{\partial L_1^*}{\partial c}}_{-} + \underbrace{\frac{\partial L_2^*}{\partial c}}_{+} + \underbrace{\frac{\partial L_2^*}{\partial q_f} \frac{\partial q_f^*}{\partial c}}_{+}, \tag{19}$$

confirming that employment protection reduces the negative employment effects of off-shoring and labour-saving technology in the second-period, at the cost of lower employment in the first period. Using (11), (14) and (18), the total effect can be expressed as

$$\frac{\partial \left(L_1^* + L_2^* \right)}{\partial c} = -\frac{1}{\phi \left(\theta + 1 \right)} \left[\frac{\phi^2 - 1}{2\beta\phi} - \frac{1}{\phi \left(K'' \left(q_f^* \right) \left(\theta + 1 \right)^2 + 2\theta\beta \left(\theta + 2 \right) \right)} \right]. \tag{20}$$

The total employment effect is negative if the sign of the expression in the square brackets is positive. We see that this will be the case if offshoring is sufficiently costly, or, more precisely, if the offshoring cost function is sufficiently convex. Thus, in the absence of offshoring possibilities, employment protection always has a negative overall effect on employment, when dynamic incentives are taken into account. However, with the possibility of offshoring, employment protection has a dampening effect on the firm's offshoring incentives, which – due to the linearity of employment protection costs – do not affect first-period decisions. This dampening effect is stronger the less convex the offshoring cost function is, as can be seen from (14). Consequently, if this effect is sufficiently strong, employment protection might have an overall positive effect on domestic employment. From (20) we see that this is more likely the more employment oriented the trade union is (increasing the second term in the square brackets).

An interesting implication of the above result and discussion is that globalisation makes employment protection a potentially more effective instrument to stimulate domestic employment. However, it should be said that this conclusion is likely to depend on the

assumption that offshoring of *all* production is not a possibility. If the firm also has the option to move the entire production abroad, stronger employment protection, while reducing the degree of partial offshoring, might well increase the probability that all production is offshored.

We summarise the effects of employment protection on domestic equilibrium employment as follows:

Proposition 3 *Stronger employment protection reduces the negative employment effect of offshoring and labour-saving technology ex post, but also reduces equilibrium employment ex ante. The overall effect is always negative if offshoring is not a possibility. In the case of offshoring, the total employment effect of stronger employment protection can be positive if the convexity of the offshoring cost function is sufficiently low.*

3   Technological progress

Will the new labour-saving technology be adopted in the second-period? We assess this question by investigating the effect of a marginal increase in the technology parameter ϕ on second-period payoffs. Before analysing union incentives, let us first confirm that the firm always benefits from better production technology. Using the Envelope Theorem, the effect on second-period profits of a marginal increase in labour productivity is given by

$$\frac{d\pi_2}{d\phi} = \frac{\partial \pi_2}{\partial \phi} + \frac{\partial \pi_2}{\partial w_2}\frac{\partial w_2^*}{\partial \phi} = \frac{(b-c)\, L_2^*}{\phi\,(\theta+1)}, \tag{21}$$

which is unambiguously positive, given that $b > c$. It can also be shown that the firm has no incentive to enforce a lower productivity on its workforce ex post. For a given level of employment, the effect of increased productivity on profits is given by

$$\frac{\partial \pi_2\,(L_2)}{\partial \phi} = L_2\,[\alpha - 2\beta\,(q_2 + q_f)]. \tag{22}$$

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Inserting the equilibrium level of employment, from (11), yields

$$\left.\frac{\partial \pi_2\left(L_2\right)}{\partial \phi}\right|_{L_2=L_2^*} = \frac{\theta \phi\left(\alpha - 2q_f\beta\right) + b - c}{\phi\left(\theta + 1\right)} L_2^*, \tag{23}$$

which, again, is always unambiguously positive if $b > c$.

3.1 Union resistance to technological progress

Due to the monopoly union assumption, whether or not improved technology increases union utility is given by the effect on labour demand. Applying the Envelope Theorem, the effect of technological change on second-period union utility is, on general form, given by

$$\frac{dU_2\left[w_2^*\left(\phi\right), L_2\left(w_2^*\left(\phi\right), q_f^*\left(\phi\right), \phi\right)\right]}{d\phi} = \left.\frac{\partial U_2\left(\cdot\right)}{\partial L_2}\left(\frac{\partial L_2}{\partial \phi} + \frac{\partial L_2}{\partial q_f}\frac{\partial q_f}{\partial \phi}\right)\right|_{w_2=w_2^*;\, q_f=q_f^*}. \tag{24}$$

Thus, the union will oppose technological change if

$$\left.\left(\frac{\partial L_2}{\partial \phi} + \frac{\partial L_2}{\partial q_f}\frac{\partial q_f}{\partial \phi}\right)\right|_{w_2=w_2^*;\, q_f=q_f^*} < 0. \tag{25}$$

In words, the union will oppose technological change if it leads to a drop in labour demand. This exact result is derived from the monopoly union assumption. Since the union is free to set the desired wage level, it is indifferent to marginal wage changes at the optimal level; only labour demand effects matter. Thus, we need to take a closer look at the effect of technological progress on labour demand.[14]

There are two counteracting effects of improved labour productivity on labour demand. On the one hand, the *effective wage* rate (w_2/ϕ) drops, which tends to increase labour demand. On the other hand, though, fewer workers are needed to produce a given level of output, which tends to reduce labour demand. What determines the relative strength of these two effects? From (7), using the definition of labour demand elasticity, we derive

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[14] The subsequent discussion is indebted to the pioneering work of Dowrick and Spencer (1994). See also Lommerud et al. (2006).

the labour demand effect of technological progress for a given level of second-period wages and offshoring:

$$\frac{\partial L_2\left(w_2, q_f\right)}{\partial \phi} = \frac{w_2\left(1 - \frac{1}{\varepsilon_2}\right) - c}{2\phi^3 \beta}. \tag{26}$$

We see that, for a given level of q_f, a positive labour demand response to technological progress requires that labour demand is sufficiently wage elastic. This is quite intuitive, since the first effect mentioned above – the (positive) labour demand response to a fall in the effective wage rate – increases with the wage elasticity of labour demand. If labour demand is very elastic, a marginal reduction in the effective wage rate (w_2/ϕ) leads to a more than proportional increase in the demand for effective labour (ϕL_2). With no employment protection, i.e., $c = 0$, we see that the critical level of labour demand elasticity is unity.[15] However, notice the effect of employment protection. An increase in c pushes up second-period labour demand, reducing the likelihood that better technology will increase labour demand even further. Thus, with $c > 0$, technological progress will increase labour demand, for a given level of q_f, only if labour demand elasticity is sufficiently larger than 1.

While (26) shows only the direct labour demand effect for a given level of offshoring, there is also an indirect effect via the firm's offshoring decision. We already know that this indirect effect is positive, since better domestic technology dampens the incentive for offshoring. Using (7) and (15) in conjunction with (26), the total labour demand effect of technological progress, at the equilibrium wage and offshoring level, is given by

$$\left(\frac{\partial L_2}{\partial \phi} + \frac{\partial L_2}{\partial q_f}\frac{\partial q_f}{\partial \phi}\right)\bigg|_{w_2=w_2^*; q_f=q_f^*} = \frac{\left[\varepsilon_2\left(w_2^*\right) - 1\right]\left[\phi\theta\left(\alpha - 2q_f^*\beta\right) + b\right] - c\left[\theta + \varepsilon_2\left(w_2^*\right)\right]}{2\phi^3\beta\left(\theta + 1\right)\varepsilon_2\left(w_2^*\right)}$$
$$+ \frac{(b - c)}{\phi^3\left[2\theta\beta\left(\theta + 2\right) + \left(\theta + 1\right)^2 K''\left(q_f^*\right)\right]}. \tag{27}$$

It is straightforward to verify that this expression is positive if labour demand is sufficiently

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[15]This result, which generalises beoynd the linear demand specification, was first demonstrated by Dowrick and Spencer (1994).

elastic. The indirect labour demand effect via the offshoring decision is given by the second term in (27). Since this term is positive, we cannot unambiguously determine whether $\varepsilon_2 > 1$ is a necessary condition for technological progress to increase labour demand.

As long as the labour demand function is not iso-elastic, the condition given in (27) directly translates into a condition on union preferences. In line with previous literature, we can therefore express the condition for union resistance to technological progress in terms of the preference parameter θ. Given that the wage elasticity of labour demand increases with the wage level – which holds for a wide class of demand functions, including the linear one[16] – a more wage oriented trade union will choose a wage on a more elastic part of the labour demand curve. Thus, there exists a unique critical value θ^*, such that $dU/d\phi < (>) \, 0$ if $\theta < (>) \, \theta^*$. We can go some way towards characterising θ^* by rewriting (27). Using the expression for $\varepsilon_2 \left(w_2^*\right)$ and rearranging, the condition for union opposition to technological change is given by

$$\underset{+}{\frac{\alpha - 2q_f^*\beta}{(\theta + 1) \, 2\beta\phi^2}} \underset{-/+}{(\theta - 1)} + \underset{+}{\frac{\beta \left(5\theta + 2\theta^2 + 1\right) + K''\left(q_f\right)\left(\theta + 1\right)^2}{\beta\phi^3 \left(\theta + 1\right) \left(2\theta\beta \left(\theta + 2\right) + K''\left(q_f\right)\left(\theta + 1\right)^2\right)}} \underset{+}{(b - c)} < 0. \quad (28)$$

The second term is unambiguously positive, while the sign of the first term depends on whether the union is wage or employment oriented. It follows from (28) that, if the union is opposed to the labour-saving innovation, it must be employment oriented, i.e., $\theta < 1$. In general, the union will oppose technological change if it is sufficiently employment oriented.

In order to derive an explicit solution for the critical value θ^*, we now assign a quadratic form to the offshoring cost function by letting $K\left(q_f\right) = \frac{k}{2}q_f^2$. We will interpret the cost parameter k as an inverse measure of 'globalisation'. Using the quadratic form, the equi-

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[16]From the definition of $\varepsilon \left(\cdot\right)$, we have that

$$\frac{\partial \varepsilon \left(\cdot\right)}{\partial w} = \frac{\varepsilon \left(\cdot\right)}{w} \left[1 + \varepsilon \left(\cdot\right)\right] - \frac{\partial^2 L \left(\cdot\right)}{\partial w^2} \frac{w}{L \left(\cdot\right)},$$

implying that $\partial \varepsilon \left(\cdot\right) / \partial w > 0$ for concave, linear and 'not too convex' labour demand functions.

librium level of offshoring is given by

$$q_f^* = \frac{\theta\,(\theta+2)\,\alpha\phi + b - c}{\phi\left(k\,(\theta+1)^2 + 2\theta\,(\theta+2)\,\beta\right)}. \tag{29}$$

Equation (28) implicitly defines a critical level of employment orientation, θ^*, below which the union will oppose technological change. Using (29), this critical level is given by

$$\theta^* = 1 - \frac{2\,(k+2\beta)\,(b-c)}{k\alpha\phi}. \tag{30}$$

We will refer to θ^* as a measure of union resistance to technological change by applying the following argument: if there are many union-firm pairs in the economy and union preferences are distributed over a wide range of θ, some unions will resist new technology while others will endorse it. An increase (reduction) in θ^* then implies that more (fewer) unions will resist technological progress, implying an overall increase in technology resistance by trade unions. The comparative statics properties of θ^* are easily derived:

$$\frac{\partial\theta^*}{\partial c} = -\frac{\partial\theta^*}{\partial b} = \frac{2\,(k+2\beta)}{\alpha\phi k} > 0, \tag{31}$$

$$\frac{\partial\theta^*}{\partial k} = \frac{4\beta\,(b-c)}{\alpha\phi k^2} > 0. \tag{32}$$

Proposition 4 *Union resistance to technological change*

    (i) increases with the degree of employment protection,

    (ii) decreases with the level of the reservation wage,

    (iii) decreases with the degree of globalisation.

    The magnitudes of all these effects increase with the degree of globalisation.

The intuition behind these results can be traced by considering the key equation (27), which illustrates the labour demand effect, in equilibrium, of better technology. We see that the parameter c works through three different channels. First, stronger employment protection implies, all else equal, that the second-period employment level is higher. This

increases the critical degree of labour demand elasticity necessary for a positive labour demand response to better technology, as can be seen from the first term in (27). Second, stronger employment protection implies, all else equal, that labour demand becomes less elastic, as shown and discussed in Section 2.1. Third, there is also an effect via the firm's offshoring decision, given by the second-term in (27). With a convex offshoring cost function, stronger employment protection implies that the reduction in offshoring, due to better domestic technology, is smaller. Thus, all three effects work in the same direction, reducing the likelihood of a positive labour demand response to better technology. In other words, stronger employment protection increases the degree of labour demand elasticity (equivalently, the degree of union wage orientation) necessary to induce a positive labour demand response from technological progress. Consequently, union resistance to technological change becomes more likely.

With respect to technology resistance, an increase in the reservation wage level, b, has the exact opposite effect, qualitatively and quantitatively, as stronger employment protection. The main effect is via the labour demand elasticity: an increase in b pushes up the domestic wage level, with a corresponding increase in offshoring, making second-period labour demand more elastic, as can be seen from (9). In addition, the negative relationship between domestic labour productivity and offshoring is increasing in b. As we can see from (27), both effects work in the same direction, making a positive labour demand response more probable, thereby reducing the likelihood of technology resistance from the trade union.

A reduction in k increases the equilibrium level of offshoring, and this increases the positive labour demand response from domestic technological progress, as reflected in the second term of (27). In addition, increased offshoring increases the wage elasticity of second-period labour demand, as we can see from (9). Both effects work in the same direction, and globalisation thus increases the scope for a positive labour demand response to domestic technological progress, making union resistance less likely.

Notice that all of the above effects are quantitatively increasing in the degree of glob-

alisation, inversely measured by the parameter k. The reason is simply that a lower k increases the magnitude of labour demand responses via the firm's offshoring decision.

With respect to policy implications, the main message is that the parameters c and b represent different labour market policies, that have opposite effects on union resistance towards technological change. While stronger employment protection is likely to slow down technology adoption, due a more union resistance, better outside options – such as a higher legal minimum wage or higher unemployment benefits – are likely to increase technology adoption. Furthermore, the qualitative difference between these policy options will quantitatively increase with the degree of globalisation.

4 Endogenous technology

So far we have focused on the incentives for rational Luddism by a trade union facing an exogenous and certain technological shock. In this section we depart from the assumption of an exogenous technology shock by looking at the firm's incentives to invest in better technology. Assume that the firm can make an investment in the first period to improve the domestic technology in the second period. Temporarily putting aside the question of union resistance to technological progress, we ask how the characteristics of the labour market institutions – given by the parameters c, b, and θ – affect the firm's incentives to invest in better technology.

4.1 Certain technology

Assume that the firm can make an investment in period 1 that yields a certain productivity $\phi > 1$ in the second period. This investment will be undertaken if the (certain) payoff is sufficiently large to cover the investment costs. Since the first-period profit is independent of second-period productivity, the investment payoff is given by the second-period profit differential $\Omega := \pi_2(\phi) - \pi_2(1)$. Using the quadratic offshoring function, the investment

payoff is given by

$$\Omega = \frac{1}{4} \left(\phi - 1\right) \left(b - c\right) \frac{2k\alpha\phi - \left(\phi + 1\right)\left(k + 2\beta\right)\left(b - c\right)}{\beta\phi^2 \left(2\theta\beta\left(\theta + 2\right) + k\left(\theta + 1\right)^2\right)} > 0. \tag{33}$$

Notice that the assumption of $L_2^* > 0$ ensures that $\Omega > 0$. Naturally, the firm's incentives to invest will increase with the magnitude of Ω.

Proposition 5 *(i) Unless the resulting productivity increase is very small, the firm's incentives to invest in better technology is decreasing in the degree of employment protection and increasing in the reservation wage level.*

(ii) The firm's incentives to invest in better technology is always decreasing in the union's wage orientation.

Proof. (i) From (33) we derive

$$\frac{\partial\Omega}{\partial c} = -\frac{\partial\Omega}{\partial b} = -\frac{1}{2} \left(\phi - 1\right) \frac{k\alpha\phi - \left(\phi + 1\right)\left(k + 2\beta\right)\left(b - c\right)}{\beta\phi^2 \left(2\theta\beta\left(\theta + 2\right) + k\left(\theta + 1\right)^2\right)}.$$

The assumption of $L_2^* > 0$ is equivalent to $k\alpha\phi - \left(k + 2\beta\right)\left(b - c\right) > 0$. It is easily verified that this assumption implies that the numerator in the above expressions is increasing in ϕ, and that there exists a set of parameters, for low values of ϕ, where $L_2^* > 0$ and the numerator is negative, implying $\partial\Omega/\partial c = -\partial\Omega/\partial b > 0$. Otherwise, unless ϕ is very low, $\partial\Omega/\partial c = -\partial\Omega/\partial b < 0$.

(ii) From (33) we derive

$$\frac{\partial\Omega}{\partial\theta} = -\left(\theta + 1\right)\left(\phi - 1\right)\left(b - c\right)\left(k + 2\beta\right) \frac{2k\alpha\phi - \left(\phi + 1\right)\left(k + 2\beta\right)\left(b - c\right)}{2\beta\phi^2 \left(2\theta\beta\left(\theta + 2\right) + k\left(\theta + 1\right)^2\right)^2} < 0.$$

∎

The intuition for these results are traced by considering the profit effect of a marginal technological progress, as given by (21). In equilibrium, technological progress has two opposite effects on profits. First, for a given wage and employment level, increased pro-

ductivity increases output and profits. However, secondly, improved labour productivity induces a wage increase which, in terms of profits, is negative. Both of of these partial effects are affected by changes in the relevant parameters: c, b and θ.

Changes in both employment protection and the reservation wage work indirectly through changes in the equilibrium levels of domestic employment and offshoring. Consider first an increase in employment protection (c). This leads to a higher level of second-period domestic employment, with a corresponding reduction in offshoring. A higher level of domestic employment increases the negative profit effect of higher domestic wages. Furthermore, a lower level of offshoring also implies that the technology-induced wage increase is larger, as can be seen from (10). Increased domestic employment also affects the direct profit gain of technological progress (for a given wage level). This effect is, in general, ambiguous; an increase in domestic employment is more likely to increase the profit gain of technological progress if the labour stock is relatively low to begin with. Unless the productivity increase is very low, the two former effects always dominate, reducing the profitability of technological progress for the firm.

The effect of a higher reservation wage level is quantitatively similar, but with an opposite sign. A higher reservation wage pushes up the wage level, leading to reduced domestic employment, with a corresponding increase in offshoring. The effects are thus exactly opposite to an increase in employment protection: unless the productivity increase is very low, the profitability of technological progress always increases in b.

A more wage oriented union, on the other hand, reduces the profitability of technological progress. An increase in wage orientation (θ) pushes up domestic wages, leading to a reduction in domestic employment, with a corresponding increase in offshoring. On the one hand, lower domestic employment reduces the profit loss of higher wages. However, on the other hand, the wage response is stronger. It is easily seen from (10) that a more wage oriented union will enforce a larger wage increase following a technological progress. Lower domestic employment also affects the direct profit gain from increased productivity of the domestic workforce. As previously mentioned, this effect is, in general, ambiguous.

In sum, though, the overall effect of a more wage oriented union is always negative with respect to the profit effect of technological progress. This result clearly resembles the well-known results by Grout (1984) and Manning (1987) about the investment-deterring effects of trade unions.

Assuming that the productivity increase from new technology is sufficiently high, so that $\partial \Omega / \partial c < 0$ and $\partial \Omega / \partial b > 0$, Proposition 5 actually reinforces the implications of our previously derived results, even if the firm and the union have conflicting interests.[17] Stronger employment protection not only increases union opposition towards technological change, it also reduces firm incentives for technology investments. Similarly, better outside options for union workers increase both the union's willingness to accept labour-saving technology and the firm's incentives for investing in such technology.

However, there is also a tension with respect to union preferences. More wage oriented unions will reduce union opposition to technological change, but at the same time reduce firm incentives for technology investments.

4.2 Uncertain technology

In addition to the investment that yields a second-period productivity ϕ, assume that the firm has also a risky investment option in the first period. The risky technology investment yields a second-period productivity $\mu > \phi$, but only with a probability $\rho < 1$. How does the labour market characteristics affect the firm's propensity to opt for the risky technology investment?

Once more, only (expected) second-period profits matter. The payoff from the safe investment option is given by $\pi_2 (\phi)$, while the expected payoff from the risky investment is given by $\rho \pi_2 (\mu) + (1 - \rho) \pi_2 (1)$. Assume that both investments are equally costly. Since $\mu > \phi$, and since second-period profits are increasing in labour productivity, the firm will choose the risky investment if ρ is sufficiently high. We can thus define a threshold value of ρ for which both investment options are equally profitable. This value, denoted ρ^*, is

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[17]Numerical simulations show that the parameter space where $\partial \Omega / \partial c > 0$ and $\partial \Omega / \partial b < 0$ is indeed very limited.

given by

$$\rho^* = \frac{\mu^2 (\phi - 1) (2k\alpha\phi - (\phi + 1) (k + 2\beta) (b - c))}{\phi^2 (\mu - 1) (2k\alpha\mu - (\mu + 1) (k + 2\beta) (b - c))}. \tag{34}$$

It follows that the firm will choose the risky investment if $\rho > \rho^*$ and the safe investment otherwise. Thus, for given levels of μ and ϕ, we can interpret ρ^* as an inverse measure of the firm's willingness to take risks. The comparative statics results follow straightforwardly from (34):

$$\frac{\partial \rho^*}{\partial c} = \frac{2k\alpha\mu^2 (\phi - 1) (k + 2\beta) (\mu - \phi)}{\phi^2 (\mu - 1) (2k\alpha\mu - (\mu + 1) (k + 2\beta) (b - c))^2} > 0,$$

$$\frac{\partial \rho^*}{\partial b} = -\frac{2k\alpha\mu^2 (\phi - 1) (k + 2\beta) (\mu - \phi)}{\phi^2 (\mu - 1) (2k\alpha\mu - (\mu + 1) (k + 2\beta) (b - c))^2} < 0,$$

$$\frac{\partial \rho^*}{\partial \theta} = 0.$$

Proposition 6 *The firm's willingness to undertake risky technology investments is decreasing in the degree of employment protection, increasing in the reservation wage level, and is independent of union preferences.*

Due to decreasing marginal revenues, the profit function is concave in labour productivity. Stronger employment protection shifts down the profit curve and also makes it more concave, since it is more costly for the firm to optimally adjust the labour stock in response to technological progress. This makes the firm less willing to invest in risky technology. A higher reservation wage, on the other hand, also shifts down the profit curve but makes it *less* concave, since the marginal profit gain of higher labour productivity increases with the wage level. Thus, a higher reservation wage makes the firm more willing to invest in risky technology.

When seen in conjunction with Proposition 5, it appears that a reduction in employment protection and/or an increase in union reservation wages do not only increase the firm's incentives to invest in better technology, it also makes the firm more willing to take risks, implying a higher expected technological progress.

5   Concluding remarks

Recent opinion polls indicate that workers in the Nordic countries fear globalisation less than workers in other rich countries.[18] This could of course stem from the fact that they are better insured against adverse events in the labour markets. But in addition the flexicurity type labour market arrangements in these countries can have paved the way for structural change and technological improvements. In turn, this could mean that the bulk of Nordic workers now have high productivity jobs that are less challenged by globalisation than jobs with less technology content. The purpose of this paper has been to contribute to this debate by carefully analysing the effect of social insurance and employment protection on trade union behaviour, on wages and employment in the industry in question, and on the union's willingness to accept new technology. The basic flavour of our results is a confirmation that flexicurity is good for change.

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