The University of Nottingham

research paper series

Theory and Methods

Research Paper 2008/28

Unions, Competition and International Trade in General Equilibrium

by

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The Centre acknowledges financial support from The Leverhulme Trust under Programme Grant F114/BF

GEP Leverhulme Centre for Research on Globalisation and Economic Policy

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Acknowledgements
We would like to thank Hartmut Egger, Rod Falvey, Gabriel Felbermayr, Kjell-Erik Lommerud, Peter Wright and participants at the Göttingen Workshop of International Economics for helpful comments. Financial support from the Leverhulme Trust (Programme Grant F114/BF) is gratefully acknowledged. Paulo Bastos thanks Fundação para a Ciência e a Tecnologia for financial support. The views expressed in this paper belong to the authors only and do not necessarily correspond to those of the European Commission.

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Abstract

We develop a two-country, multi-sector model of oligopoly in which unionised and non-unionised sectors interact in general equilibrium. The model is used to study the impact of trade liberalisation, deunionisation and firm entry on wages in unionised and non-unionised sectors, and on welfare. We find that a shift from autarky to free trade increases non-union wages and welfare, whereas the effect on union wages is ambiguous. We also show that partial deunionisation leads to higher wages in both unionised and non-unionised sectors, but only increases welfare when the proportion of unionised sectors is sufficiently low. Finally, wages in non-unionised sectors necessarily increase with firm entry, while the response of union wages and welfare depends on the trade regime.

JEL classification: F15, F16, L13

Keywords: Trade Unions, Product Market Competition, General Oligopolistic Equilibrium, Trade Liberalisation

Outline

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3. *Solving the model in partial equilibrium*
4. *General oligopolistic equilibrium*
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Non-Technical Summary

We develop a two-country, multi-sector model of oligopoly in which unionised and non-unionised sectors interact in general equilibrium. The model is used to study the impact of trade liberalisation, deunionisation and firm entry on wages in unionised and non-unionised sectors, and on welfare. We find that a shift from autarky to free trade increases non-union wages and welfare, whereas the effect on union wages is ambiguous. We also show that partial deunionisation leads to higher wages in both unionised and non-unionised sectors, but only increases welfare when the proportion of unionised sectors is sufficiently low. Finally, wages in non-unionied sectors necessarily increase with firm entry, while the response of union wages and welfare depends on the trade regime.

Our framework builds on the model by Neary (2007a) who provides a theoretically consistent but tractable model of general oligopolistic equilibrium (GOLE). There is a small number of firms operating in each of a continuum of sectors, yielding a framework in which firms are large in their own sector but small in the economy as a whole. Hence they behave strategically against other firms in their own sector but treat factor prices and national income parametrically. As a distinguishing feature of our setup, we assume that unions are present in an exogenous subset of sectors – thereby transforming Neary's GOLE framework into a unionised general oligopolistic equilibrium (UGOLE) model. As each sector represents an infinitesimal part of the economy, firms and unions behave as in partial equilibrium models. In particular, as in Naylor (1998, 1999), unions set their wage demands in partial equilibrium, taking as given the wage rate in non-union sectors. Aggregation across sectors allows for the endogenous determination of economy wide variables, most importantly the competitive wage rate and aggregate welfare.

1 Introduction

In recent years the labour market effects of increased globalisation have inspired many passionate discussions. Advocates of globalisation often argue that fiercer product market competition and trade liberalisation have the potential to induce a generalised increase in living standards. Less enthusiastic observers, however, often voice the concern that a more competitive product market goes hand in hand with the erosion of trade union power, thereby implying the end of decent pay for many workers.[1] How might we expect harsher competition and trade liberalisation to impact on labour market outcomes when unions are present? This is the question we set out to address in our paper.

There is, of course, a sizeable body of theoretical research that does just that. The framework used in the central contributions to this literature is the partial equilibrium oligopoly model, augmented to allow for union wage setting in the labour market. An important early result in this literature, due to Huizinga (1993) and Sørensen (1993), shows that in a symmetric two-country model where labour markets in both countries are unionised, the wage under free trade is lower than in autarky. Using the same framework, Naylor (1998, 1999) looks at a complementary question and shows that in a situation of restricted trade a reduction in trade barriers *increases* wages. The public perception that international trade reduces the power of labour unions is therefore supported by the model if one compares the two extreme situations of autarky and free trade, but not for the intermediate case of gradual liberalisation.[2] In addition to the papers that look at the situation where unions are present in both countries, there are some high-profile contributions that look at the asymmetric case where unions are only present in one of the countries.[3]

[1] See e.g. Rodrik (1997, pp. 23ff.) and the references cited therein.

[2] Munch and Skaksen (2002) allow for the presence of both fixed and variable trade costs and show that the results are sensitive as to which of these costs is lowered.

[3] See Brander and Spencer (1988), and Mezzetti and Dinopoulos (1991). The asymmetric oligopoly model has been extended by Lommerud, Meland and Sørgard (2003) to allow for FDI, while Straume (2003) and Lommerud, Straume, and Sørgard (2006) look at international mergers, and Lommerud, Meland and Straume (2006) focus on technological change.

A key advantage of the oligopoly framework is to allow for strategic interactions between firms and unions within an industry, and to investigate how these interactions are affected by lower trade barriers. An important shortcoming of that modelling approach, however, is that it abstracts from general equilibrium linkages between sectors or between goods markets and factor markets that have traditionally been of interest to trade economists. In fact, the analysis in this literature focuses on a single industry, where oligopolistic competition generates rents that organised labour seeks to capture in the form of higher wages. Although it is assumed that workers of the unionised industry can always find employment in a non-unionised sector, the wage rate in that industry (which constitutes the reservation wage of union workers) is exogenously given, and hence unaffected throughout the analysis.

In this paper, we develop a framework that allows for the interaction between unionised and non-unionised sectors in general equilibrium. To this end we build on the model by Neary (2007a) who provides a theoretically consistent but tractable model of general oligopolistic equilibrium (GOLE).[4] There is a small number of firms operating in each of a continuum of sectors, yielding a framework in which firms are large in their own sector but small in the economy as a whole. Hence they behave strategically against other firms in their own sector but treat factor prices and national income parametrically. As a distinguishing feature of our setup, we assume that unions are present in an exogenous subset of sectors – thereby transforming Neary's GOLE framework into a *unionised general oligopolistic equilibrium* (UGOLE) model. As each sector represents an infinitesimal part of the economy, firms *and* unions behave as in partial equilibrium models. In particular, as in Naylor (1998, 1999), unions set their wage demands in partial equilibrium, taking as given the wage rate in non-union sectors. Aggregation across sectors allows for the endogenous determination of economy wide variables, most importantly the competitive wage rate and aggregate welfare. The model is used to study the impact of trade liberalisation, deunionisation and firm entry on wages in unionised and non-unionised sectors,

[4]See also Neary (2003) for a non-technical overview, and Neary (2007b) for an application to cross-border mergers.

and on welfare.

Our main results are as follows. Within a context of intra-industry trade, further product market integration impacts on union wages through two different channels. Firstly, as shown by Naylor (1998, 1999), by reducing labour demand elasticity, integration leads monopoly unions to set higher wages. Secondly, by causing an increase in aggregate labour demand, integration causes an increase in the competitive wage, inducing a further rise in union wages. Because of this additional positive (general equilibrium) effect, union wages may actually be higher under free trade than in autarky, a result that contrasts with the previous literature. Another well established result from the unionised oligopoly in partial equilibrium, due to Dowrick (1989), states that firm entry does not have direct impact on union wages in a closed economy when wages are set at the industry-level.[5] In the UGOLE framework firm entry in all sectors of a closed economy increases aggregate labour demand, leading to a higher competitive wage which in turn leads to a higher union wage. It is shown that this result has to be qualified somewhat in the open economy. General equilibrium links are also important when looking at the effects of "deunionisation", i.e. a reduction in the proportion of sectors that are unionised: Aggregate labour demand increases, putting upward pressure on both competitive and union wages.

Besides the wage effects, we also consider the aggregate welfare effects of the different policy scenarios. We find that aggregate welfare increases as the economy moves from autarky to free trade, and rises with harsher product market competition in the open economy, but not in the closed economy. Our results also indicate that, although a perfectly competitive labour market always leads to the welfare maximum, partial deunionisation may reduce aggregate welfare. The remainder of the paper is organised as follows. Section 2 sets out the basic model. Section 3 shows how the partial equilibrium in each sector is determined, before Section 4 explores the general oligopolistic equilibrium. The comparative statics of the model are analysed in Section 5. Section 6 concludes.

[5]See also Dhillon and Petrakis (2002) and Naylor (2002).

2 Model setup

In this section we present a model of oligopoly in general equilibrium which allows for labour market unionisation in part of the economy. In doing so, we generalise the models developed by Naylor (1998, 1999) in two ways: firstly, we extend Naylor's partial equilibrium analysis to the case where n firms operate in each country and union wage setting occurs at the industry-level; secondly, we embed the resulting framework into the GOLE model introduced by Neary (2007a).

Consider, then, a world consisting of two countries, 1 and 2, which are assumed to be identical in all respects. We describe the economy of country 1, simply noting that analogous conditions hold in country 2.

2.1 Technology

In country 1 there is continuum $[0, 1]$ of imperfectly competitive industries, each producing a differentiated good. Each industry has n symmetric firms, where n is small. Hence, firms are relatively large in their own industry but represent an infinitesimal part of the economy as a whole. As a result, they have market power within their own sector but treat economy-wide variables parametrically.

Competition in each industry is Cournot. There are unspecified barriers facing new firms, and hence oligopoly rents are not eroded by entry. All income accrues to the aggregate household. Labour is the only factor of production. The marginal product of labour is constant, and is normalised to unity so that we can discuss output and employment interchangeably. In line with Brander (1981), national markets are assumed to be segmented and there is a specific tariff t per unit of commodity traded internationally.

2.2 Preferences, demand and utility

The representative consumer in country 1 has an additively separable utility function defined over the continuum of goods, with each sub-utility function quadratic:

$$U_1[\{x_1(z)\}] = \int_0^1 \left[ax_1(z) - \frac{1}{2}bx_1(z)^2\right] dz \tag{1}$$

where $x_1(z)$ denotes consumption of good z in country 1. Utility is maximised subject to the budget constraint:

$$\int_0^1 p_1(z)x_1(z)dz \leq I_1 \tag{2}$$

where $p_1(z)$ denotes price of the good z, and I_1 aggregate income. The first order conditions give the inverse demand functions for each good:

$$p_1(z) = \frac{1}{\lambda_1}\left[a - bx_1(z)\right], \qquad \text{with} \qquad \lambda_1[\{p_1(z)\}, I_1] = \frac{a\mu_1 - bI_1}{\sigma_1^2}. \tag{3}$$

Here, λ_1 is the marginal utility of income, which is the Lagrange multiplier attached to the budget constraint, and μ_1 and σ_1^2 are the mean and uncentered variance of prices, respectively:

$$\mu_1 = \int_0^1 p_1(z)dz \qquad \sigma_1^2 = \int_0^1 p_1^2(z)dz \tag{4}$$

Firms treat λ_1, which is determined in general equilibrium, parametrically, and hence the perceived subjective inverse demand functions are linear.

The indirect utility function can be obtained by substituting the demand function in (3) into (1), which leads to:

$$\widetilde{U}_1 = \frac{a^2 - \sigma_1^2}{2b} \tag{5}$$

Hence, aggregate consumer welfare is strictly decreasing in the uncentered variance of prices.[6]

2.3 Trade unions and the labour market

There are L workers in country 1. Workers are ex-ante identical in all respects, but their wage depends on the institutional features of the industry in which they are employed. Labour market institutions differ across sectors: Trade unions are present in some sectors

[6] As stressed by Neary (2007a), the quadratic specification of preferences in (1) is a special case of the Gorman (1961) polar form. This property allows for consistent aggregation over individuals with different incomes (provided the parameter b is the same for all), and enables the use of a single representative consumer to characterise demands in each country. Furthermore, it facilitates the normative applications of the model, as it rationalises the use of the indirect utility function of the single representative consumer to evaluate aggregate consumer welfare in each country.

but not in others. Sectors are ordered in such a way that those where trade unions are present have low values of z. There is a threshold sector $\widetilde{z}$, with $\widetilde{z} \in [0,1)$, such that trade unions are present in all sectors for which z is less than or equal to $\widetilde{z}$, while they are absent in all other sectors, making the labour market in these latter sectors perfectly competitive.

In each sector $z \in [0, \widetilde{z}]$, there is a single trade union representing all workers employed by the firms operating in that sector. We adopt a Stone-Geary utility function to represent the union's preferences, assuming that each union aims to maximise rents (weighted by the marginal utility of income). Hence, the utility of each union in country can be written as:

$$\Omega_1(z) = \lambda_1[w_1(z) - w_1^c]l_1(z) \tag{6}$$

where $w_1(z)$ is the nominal union wage in sector z, w_1^c is the nominal wage in the non-union sectors, and $l_1(z)$ represents total demand for labour from the firms that operate in sector z in country 1. Hence, $l_1(z) = n[y_{11}(z) + y_{12}(z)]$, where $y_{11}(z)$ and $y_{12}(z)$ represent the output (employment) level of a firm in sector z of country 1 for its home and foreign market, respectively.

As in Naylor (1998, 1999) we adopt a monopoly union framework to represent wage determination in each unionised sector: The trade union sets the wage and, subsequently, firms choose the level of employment. Wage setting occurs simultaneously in all unionised sectors, and each union treats parametrically the wage set by the corresponding foreign union. Due to the assumption of a continuum of sectors, unions are small in their own economy, and therefore take aggregate income, product prices in the other sectors, and factor prices in the rest of the economy as given when setting their wage demands.

3 Solving the model in partial equilibrium

In each union sector, wages and employment can be described as the outcome of a two-stage game. In stage 1, the union sets its wage demand, taking as given w^c and the wage demand of the corresponding foreign union. In stage 2, each firm chooses its output (and

hence employment), taking as given the wage set in the first stage and the output of competitors. We solve by backward induction. In non-union sectors, the model is a simple one-stage Cournot game: Firms choose employment, taking as given the competitive wage rate and the output of competitors. Since countries are identical in all respects, it must be the case that the marginal utility of income and the competitive wage are the same for both countries: $\lambda_1 = \lambda_2$ and $w_1^c = w_2^c$, and therefore country indices for λ and w^c are omitted henceforth.

3.1 Production

Profits of a typical firm in sector z of country 1 are given by

$$\pi_1(z) = [p_1(z) - c_1(z)]y_{11}(z) + [p_2(z) - c_1(z) - t]y_{12}(z), \tag{7}$$

where $c_1(z)$ is the marginal cost of labour faced by the typical firm in sector z, and we have

$$c_1(z) = \begin{cases} w_1 & \text{if} \quad z \leq \widetilde{z} \\ w^c & \text{if} \quad z > \widetilde{z} \end{cases} \tag{8}$$

Maximisation of (7) leads to the reactions functions of each firm in sector z of country 1, which are given by the following standard expressions:

$$y_{11}(z) = \frac{a - \lambda c_1(z)}{b(n+1)} - \frac{n}{n+1} y_{21}(z) \tag{9}$$

$$y_{12}(z) = \frac{a - \lambda(c_1(z) + t)}{b(n+1)} - \frac{n}{n+1} y_{22}(z) \tag{10}$$

By solving these, we may obtain the equilibrium output of each firm, under each possible trade regime.

For sufficiently high trade costs, there will be no trade, and (9) simplifies to

$$y_{11}(z) = \frac{a - \lambda c_1(z)}{b(n+1)}. \tag{11}$$

For sufficiently low trade costs, firms in both countries will start to export. There is

two-way trade in equilibrium, and we get

$$y_{11}(z) = \frac{a + \lambda\big[n(c_2(z) + t) - (n+1)c_1(z)\big]}{b(2n+1)} \tag{12}$$

$$y_{12}(z) = \frac{a + \lambda\big[nc_2(z) - (n+1)(c_1(z) + t)\big]}{b(2n+1)} \tag{13}$$

as the outputs (or employment levels) of a firm in sector z for their respective domestic and export market. Notably, eqs. (6), (12) and (13) are homogenous of degree zero in λ^{-1}, w_1 and w^c. As in Neary (2003), we choose utility as the numeraire, thereby normalising $\lambda = 1$.

3.2 Union wage setting

We now proceed by analysing union wage setting under autarky and two-way trade.[7] In autarky, trade unions in both countries set their wage demands in isolation. Union utility is then given by:

$$\Omega_1 = (w_1 - w^c)n\frac{a - w_1}{b(n+1)} \tag{14}$$

By maximising (14) with respect to w_1 we obtain the union wage demand under autarky:

$$w_1 = \frac{a + w^c}{2} \tag{15}$$

As shown in Appendix A, for sufficiently low trade costs each union will find it optimal to abandon its previous high wage strategy and instead lower their wage demand in order to allow the corresponding firms to compete internationally, benefiting from the employment gains associated with such strategy. There is, therefore, two-way trade and union utility is given by:

$$\Omega_1 = (w_1 - w^c)n\left[\frac{a - (n+1)w_1 + n(w_2 + t)}{b(2n+1)} + \frac{a - (n+1)(w_1 + t) + nw_2}{b(2n+1)}\right] \tag{16}$$

Maximising (16) with respect to w_1, we obtain the low wage best reply function of each union in country 1 to the wage demand of the corresponding union in country 2, for a

[7] As in Naylor (1998, 1999) the equilibrium trade regime depends both on the exogenous trade cost and on the endogenous union wage. In Appendix A, we derive the conditions under which there is two-way trade in equilibrium.

given competitive wage w^c:

$$w_1 = \frac{2a - t - 2(n+1)w^c + 2nw_2}{4(n+1)}$$

Given perfect symmetry, there is an analogous best reply function for each union in country 2. The sub-game perfect Nash equilibrium is given by:

$$w_1 = w_2 = w = \frac{2a - t + 2(n+1)w^c}{2(n+2)} \tag{17}$$

Hence, within the two-way trade regime the wage set by each union increases if trade is liberalised, i.e. if t falls. Thus, the key result of Naylor's (1998, 1999) unionised duopoly model remains valid in a set-up with multiple firms and industry-level wage setting. The same applies to the earlier findings of Huizinga (1993) and Sørensen (1993): From (15) and (17) it is clear that, in partial equilibrium, union wages are lower under free trade ($t = 0$) than in autarky. These are partial equilibrium results in the sense that the competitive wage w^c is treated as a parameter.

4 General oligopolistic equilibrium

We now turn to the determination of w^c in general equilibrium. Since industries with trade unions pay a wage premium, workers naturally prefer to be employed in those industries. However, the number of high-wage jobs is limited by the labour demand of firms in the unionised sectors. The allocation of workers to sectors is determined by a lottery. Lucky workers find employment in a unionised sector, unlucky workers become part of the labour supply available to non-union sectors. The wage rate in non-union sectors w^c is obtained from the equilibrium labour market condition that exogenous labour supply must equal total labour demand in the economy (that is, the sum of labour demand in the unionised and non-unionised sectors).

4.1 Equilibrium wages in union and non-union sectors

The full-employment condition in country 1 is given by:

$$L = n \int_0^1 [y_{11}(z) + y_{12}(z)]dz \tag{18}$$

In autarky, the general equilibrium level of wages in non-union sectors is obtained by substituting in the full-employment condition for $y_{11}(z)$, using (8) and (11), and setting $y_{12}(z) = 0$. This gives

$$w^c = a - \frac{2(n+1)}{(2-\widetilde{z})n} bL. \tag{19}$$

We can now substitute in the partial equilibrium union wage demand function (15) for w^c, thereby arriving at the union wage expressed in terms of the model parameters:

$$w = a - \frac{n+1}{(2-\widetilde{z})n} bL \tag{20}$$

If there is two-way trade, general equilibrium wages may be obtained in a similar way. In particular, to find the non-union wage we substitute in full employment condition (18) for $y_{11}(z)$ and $y_{12}(z)$, using (8), (12) and (13). This gives:

$$w^c = a - \frac{t}{2} - \frac{(2n+1)(n+2)}{2n(n+2-\widetilde{z})} bL \tag{21}$$

Substituting (21) into (17) we obtain the equilibrium level of wages in union sectors as a function of the model parameters:

$$w = a - \frac{t}{2} - \frac{(2n+1)(n+1)}{2n(n+2-\widetilde{z})} bL \tag{22}$$

There is a straightforward link between our equations to determine the competitive wage in eqs. (19) and (21) under autarky and trade, respectively, with the corresponding equations in Neary (2007a). In particular, the corresponding equations coincide if both models are stripped of the features that lead to asymmetries between markets and sectors: in our model this would require to eliminate unionisation in all sectors ($\widetilde{z} = 0$) and to set $t = 0$, while in Neary's original GOLE model it would mean to eliminate technology differences between sectors and countries.

4.2 Output, prices, profits, and welfare

Using the above expressions for general equilibrium wages in union and non-union industries, it is straightforward to derive the expressions for output, prices and industry profits

for each sector, under each of the trade regimes considered above.[8] Table 1 reports the resulting expressions. As can be expected, under both autarky and trade output and profits in non-unionised sectors are higher than in unionised sectors, while prices are lower. Furthermore, outputs and prices in the trade equilibrium can be seen to be independent of the tariff level.

Table 1: Outputs, prices and profits in union (U) and non-union (NU) sectors

		$n(y_{11}+y_{12})$	p_1	$n(\pi_{11}+\pi_{12})$
Autarky	U	$\frac{1}{2-\widetilde{z}}L$	$a-\frac{1}{2-\widetilde{z}}bL$	$\frac{b}{n(2-\widetilde{z})^2}L^2$
	NU	$\frac{2}{2-\widetilde{z}}L$	$a-\frac{2}{2-\widetilde{z}}bL$	$\frac{4b}{n(2-\widetilde{z})^2}L^2$
Trade	U	$\frac{n+1}{n+2-\widetilde{z}}L$	$a-\frac{n+1}{n+2-\widetilde{z}}bL$	$\left[\frac{(n+1)^2bL}{2n(n+2-\widetilde{z})}+nt\right]\frac{L}{2n(n+2-\widetilde{z})}$
	NU	$\frac{n+2}{n+2-\widetilde{z}}L$	$a-\frac{n+2}{n+2-\widetilde{z}}bL$	$\left[\frac{(n+1)(2n+1)bL}{2n(n+2-\widetilde{z})}+nt\right]\frac{L}{2n(n+2-\widetilde{z})}$

Using eq. (4) and the expressions for prices presented in Table 1 for both union and non-union sectors it is straightforward to obtain the uncentered variance of prices (and hence aggregate welfare) in country 1, for each trade regime. Under autarky in all sectors, the variance of prices can be expressed as:

$$\sigma_1^2 = a(a-2bL) + \frac{4-3\widetilde{z}}{(2-\widetilde{z})^2}(bL)^2 \tag{23}$$

Similarly, for the case of two-way trade in all sectors we find:

$$\sigma_1^2 = a(a-2bL) + \frac{(2+n)^2-(3+2n)\widetilde{z}}{(2+n-\widetilde{z})^2}(bL)^2 \tag{24}$$

It should be noted that due to our model setup there are only two goods prices, and hence the price difference between unionised and non-unionised sectors is a sufficient statistic for the variance of prices as long as the proportion of unionised sectors is held constant.

[8] To obtain the output of the representative firm in non-union and union sectors under autarky we need to substitute (19) and (20), respectively, into (11). When there is two-way trade in all sectors, we need to substitute (21) and (22), respectively, into (12) and (13). Once industry output levels are known, it is then straightforward to obtain industry prices and profits by using (3) and (7), respectively.

5 Comparative statics

We now consider three types of comparative static exercises. First, as in the partial equilibrium model by Naylor (1998, 1999), two trade liberalisation scenarios are analysed, namely a comparison of autarky with free trade and a marginal liberalisation of tariffs within the regime of restricted trade. Second, we assess more closely the effect that unions have in the economy by looking at the effects of deunionisation, modelled as a decrease in the number of sectors that are unionised. The third shock considered is one of firm entry in all sectors of the economy.

5.1 Trade liberalisation

Consider first the comparison between autarky and free trade. It can easily verified by comparing eqs. (19) and (21) that the competitive wage w^c is higher under free trade than under autarky.[9] Combining this with the earlier result that for a *given* value of the competitive wage the union wage w is lower under free trade than under autarky suggests that there may be circumstances under which this well established partial equilibrium result by Huizinga (1993) and Sørensen (1993) may be overturned in general equilibrium. Indeed, as the comparison of eqs. (20) and (22) shows, this is the case if the proportion of sectors that are unionised is sufficiently large: $\widetilde{z} > 1 - 1/(2n-1)$.

The partial equilibrium result survives in the sense that the absolute union wage premium $w - w^c$ is lower under free trade than under autarky.[10] Quite intuitively (and confirmed by table 1) there is a reallocation of employment from non-unionised to unionised sectors and a decline in the price premium of unionised sectors. As a result, the variance of prices is lower with free trade than in autarky, and hence welfare is higher. The results are summarised as follows:

Proposition 1 *A shift from autarky to free trade leads to (i) an increase in the competitive wage, (ii) an increase in the union wage if* $\widetilde{z} > 1 - 1/(2n-1)$*, and (iii) an increase in*

[9] The same is true in Neary (2007a) if the technology distributions for both countries are identical.

[10] This follows directly from eqs. (15) and (17).

welfare.

We now look at the intermediate case of restricted two-way trade and consider the effects of a marginal reduction in bilateral tariffs. It is immediate from eqs. (21) and (22) that $dw/dt = dw^c/dt = -1/2$, and hence a marginal reduction in tariff rates reduces the competitive wage and the union wage by the same amount, leaving the absolute union wage premium constant. The effect on the union wage can be compared to the corresponding partial equilibrium effect (Naylor 1998, 1999) by combining eqs. (17) and (21):

$$\frac{dw}{dt} = \frac{\partial w}{\partial t} + \frac{\partial w}{\partial w^c}\frac{\partial w^c}{\partial t} = -\left(\frac{1}{2(n+2)} + \frac{n+1}{2(n+2)}\right) = -\frac{1}{2}$$

The first term in brackets is the well-known partial equilibrium effect, the second term is the general equilibrium effect. One can see that the two effects work in the same direction, but the general equilibrium effect is larger, with its relative importance increasing in the number of firms in each sector.

The constancy of the absolute union wage premium $w - w^c$ implies that a reduction in t also leaves relative employment levels across sectors and relative goods prices unchanged. Inspection of table 1 shows the even stronger result that *absolute* goods prices in all sectors stay constant. Hence the variance of prices is constant, and so is aggregate welfare. Furthermore the price markup over marginal (wage) cost falls in all sectors, and therefore profits in all firms decrease with marginal trade liberalisation. The results are summarised as follows:

Proposition 2 *From an initial situation of two-way trade in all industries, a marginal reduction in tariffs increases wages and reduces profits in both unionised and non-unionised sectors but has no impact on sectoral employment, product prices and aggregate welfare.*

5.2 Deunionisation

Consider now the implications of deunionisation, which we model as a marginal decrease in $\widetilde{z}$, the proportion of sectors that are unionised, in both countries. The effects on the competitive wage and the union wage can be directly inferred from eqs. (19) to (22):

Reducing $\widetilde{z}$ increases the competitive wage and the union wage, while reducing the absolute union wage premium, under both autarky and two-way trade. The intuition is as follows. Since non-unionised sectors pay a lower wage, increasing their number while reducing the number of unionised sectors one-for-one increases aggregate labour demand, thereby putting upward pressure on the competitive wage w^c. An increase in the competitive wage induces an increase of the union wage that is smaller in absolute value – see eqs. (15) and (17) – and hence the stated results follow.

For the analysis of welfare effects it is useful to look at the polar cases first. For $\widetilde{z} = 0$ we have $p = a - bL$ in all sectors, while for $\widetilde{z} \to 1$ we have $p \to a - bL$ in the unionised sectors (see Table 1), which in this case make up "nearly" all sectors of the economy. Hence the uncentered variance of prices is equal to $p^2 = (a - bL)^2$ in the absence of unionisation, while it approaches the same value if the economy approaches the limiting case of full unionisation. The uncentered variance of prices is maximised, and hence aggregate welfare is minimised, at some intermediate level of unionisation $\widetilde{z}^*$, which is the threshold below which further deunionisation increases welfare. From partial differentiation of eqs. (23) and (24) we find $\widetilde{z}^* = 2/3$ in autarky and $\widetilde{z}^* = (2+n)/(3+2n)$ under two-way trade. Therefore, with two-way trade in all sectors, the threshold level of unionisation $\widetilde{z}^*$ is lower than under autarky, and this difference increases with the number of firms operating in each industry. The results are summarised as follows:

Proposition 3 *Deunionisation increases the competitive wage and the union wage and reduces the union wage premium. Deunionisation increases welfare once the proportion of sectors that are unionised falls below a threshold level.*

5.3 Firm entry

In a closed economy, the wage elasticity of labour demand faced by each sectoral union sector is independent of the number of firms. For this reason, firm entry has no direct impact on union wages, a result that is well known in the literature (Dowrick, 1989; Dhillon and Petrakis, 2002 and Naylor, 2002) and can be seen to hold in the partial equilibrium setup in section 3 of the present paper, eq. (15). This changes once we move to the UGOLE

model: As in Neary (2003), an increase in n in all sectors increases the competitive wage in the closed economy, and therefore the union wage as well. Specifically, from eqs. (19) and (20) we find

$$\frac{dw}{dn} = \frac{1}{2}\frac{dw^c}{dn} = \frac{bL}{n^2(2-\widetilde{z})} > 0$$

As union wages increase less than proportionally with w^c, the union wage premium necessarily falls as the number of firms operating in each sector increases. With a declining union wage premium the relative output of firms in unionised sectors increases. This does *not* translate into higher output in unionised sectors though, because the number of firms in all sectors is increased, and the firms entering non-unionised sectors are larger. In fact, both effects compensate each other exactly, and relative sectoral output levels as well as goods prices stay constant (see Table 1). Hence, welfare is unaffected as well.

With two-way trade in all sectors, it can easily verified from inspecting eqs. (21) and (22) that firm entry increases the competitive wage, has an ambiguous effect on the union wage, and reduces the union wage premium $w - w^c$. In the open economy, the resulting increase in the relative size of unionised firms is also reflected in an increasing relative output of unionised sectors (see Table 1). The price of unionised sectors falls, the price of non-unionised sectors increases, and the resulting lower price variance means that aggregate welfare goes up. In summary we have:

Proposition 4 *In autarky, symmetric firm entry in all sectors leads to higher competitive and union wages while welfare stays constant. With two-way trade, symmetric firm entry in all sectors increases the competitive wage and has an ambiguous impact on the union wage. Welfare increases.*

6 Concluding remarks

We have developed a model of oligopoly in general equilibrium for investigating the effects of trade liberalisation, deunionisation and firm entry on wages in unionised and non-unionised sectors, and on aggregate welfare. In this framework, unions and firms behave as in partial equilibrium models, but aggregation across sectors allows for the endogenous

determination of economy wide variables, most importantly the competitive wage and aggregate welfare. General equilibrium interactions between unionised and non-unionised sectors play an important role in our analysis of the wage effects in the different policy scenarios. Indeed, we have shown that trade liberalisation and firm entry impact not only on union wage setting incentives directly, but also on the outside option of unionised workers. For this reason, wages in unionised sectors may increase with firm entry and be higher with free trade than in autarky. Furthermore, we have shown that partial deunionisation increases wages in both unionised and non-unionised sectors, but only leads to higher welfare when the proportion of unionised sectors is sufficiently low.

While these results are interesting in their own right, an important contribution of this paper is to offer a general equilibrium framework for studying the implications of competition policy and globalisation when trade unions are present. One way in which this framework might usefully be extended in the future is by introducing asymmetries between the countries, e.g. in labour market institutions, labour productivity, or market size. Other promising avenues for future research include allowing for national and international mergers, or foreign sourcing.

A Appendix

Here, we derive the value of t below which there is two-way trade in all sectors. In union sectors, the transition between autarky and two-way trade occurs when bilateral tariffs are sufficiently low such that each union finds it optimal to abandon its previous high wage strategy and instead lower their wage demand in order to allow the corresponding firms to compete internationally. In non-union sectors, firms treat w^c parametrically and hence the trade regime depends solely on their decisions. While the trade regime is determined by the actions of unions and/or firms in partial equilibrium, the boundary conditions may also be expressed in terms of the model parameters in general equilibrium.

We begin by deriving the boundary condition under which there is two-way trade in union sectors. To represent a Nash-equilibrium, the wage in (17) needs to exceed a critical level, which has been defined by Naylor (1998, 1999) as the *switching wage.* That is, the wage level that makes each union just indiferent between a high wage strategy and a low wage strategy. The maximum union utility associated to a high-wage strategy is given by:

$$\Omega_1^H = (w_1 - w^c) n y_{11} \tag{A.1}$$

where y_{11} is given by (12) and $w_1 = \arg\max \Omega_1^H$. After straighforward computations, we may express (A.1) as:

$$\Omega_1^H = n \frac{[a - w^c + n(t - w^c + w_2)]^2}{4b(1+n)1+2n)} \tag{A.2}$$

Similarly, the optimal utility associated with a low wage strategy is given by:

$$\Omega_1^L = (w_1 - w^c) n (y_{11} + y_{12}) \tag{A.3}$$

where from (12) and (13) and $y_{11} + y_{12} = (2a - t - 2(1+n)w_1 + 2nw_2)/(b(2n+1))$ and $w_1 = \arg\max \Omega_1^L$. Therefore, it is readily shown that:

$$\Omega_1^L = n \frac{(t - 2a + 2(1+n)w^c - 2nw_2)^2}{8b(1+n)(1+2n)} \tag{A.4}$$

From comparison of (A.2) and (A.4), each union in country 1 will be indifferent between the two strategies if:

$$w_2 = -\frac{a}{n} + \frac{n+1}{n} w^c + \frac{2 + \sqrt{2} + 2n + 2\sqrt{2}n}{2n} t \tag{A.5}$$

Hence (A.5) defines the switching wage, which is increasing in t. Using (17) and (A.5), we find the critical level of trade costs at which the equilibrium wage and the switching wage coincide:

$$t^* = \frac{4(1+n)}{4+n(7+2n)+\sqrt{2}(2+n)(1+2n)}(a-w^c) \tag{A.6}$$

Thus, lowering the tariff below t^* induces both unions to play a low wage strategy. There is, therefore, two-way trade and the equilibrium wage is given by (17).

We now turn to the analysis of the boundary condition below which there is two-way trade in non-union sectors. From (10) and (8) it follows that the critical level of t below which the representative firm starts exporting ($y_{12} > 0$) is given by:

$$t^{**} = \frac{1}{n+1}(a-w^c) \tag{A.7}$$

Comparing (A.6) and (A.7) it can be easily checked that $t^{**} > t^*$. Hence, we conclude that the the equilibrium trade regime is two-way trade in all sectors if $t \in [0, t^*)$. Substituting (21) into (A.6) we obtain the boundary condition t^* in terms of the model parameters:

$$t^* = \frac{2(\sqrt{2}-1)(n+1)}{n(2+n-\widetilde{z})}bL \tag{A.8}$$

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