Product and Labor Market Deregulation in Unionized Oligopoly with Asymmetric Countries

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Abstract

This paper sets up a general oligopolistic equilibrium trade model for two integrated countries that are similar in all respects except of the prevailing labor market institutions. In one country, the labor market is perfectly competitive, while in the other country labor unions are active in a subset of industries. The differences in labor market institutions are a source of comparative advantage, which crucially impact inter-industry trade and welfare in the open economy. In this setting, we study the trade and welfare implications of labor market deregulation and compare these implications with the consequences of product market deregulation. Thereby, we take into account that labor market reforms are subject to national policy decisions and thus associated with unilateral intervention, while product market deregulation is determined at an international – for instance European – level and thus associated with coordinated intervention in both economies. As a key result, we find that both forms of policy intervention generate a conflict of interest between the two trading partners and that welfare losses materialize for the country with the competitive labor market regime whenever global gains are realized.

JEL-Code: F120, F160, J510.

Keywords: general oligopolistic equilibrium, labor unions, comparative advantage, product and labor market deregulation.

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1 Introduction

Since the controversy between Krugman (1994) and Davis (1998) upon labor market linkages in open economies,[1] economists have got increasing interest in the role of labor market institutions for employment, wage, and welfare outcomes in countries that are linked by international trade flows. The subsequent literature has brought to the forefront the research question how differences in labor market institutions govern comparative advantages and thus inter-industry trade in open economies. In fact, this is not only an academic issue but equally relevant for policy circles. Since international rules of non-discrimination have led to a banishment of bureaucratic impediments to firm entry – at least in the industrialized world – policy makers have to search for alternative instruments if the aim is to manipulate the market outcome in their own interest. There is evidence that labor markets, which are still in national hands, may fill the gap and become the new arena for self-interested policy intervention in open economies. For instance, the German government has been accused by politicians of other EU member countries to use wage moderation strategically in order to improve its export performance relative to its trading partners. It is thus important to understand the nexus between labor market institutions and trade patterns as it is crucial for the costs and benefits involved in labor market reforms, as well as the spillover of such reforms on a country's trading partners.

Shedding light on the link between labor market institutions and trade patterns is the purpose of this paper. Since we are particularly interested in the role of labor market institutions for a country's comparative advantage, we consider trade between two economies which are identical in all respects except of their labor market conditions. We choose the simplest possible structure to account for this asymmetry and assume that labor market imperfection arises just in one economy. Labor market imperfection is associated with the

[1] Krugman's (1994) two-sides-of-the-same-medal hypothesis for explaining the different labor market outcomes in Europe and the US in the 1980s has been criticized by Davis (1998), who argued that treating labor market outcomes in different economies as independent phenomena contradicts the idea of general equilibrium trade models. See Egger, Egger, and Markusen (2011) for a detailed discussion of this argument.

ability of workers to extract rents that are generated by production. In line with a large part of the literature dealing with labor market imperfection in trade models, we consider collective wage setting as the main source of rigidity and investigate rent sharing between firms and unions in an oligopoly market. The assumption of a (Cournot) oligopoly is attractive as it gives rise to pure rents in equilibrium, and embedding this model into a general equilibrium framework with a continuum of (industrialized) sectors gives the additional attractive feature that firms are large in their industry but small in the aggregate (see Neary, 2003, 2009). Imposing the additional assumption that only a subset of industries is unionized implies that institutional differences between the two economies, which are modeled in a parsimonious way by differences in union density, give rise to inter-industry trade.[2] However, even though inter-industry trade is caused by (institutional) comparative advantage, higher levels of trade are not necessarily associated with higher global welfare in our setting, as they may simply reflect stronger labor market distortions in the country with the unionized labor market.

Aside from characterizing the open economy equilibrium, we are also interested in two comparative-static experiments. In the first one, we investigate the consequences of a decline in the share of unionized industries. In our model, there is only one country in which labor is unionized, implying that labor market deregulation amounts to a unilateral reform which harmonizes union influence on labor market outcomes. This is in accordance with empirical evidence, as union density has not only fallen in general but has also become more similar across countries.[3] Since only one country deregulates its labor market, our

[2]Since we consider a "closed shop" union model in which all workers in a unionized sector are union members (cf. Oswald, 1985), union density equals union coverage and both measures are directly related to the share of unionized industries in our setting. In an "open shop" union model, union density may differ from union coverage as unionized firms can also employ non-unionized workers, at the same time paying identical wages to all workers of the same skill type (see Booth, 1984). Models of the latter type are useful for endogenizing union membership, but, due to lower tractability, less common in models with exogenous membership.

[3]Based on OECD statistics, one can calculate an unweighted average of union density of about 38 percent in 1988 and 28.4 percent in 2008. Accordingly, one can calculate a standard deviation in union density of 19.26 for 1988 and of 18.57 for 2008. The respective numbers are based on own calculations

model provides insights into the scope of policy makers for using labor market deregulation in their self-interest as a stimulus for domestic welfare. In this respect, the results from our analysis are not encouraging, as unilateral labor market reforms cannot be a blessing for both countries. Hence, if deunionization in the country with the more rigid labor market regime is fuelled by domestic welfare considerations, it should lead to no big cheers of the trading partner.

In the second experiment, we look at the consequences of product market deregulation. In contrast to labor market policy, product markets are usually shielded by international agreements from discretionary intervention of self-interested policy makers. For instance, it is one of the main purposes of the Single Market program in the European Union to abolish barriers to firm entry and to foster competition in the integrated market. Unambiguously, the program has led to a significant deregulation of product markets in European countries over the last two decades, and the easiest way to capture this development in our model is by a uniform increase in the number of competitors in the two economies. However, due to the prevailing differences in the labor market institutions, the consequences of this deregulation process are remarkably different in the two economies. On the one hand, the stronger competition reduces the scope of unions for excessive wage claims and thus reduces the negative welfare implications of collective wage setting. Thus, welfare increases in the country with the more rigid labor market regime. However, welfare deteriorates in the other country, and this welfare loss materializes despite an increase in inter-industry trade. This implies that in the presence of different labor market institutions, even coordinated measures of product market deregulation may be controversial in open economies. And if countries act in their self-interest and a redistribution of welfare gains is not implemented, we can therefore expect that the endeavor to deregulate product markets is too small relative to what would be optimal from a global point of view.

The remainder of this paper is organized as follows. In Section 2, we briefly discuss related literature. Section 3 introduces the basic model setup and characterizes inter-

for a sub-sample of 25 OECD countries for which union density figures are available over the time period 1988-2008.

industry trade and welfare in the open economy. In Section 4, we analyze the impact of deunionization on wages, welfare, and inter-industry trade. In Section 5, we consider the impact of product market deregulation, while the last section summarizes the main results and applies our model to reconsider a controversy within Europe regarding the role of German labor market policy for explaining the economic problems of some of its neighboring countries.

2 Relationship to existing literature

Our model contributes to a large literature that studies the interaction of firms and unions in open economies. Most of the existing papers consider oligopolistic competition in the product market and focus on a partial equilibrium environment in which there is a large competitive industry that absorbs all workers who do not find a job in the unionized sector and pays a given wage rate to these workers. Examples to this literature include Huizinga (1993) Sørensen (1993), Naylor (1998, 1999), and Lommerud, Meland, and Sørgard (2003).[4] The first paper that has embedded the unionized oligopoly framework into a general equilibrium environment with a continuum of industries is Bastos and Kreickemeier (2009). Similar to us, they consider a framework along the lines of Neary (2003, 2009) and enrich this framework by assuming that a subset of industries is unionized, while firms in the residual ones pay the competitive (market-clearing) wage. Bastos and Kreickemeier also study the consequences of product and labor market deregulation. However, by focussing on two symmetric countries, they can neither discuss the role of labor market institutions for a country's comparative advantage, nor can they analyze the consequences of unilateral labor market reforms or the consequences of product market deregulation under differing labor market institutions, which are in the center of this paper's interest.

By pointing to the role of labor market institutions for a country's comparative ad-

[4]Most of the existing models consider a monopoly union model in which the union unilaterally sets the wage, while the firm chooses employment. This can be interpreted as the limiting case of a right-to-manage model in which unions have all the bargaining power in the wage setting process.

vantage, our analysis is related to an old and well-established literature dealing with labor market imperfections in traditional trade models. This literature has been launched by the seminal paper of Brecher (1974) who introduced minimum wages into an otherwise standard two-country, two-sector, two-factor Heckscher-Ohlin framework. Davis (1998) has used this setting for explaining labor market linkages in open economies and has emphasized the role of labor market institutions for the pattern of inter-industry trade in a Europe/US context.[5] Our model deviates from these early approaches by considering a model which simultaneously accounts for product and labor market imperfection. This approach seems to be more realistic than relying on the assumption of a perfectly competitive goods market, and it allows us to distinguish between the consequences of product and labor market deregulation.[6]

This distinction has played a prominent role in macroeconomics. The seminal work by Blanchard and Giavazzi (2003) has brought the differential impact of these two forms of market deregulation to the center stage of economic research. Their results indicate that governments should combine labor and product market deregulation in order to reduce workers' opposition to such reforms. In subsequent years, economists have shed further light on the interaction between product and labor market deregulation, putting particular emphasis on the role of product market deregulation in different labor market regimes[7] (Amable and Gatti (2004); Spector, 2004, Koeniger and Prat, 2007) as well as the impact

[5]A key feature of the Davis (1998) model is factor price equalization that materializes due to diversified production and zero trade costs. This has two implications. First, a higher minimum wage in Europe is beneficial for (low-skilled) workers in the US and, second, any macroeconomic shock is entirely absorbed by the European labor market, provided that Europe has the binding minimum wage. These two implications are controversial and their robustness has been subject to research for many years (see Oslington, 2002; Kreickemeier and Nelson, 2006; Meckl, 2006 and Egger, Egger, and Markusen, 2011).

[6]However, our paper is of course not the first one that features both product and labor market imperfection in a general equilibrium trade model. An early example is Matusz (1996) who considers a new-trade theory model with monopolistic competition in the goods market and efficiency wages as source of labor market imperfection.

[7]Relying on data for OECD countries over the 1980s and 1990, Griffith, Harrison, and Macartney (2007) provide empirical support for the idea that the impact of product market deregulation on employment and wages depends crucially on the prevailing labor market institutions.

of product market deregulation on the evolution and change of labor market institutions (Ebell and Haefke, 2006 and Fiori, Nicoletti, Scarpetta, and Schiantarelli, 2010). Most of the existing studies look at the consequences of product and labor market deregulation in closed economies and hence do not account for market linkages arising from firms being active in international markets. An exception is Boulhol (2009) who investigates the role of globalization – as a specific form of product market deregulation – for the incentives to deregulate labor markets. His findings are well in line with Gaston and Nelson's (2004) argument that globalization does not only change wages and employment directly but also changes political institutions and thus the structure of the labor market. However, these papers do not shed light on the consequences of reducing the impediments to firm entry, nor do they account for the different levels at which reforms of institutional settings are designed and implemented: the national vs. the international level.

3 Basic Model Setup

We conduct our analysis in a general oligopolistic equilibrium (GOLE) model along the lines of Neary (2003, 2009), with a continuum of industries (with mass one) and a small (finite) number of firms competing in quantities within each industry. In this framework, firms are large in their own industry but small in the aggregate, and hence they rationally treat economy-wide variables parametrically. The starting point of our analysis is a two-country model ($i = 1, 2$) with an integrated world market for industrial goods, so that consumer prices are the same in the two economies. Both economies are populated by N firms and L workers who supply one unit of labor for domestic production. All firms share the same technology and use one unit of labor to produce one unit of output. There are no fixed costs.

Workers are assumed to be shareholders of domestic firms and thus are the residual claimants of profits. For simplicity, we assume that shares are uniformly distributed so that all workers in an economy end up with identical profit income. Workers add up to the total mass of domestic consumers, whose preferences are assumed to be quadratic and the same in the two economies. Country i's demand for industrial goods can be determined by maximizing its representative consumer's utility

$$U_i = \int_0^1 \left(a - \frac{b}{2} x_i(z) \right) x_i(z) dz \tag{1}$$

subject to this consumer's budget constraint

$$\int_0^1 p(z) x_i(z) dz = I_i \tag{2}$$

and the usual non-negativity constraint $x_i(z) \geq 0$.[8] Thereby, $a, b > 0$ are two preference parameters, $x_i(z)$ denotes country i's demand for the output of industry z, $p(z)$ is the respective price of this good, and I_i is aggregate income in country i. The solution for the representative consumer's maximization problem gives country i's demand for industrial good z, which can be written in direct or indirect form:

$$x_i(z) = \frac{1}{b}\big(a - \lambda_i p(z)\big), \qquad \lambda_i p(z) = a - b x_i(z), \tag{3}$$

respectively. Thereby, λ_i denotes the marginal utility of income, which depends on the first and second moment of the price distribution: $\mu_1 \equiv \int_0^1 p(z)dz$ and $\mu_2 \equiv \int_0^1 p^2(z)dz$ as well as aggregate income I_i. Substituting (3) into (2) gives

$$\lambda_i = \frac{a\mu_1 - bI_i}{\mu_2}. \tag{4}$$

Throughout our analysis, we focus on interior solutions with $x_i(z) > 0$ (*participation*) and $\lambda_i > 0$ (*non-satiation*). As formally shown in a supplement, $a > 9bL/4$ guarantees this outcome, and hence in the subsequent discussion we assume that this condition is fulfilled.[9]

Adding up $x_i(z)$ over both countries gives world-wide demand for industrial good z

$$X(z) = \frac{1}{b}\big(2a - \lambda p(z)\big), \tag{5}$$

[8] Since preferences are quasi-homothetic, the representative consumer also has a normative interpretation and we can rely on his/her utility when making welfare comparisons.

[9] Note that condition $a > 9bL/4$ also guarantees participation and non-satiation of *all* individual workers – despite differences in wage income of unionized and non-unionized workers (see the supplementary material for details). Furthermore, this condition establishes positive wage income of all workers in our setting (see below).

where $\lambda \equiv \lambda_1 + \lambda_2$. It is convenient in this framework to set λ equal to one and thus measure nominal variables in units of the world representative consumer's utility (see Neary, 2003). However, since in this case the numéraire is not a commodity, we need to be careful when interpreting changes in prices and factor returns in the subsequent analysis. As pointed out by Neary (2009), such changes measure real effects at the margin and thus do not have a direct implication for utility.

To keep the analysis as simple as possible, we set $N = 1$ and focus on the case of an international Cournot duopoly in this and the next section, while delegating a discussion of the more sophisticated case with $N > 1$ to Section 5. With a single producer in either economy, the non-cooperative outcome in the output game is given by

$$q_i(z) = \frac{2a - 2w_i(z) + w_j(z)}{3b}, \qquad i \neq j, \tag{6}$$

where the goods market clearing condition, $X(z) = q_1(z)+q_2(z)$, has been considered in the maximization problem of firms.[10] Furthermore, equilibrium profits are $\pi_i(z) = b(q_i(z))^2$. Thus, a firm's output and profits depend on both the own wage costs and the wage costs of the competitor. Wages, on the other hand, depend on the prevailing labor market institutions, which in general may differ between the two countries as well as across sectors. In the following, we associate country 1 with the more market-oriented economy and assume that all firms in this country pay the competitive wage w_1^c. On the contrary, in country 2 there is a subset $\alpha \in (0, 1)$ of industries, in which wages are unilaterally set by firm-level unions. Unions are utilitarian and maximize an objective function $V_2(z) = \left[w_2(z) - w_2^c\right] l_2(z)$, where w_2^c denotes the competitive wage in country 2, which is paid in the $1 - \alpha$ non-unionized industries. Firms keep the right-to-manage employment, $l_2(z)$, and thus choose an employment level along the marginal revenue product curve, once the wage has been set by the union.

Recollecting from above that firms must employ one worker to produce one unit of output, i.e. $q_i(z) = l_i(z)$, and accounting for (6), the solution to the union's maximization problem is given by

$$w_2^u(z) = \frac{2a + w_1^c + 2w_2^c}{4}. \tag{7}$$

[10]Clearly $q_i(z)$ must be non-negative and (6) fulfills this condition in equilibrium (see below).

From (7) we can conclude that an increase in either country's competitive wage stimulates the union's wage claim in country 2. However, the reasons for the respective stimuli differ. A higher competitive wage in country 1 implies that local producers become relatively less competitive. Outputs being strategic substitutes, this leads firms in country 2 to increase their output and thus their demand for labor at any given wage rate. This lowers the wage elasticity of labor demand, and unions respond to these changes by setting higher wages. On the other hand, if the competitive wage in country 2 increases, losing the job in the unionized sector becomes less costly from the perspective of workers, so that the union has an incentive to raise its wage claim.

Based on these insights regarding the product and the labor market outcome at the sectoral level, we can now solve for the general equilibrium. For this purpose, we substitute (7) into (6) and use the resulting expression in the labor market clearing conditions for the two economies. Rearranging terms, the full employment conditions can be written as[11]

$$w_1^c = 2a - 3bL, \qquad w_2^c = 2a - \frac{1}{2}\,\frac{3bL(4-\alpha)}{2-\alpha}. \tag{8}$$

Furthermore, the unionized wage in country 2 then follows from (7):

$$w_2^u = 2a - \frac{1}{2}\,\frac{3bL(3-\alpha)}{2-\alpha}. \tag{9}$$

From (8) and (9), we can deduce that unions, by claiming a wage premium, lower domestic labor demand and thus induce a fall in country 2's competitive wage rate. Provided that $\alpha \in (0,1)$, this leads to the following wage ranking: $w_2^u > w_1^c > w_2^c$, which implies that the differences in the labor market institutions are a source of comparative advantage, with country 1 possessing a cost advantage in those industries that are unionized in country 2, and country 2 possessing a cost advantage in its non-unionized industries.

Consequently, with sectors being ordered as in Bastos and Kreickemeier (2009), country 1 will be a net exporter in industries $z \in (0,\alpha)$ and a net importer in the residual industries. To shed further light on the role of labor market institutions for the inter-industry trade pattern, we can consider country i's balance of payments condition:

[11]Notably, condition $a > 9bL/4$ ensures that all wages are strictly larger than zero in our setting.

$\int_0^1 \big(q_i(z) - x_i(z)\big) p(z) dz = 0$. Then, assuming that consumers choose local products in the case of indifference, the value of country i's exports is given by[12]

$$T_i = \int_0^\alpha \big|q_i(z) - x_i(z)\big| p(z) dz. \tag{10}$$

Furthermore, applying the condition of balanced trade, the world-wide value of exports is given by $T^w \equiv 2T_i$. As shown in the appendix, we can express the latter by

$$T^w = \frac{3L(a - bL)\alpha(1 - \alpha)p^u p^c}{(2 - \alpha)\left[\alpha(p^u)^2 + (1 - \alpha)(p^c)^2\right]}, \tag{11}$$

where

$$p^u = 2a - \frac{bL}{2}\frac{7 - 3\alpha}{2 - \alpha}, \qquad p^c = 2a - \frac{bL}{2}\frac{8 - 3\alpha}{2 - \alpha} \tag{12}$$

denote the price levels in unionized and non-unionized sectors, respectively. Dividing the total value of exports by world-wide GDP (i.e. world-wide income),

$$I^w = \frac{L}{2}\left[8(a - bL) - \frac{bL}{2}\frac{\alpha(1 - \alpha)}{(2 - \alpha)^2}\right], \tag{13}$$

finally gives a suitable measure of the extent (share) of inter-industry trade in our model:

$$s^w = \frac{6(a - bL)\alpha(1 - \alpha)p^u p^c}{(2 - \alpha)\left[\alpha(p^u)^2 + (1 - \alpha)(p^c)^2\right]}\left[8(a - bL) - \frac{bL}{2}\frac{\alpha(1 - \alpha)}{(2 - \alpha)^2}\right]^{-1}. \tag{14}$$

Intuitively, if $\alpha = 0$, both countries are fully symmetric, and hence there is no inter-industry trade, i.e. $s^w = 0$. Furthermore, inter-industry trade vanishes as well if $\alpha \to 1$. In this limiting case, all industries in country 2 become unionized and w_2^u falls to w_1^c so that production costs are again the same in both economies. However, for intermediate levels of α, there is inter-industry trade due to differences in the two countries' labor market institutions.

This completes the characterization of the open economy equilibrium. In the next section, we conduct a comparative-static analysis, that aims at shedding light on the consequences of deunionization in country 2 for trade and welfare.

[12]Without any trade barriers, the total volume of trade is in general not determined. With the additional assumption of consumers choosing local products in the case of indifference, we avoid this source of ambiguity and direct our attention to inter-industry trade.

4 Deunionization and its implication for trade and welfare

In the subsequent analysis, we associate deunionization with a decline in the number of sectors that are exposed to union wage setting, i.e. a decline in α. From (8), we can conclude that a reduction in α stimulates labor demand in country 2 and thus increases the competitive wage there, i.e. $dw_2^c/d\alpha < 0$.[13] At the same time, it follows from (9) that a higher competitive wage increases union wage claims, so that $dw_2^u/d\alpha < 0$. Regarding the wage effects in country 1, we can distinguish two counteracting effects. On the one hand, country 2 gains a cost advantage in those industries that are newly deunionized. This lowers labor demand in country 1, ceteris paribus. On the other hand, the increase in country 2 wages counteracts this effect and tend to raise labor demand in country 1. From Eq. (8), we can conclude that these two counteracting effects exactly offset each other, so that total labor demand in country 1, and thus wage rate w_1^c, remain unaffected by a decline in α.

Clearly, these relative factor price effects influence comparative advantages and thereby affect the inter-industry trade pattern in our model. From Section 3, we already know that $s^w = 0$ if $\alpha = 0$ or $\alpha \to 1$. This indicates that the relationship between deunionization and the inter-industry trade share is non-monotonic. As formally shown in the appendix and graphically depicted in Figure 1, the respective relationship is hump-shaped, with s^w reaching a maximum at an intermediate level of α. Intuitively, the scope for inter-industry trade is largest, if the share of exporting and importing sectors is of approximately the same size. However the s^w-maximum is not exactly at $\alpha = 0.5$, where the number of exporting sectors equals the number of importing ones. Rather, the s^w-maximizing α-level also depends on the value of exports (or imports) in each industry, and thus on sectoral prices and outputs, which in our model are determined by a non-trivial interplay of labor market and product market imperfections.

[13] Even though wages must be interpreted as real wages at the margin, so that changes in wages do not have direct implications for utility (see Neary, 2009), looking at the respective changes is still instructive as they provide insights upon the impact of deunionization on the relative production costs in unionized and non-unionized industries and thus the terms-of-trade effects in the open economy.

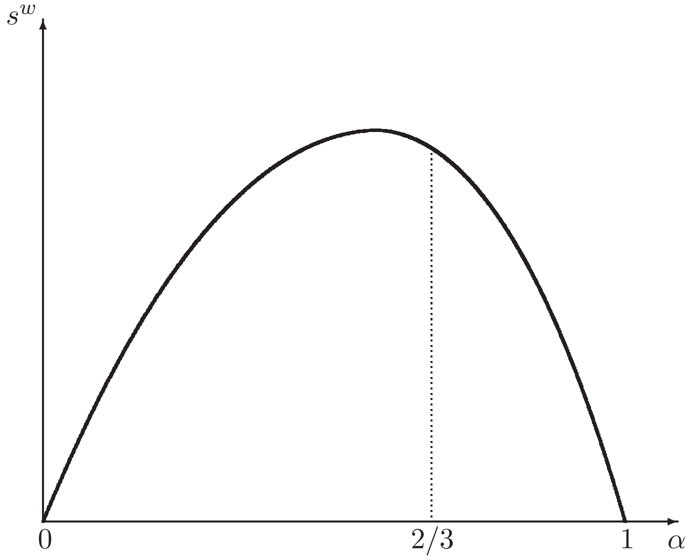

Figure 1: Deunionization and inter-industry trade

Regarding the welfare implications of deunionization, we can note that indirect utility of country i's representative consumer is given by

$$U_i = \int_0^1 \frac{1}{2b}\big(a^2 - \lambda_i^2 p^2(z)\big)dz. \tag{15}$$

Ignoring constants we can evaluate welfare in country i by looking at changes in the monotonically transformed welfare measure $v_i = -\lambda_i^2 \mu_2$. Then, considering first the two limiting cases $\alpha = 0$ and $\alpha \to 1$, we find the following. If $\alpha = 0$, labor market institutions are the same in the two economies, and hence both countries reach the same welfare level: $v_1 = v_2$. On the contrary, if $\alpha \to 1$, all sectors in country 2 become unionized and w_2^u falls to w_1^c, so that labor costs are again the same in the two economies and both countries end up with the same welfare level. In all other cases, the institutional differences drive a wedge between the welfare levels in the two economies, with the more market-oriented country being strictly better off than the country with the stronger labor market distortion – at least according to our welfare criterion. As graphically depicted in Figure 2 and formally shown in the appendix, the relationship between α and v_1 is hump-shaped with a maximum at $\alpha = 2/3$, while the relationship between α and v_2 is u-shaped with a minimum at $\alpha = 2/3$. Beyond that, Figure 2 also depicts global welfare implications of a reduction in α, with world (global) welfare being defined as the indirect utility of the global representative consumer: $v^w = -\lambda^2 \mu_2$ (where $\lambda = 1$, due to our choice of numéraire). In the interest of a better graphical representation, the figure shows the monotonically transformed welfare measure $\tilde{v} = v^w/2$, which, similar to v_2, reaches a minimum at $\alpha = 2/3$.

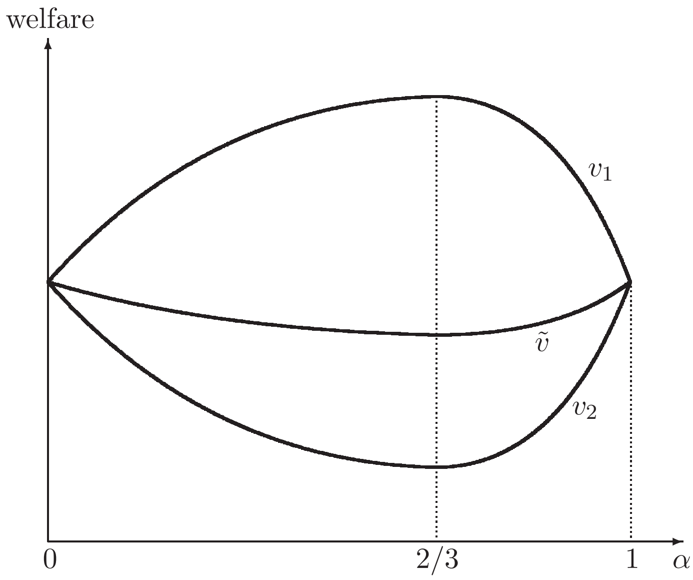

Figure 2: Deunionization and welfare

The welfare patterns in Figure 2 confirm the insights from other studies that union wage setting has efficiency costs and thus lowers world welfare. However, this does not mean that deunionization is necessarily beneficial. On the one hand, since in an integrated world economy trading partners can benefit from strong labor market institutions in a foreign economy, unilateral deunionization may exert an unintended negative externality on a country's trading partner. On the other hand, partial deunionization may actually exert detrimental domestic and global welfare effects in our setting. Clearly, this is not an argument against labor market reforms *per se*, as a movement towards a distortion-free labor market regime is always beneficial from an efficiency point of view. Rather, our results indicate that policy intervention needs to be sophisticated, taking into account the possible adverse welfare implications of minor reforms as well as the distributional effects triggered by labor market deregulation.

We summarize the main insights from above in the following proposition.

Proposition 1. *Both inter-industry trade and welfare in country* 1 *are stimulated by (marginal) deunionization in country* 2 *if* α *is large, while both of these measures are reduced if* α *is small. The opposite effects materialize with respect to welfare in country* 2 *as well as world welfare. Both of these measures fall in response to (marginal) deunionization if* α *is large, while they increase if* α *is small.*

Proof. Analysis in the text. □

Since in our setting inter-industry trade itself is triggered by a labor market imperfection, it is necessarily associated with a suboptimal world welfare level. However, it is obvious from an inspection of Figures 1 and 2 that the world welfare-minimizing and the trade-maximizing degree of unionization do not coincide in our model. The reason for the latter lies in the non-trivial interplay of product and labor market imperfections in our setting. To be more specific, due to their oligopoly power firms absorb part of the wage cost increase involved in the reduction of α by accepting a lower price-cost mark-up. This ceteris paribus lowers the extent of inter-industry trade as compared to a scenario with a perfectly competitive product market and thus drives a wedge between the $\tilde{v}$-minimizing and the s^w-maximizing α-levels.[14]

One final remark is in order here. While inter-industry trade is a consequence of the labor market imperfection in country 2 and thus associated with a suboptimal global welfare level, this does not imply that trade needs to be detrimental. On the contrary, as in Brander (1981) a movement from autarky to trade disciplines firms, all other things equal, and lowers their price-cost margins. Furthermore, it also disciplines unions and ceteris paribus lowers their wage claims (Huizinga, 1993; Sørensen, 1993). Both of these effects stimulate

[14] It is indeed the case that an increase in the number of competitors lowers the gap between $\tilde{v}$-minimizing and s^w-maximizing α-levels.

welfare in a partial equilibrium setting. However, as extensively discussed in Bastos and Kreickemeier (2009), these mechanisms need not be effective if general equilibrium feedback effects are accounted for. In their model, a country's movement from autarky to free trade with a symmetric partner country lowers the price dispersion between unionized and non-unionized industries, and hence the country benefits as consumers dislike price heterogeneity. In our setting, the price dispersion only falls in the country with an imperfect labor market (country 2), and this effect clearly contributes to a positive welfare effect in this economy. Things are different in country 1, where the price dispersion increases, which lowers domestic welfare ceteris paribus. However, this effect is counteracted and dominated by an overall increase in domestic consumption, as country 1 exports the more expensive goods and thus receives a greater volume of imported goods in an open economy (terms-of-trade effect). Also country 2 specializes on those goods that are produced at a relatively low costs compared to its trading partner, so that gains from trade materialize according to the law of comparative advantage. This renders institutional differences instrumental for positive welfare implications of a country's movement from autarky to free trade in our setting.

5 More than two producers and the consequences of product market deregulation

In this section, we extend the previous analysis to one with more than two producers in the world market for industrial goods and analyze how an increase in the number of competitors – associated with product market deregulation – affects welfare and inter-industry trade. Since it is the main purpose of this section to investigate the differences between deunionization and product market deregulation, we keep the analysis as simple as possible and maintain the assumption of a symmetric product market structure in the two economies. Of course, restricting our attention to *pari passu* changes of N in both economies constitutes a notable difference to the comparative-static experiment in Section 4, where labor market deregulation was an asymmetric phenomenon, associated with a decline in the share of unionized sectors in country 2. However, the comparison still makes sense as stronger product market competition is usually seen as an effective measure of lowering the labor unions' ability to set excessive wages (see Huizinga, 1993; Sørensen, 1993; Bastos and Kreickemeier, 2009). We analyze, whether this insight extends to a model with asymmetric labor market institutions and in addition shed light on the consequences for welfare and inter-industry trade in a general equilibrium environment.[15]

Assuming that N competitors are active in either economy, the non-cooperative outcome of the output game is given by

$$q_i(z) = \frac{2a - (N+1)w_i(z) + Nw_j(z)}{b\,(2N+1)}, \qquad i \neq j, \tag{6'}$$

which reduces to Eq. (6) in the borderline case of $N = 1$. Plugging the latter into the objective function of firm-level unions in country 2 and maximizing the resulting expression, with respect to the union wage rate, yields

$$w_2^u(z) = \frac{2a + Nw_1^c + (N+1)w_2^c}{2(N+1)}. \tag{7'}$$

Furthermore, applying the labor market clearing condition in both economies, we obtain explicit solutions for the three wage rates in our model:

$$w_1^c = 2a - \frac{(2N+1)bL}{N}, \qquad w_2^c = 2a - \frac{(2N+1)bL}{N+1}\,\frac{N(2-\alpha)+2}{N(2-\alpha)}, \tag{8'}$$

$$w_2^u = 2a - \frac{(2N+1)bL}{N+1}\,\frac{N(2-\alpha)+1}{N(2-\alpha)}. \tag{9'}$$

An increase in the number of competitors N fosters product market competition and thus raises demand for production workers. This stimulates the competitive wage rate in both economies and lowers the wage premium paid in unionized industries in country 2, i.e. $w_2^u - w_2^c$ shrinks. Unions set higher wages in response to the increase in the competitors' wages, as well as their reference wage. However, they also realize that they can raise employment by choosing just a moderate wage increase relative to domestic and foreign firms that face competitive wages. In country 2 this wage moderation implies

[15]In this section, we focus on an intuitive discussion of our results and refer the interested reader to a technical supplement for formal details of the analysis. This supplement is available upon request.

that labor is relocated to unionized industries, and the union wage premium falls. This labor relocation, while leaving $\mu_1 = 2(a - bL)$ constant, reduces the second moment of the price distribution, μ_2, and thus stimulates global welfare, $v^w = -\mu_2$. However, the two economies do not equally participate in this welfare gain. With prices increasing in non-unionized industries, country 2 benefits from a positive terms-of-trade effect, i.e. its export prices increase relative to its import prices. The opposite is true in country 1, where export prices decrease relative to import prices, generating welfare losses due to a negative terms-of-trade effect.[16]

Regarding the impact of an increase in the number of competitors N on the trade pattern, we can distinguish between a direct and an indirect effect. First, an increase in N raises the number of exporters and thus provides a direct stimulus on the value of exports, T_i. Second, stronger product market competition lowers the wage premium in unionized industries and thus induces a relocation of resources (workers) towards these industries in country 2. This lowers the price in unionized industries and increases the price in non-unionized industries. Since country 2 has a comparative advantage in non-unionized industries, the value of its exports is stimulated by the increase in p^c, while it is dampened by the resource relocation towards unionized industries (which lowers the volume of inter-industry trade ceteris paribus). It is in general not clear, whether the price or the volume effect dominates, rendering the indirect effect ambiguous. However, adding direct and indirect effects, an increase in N unambiguously raises the value of exports T_i in our setting, and this effect is decisive for a stimulus on the extent (share) of inter-industry

[16]The result that product market deregulation is harmful for workers in the country with the competitive labor market, while beneficial for workers in the country with a unionized labor market, may seem to be at odds with the empirical findings in Griffith, Harrison, and Macartney (2007) who report for OECD economies positive real wage effects in response to product market deregulation which are strongest for countries with low bargaining power of unions. However, the results of the two studies are not directly comparable. To be more specific, the welfare effects in our study also depend on adjustments in profits, which are redistributed to workers in a lump-sum fashion, and adjustments in the price dispersion, both of which are not accounted for in the empirical estimates for real wage effects in Griffith, Harrison, and Macartney (2007).

trade, s^w.[17]

We complete the discussion in this section by summarizing the main insights in the following proposition.

Proposition 2. *A pari passu increase in the number of local competitors in both economies lowers the union wage premium and increases inter-industry trade as well as world welfare. However, welfare gains are not equally distributed between the two economies. While the country with the unionized labor market benefits from firm entry, the country with a competitive labor market loses.*

6 Further discussion and concluding remarks

In this paper, we have set up a two-country general equilibrium model with a continuum of industries and Cournot competition between a small number of firms within each sector. Assuming that countries are symmetric except of the prevailing labor market institutions, the analysis provides insights on how differences in labor market institutions determine the two countries' comparative advantages and thus the pattern of inter-industry trade and welfare in the open economy. Furthermore, our analysis provides insights on how labor market deregulation in one country, modeled by deunionization in part of the industries, affects the open economy equilibrium. In a final step, we have have shed light on the consequences of product market deregulation and have contrasted the impact of this policy reform with the implications of labor market deregulation.

Instead of repeating the main results from the different comparative-static experiments in this paper, we conclude our analysis and highlight the main differences between product and labor market deregulation by applying our model to shed new light on a recent controversy about the role of Germany in the current economic crises of Southern EU member countries.[18] There is increasing disapproval about German wage moderation pol-

[17] Aside from this comparative-static exercise, we have also studied the impact of N on the comparative-static effects of deunionization on welfare and inter-industry trade. We can show that the main results from Sections 4 remain unaffected when accounting for more than just a single producer in either economy.

[18] Of course, relying on a static trade model without a public sector, the following discussion must be

icy over the last decade, with wage increases far below the country's productivity growth. The former French finance minister, Christine Lagarde, has articulated the widespread concern when accusing Germany to use a wage dumping policy in order to improve its competitiveness in the export market.[19] The insights from our analysis suggest that this line of reasoning – while maybe convincing at a first glance – is misguided in a general equilibrium context.

If a country like Germany deregulates its labor market, as captured by a decline of α in our setting, it reduces labor costs and thus stimulates production in the newly deunionized industries. Deunionization extends the number of sectors in which the country has a comparative advantage and thus increases this country's exports ceteris paribus.[20] However, in a general equilibrium environment, this is just part of the story. Labor market deregulation raises economy-wide labor demand and thus induces a surge in the competitive as well as the union wage. Hence, exports shrink in other German industries, and this effect may be strong enough to outweigh the export stimulus in the newly deunionized sectors. It is therefore in general not clear if labor market deregulation increases the extent of inter-industry trade. Total exports are stimulated if labor market imperfection was strong (i.e. the share of unionized sectors large) prior to the reform, and in this case it is indeed possible that the trading partner (France, in our example) experiences welfare losses, while the respective labor market reform is beneficial from a global point of view.[21]

seen under the caveat of abstracting from important aspects of the recent economic crises in the Euro area, including unbalanced trade, foreign debt, and public deficits. Still, the following discussion is instructive and helpful for assessing some of the arguments raised by policy makers in the public debate of the last few months.

[19] Heiner Flassbeck, the chief economist at UNCTAD, shares this view and argues that German wage moderation is responsible for economic troubles in some of its European neighbors (see Spiegel, 2010).

[20] Of course, representing labor market deregulation in Germany by a decline in α is a very parsimonious way to capture the respective reforms at the beginning of the 21^{st} century. However, taking into account that recent labor market reforms were accompanied by a steady decline in union density (of more than 5 percentage points over the last decade according to OECD statistics), it is fair to say that a decline in α at least captures important aspects of the institutional changes in the German labor market.

[21] According to our model, deunionization can trigger an increase in inter-industry trade and at the same time lower welfare of the trading partner only if $\alpha < 2/3$. However, in this case global welfare

This suggests that Ms. Lagardes criticism of German labor market policy may reflect the self-interest of France rather than her concern about global welfare losses.

Our model suggests that there may be a different reason for a country losing from a foreign economy's exceptional export performance. In the presence of asymmetric labor market institutions, product market deregulation stimulates inter-industry trade and generates global welfare gains but these gains come at the cost of welfare losses in the country with a more competitive labor market regime. Hence, by leaving labor market regulation a matter of national policy, the endeavor of jointly reducing impediments to product market entry in the common European market (see CESifo, 2009, for an overview) may backfire on the member countries with the less restrictive labor market institutions. Taking this argument literally, one may conclude that France is harmed by German exports because it has the more competitive labor market and is equally exposed to European-wide measures of product market deregulation. But does France really have the more competitive labor market?

According to OECD statistics, union density in Germany is more than twice as high as union density in France.[22] This indicates that product market deregulation in the European Union can indeed explain part of the negative experience of France (and several Southern EU members) due to the strong German export performance in recent years. However, this finding does not imply that product market deregulation in the European Union is a bad thing *per se*. Rather it is clear from our analysis, that stronger product market competition is always beneficial from a global point of view, as it lowers the scope of unions to set excessive wages. However, if it is the goal of policy makers to compensate losers from product market deregulation, according to our analysis it is necessary to supplement the respective reform by a redistribution scheme that implements income

unambiguously increases, according to Figure 2.

[22]While union density is significantly higher in Germany than in France, this is not true for collective bargaining coverage (see OECD, 2004). It may therefore be better to rely on more general measures of labor market imperfection in order to get a better intuition about the relative labor market performance of the two countries. Venn (2009) provides such information. The figures presented in this study provide support for the view that labor market imperfection is more pronounced in Germany than in France.

transfers from countries with a more rigid labor market to countries with a more flexible one.

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7 Appendix

Derivation of Eq. (11)

Substituting $x_2(z) = \big(a - \lambda_2 p^u(z)\big)/b$ from (3) into (10), we obtain $T_2 = \alpha p^u\big(a - \lambda_2 p^u - bq_2^u\big)/b$. Noting further that $\lambda_2 = \big(a\mu_1 - bI_2\big)/\mu_2$ and that $\mu_1 = \alpha p^u + (1-\alpha)p^c$, $\mu_2 = \alpha(p^u)^2 + (1-\alpha)(p^c)^2$, $I_2 = \alpha p^u q_2^u + (1-\alpha)p^c q_2^c$, the latter can be reformulated as

$$T_2 = \frac{\alpha(1-\alpha)p^c p^u}{b} \frac{a(p^c - p^u) + b(p^u q_2^c - p^c q_2^u)}{\alpha(p^u)^2 + (1-\alpha)(p^c)^2}. \tag{16}$$

Then, considering

$$p^c - p^u = -\frac{bL}{2(2-\alpha)}, \qquad p^u q_2^c - p^c q_2^u = \frac{L}{2-\alpha}\left(2a - \frac{3bL}{2}\right), \tag{17}$$

according to (6), (8) and (9), we arrive at

$$T_2 = 3L(a - bL)\frac{\alpha(1-\alpha)p^c p^u}{2(2-\alpha)\left[\alpha(p^u)^2 + (1-\alpha)(p^c)^2\right]}. \tag{18}$$

Finally, substituting T_i into $T^w = 2T_i$ gives (11). *QED.*

Proof of a hump-shaped relationship between s^w and α

Differentiating the right-hand side of (14) with respect to α we find, after tedious but straightforward calculations, $ds^w/d\alpha \equiv \phi(\alpha)\Gamma(\alpha)$, where $\phi(\alpha)$ is a function of α with a positive function value that is of no further interest and $\Gamma(\alpha) \equiv \Gamma_1(\alpha) - \Gamma_2(\alpha)$, with

$$\Gamma_1(\alpha) \equiv (1-\alpha)^2\left[\alpha K + 2(2-\alpha)p^c p^u\right]\left[8(a - bL)(p^c)^2(2-\alpha)^2 + \frac{bL}{2}\alpha^2(p^u)^2\right] \tag{19}$$

$$\Gamma_2(\alpha) \equiv \alpha^2\left[(1-\alpha)K + (2-\alpha)p^c p^u\right]\left[8(a - bL)(p^u)^2(2-\alpha)^2 + \frac{bL}{2}(1-\alpha)^2(p^c)^2\right] \tag{20}$$

and

$$K \equiv 2p^u - p^c = \frac{bL}{2}\left(2a - \frac{3bL}{2}\right). \tag{21}$$

It is then obvious that $ds^w/d\alpha >, =, < 0$ is equivalent to $\Gamma(\alpha) >, =, < 0$. Due to $\Gamma(0) > 0$, $\Gamma(1) < 0$, and the fact that Γ is continuous and differentiable in α, it is immediate that

s^w has an extremum in α-interval $(0, 1)$. Thereby, an extremum is reached if there exists an $\hat{\alpha}$, such that $\Gamma(\hat{\alpha}) = 0$.

In a next step, we show that $\alpha \geq 2/3$ is not consistent with an extremum. For this purpose, we can note that $(1-\alpha)\left[\alpha K + 2(2-\alpha)p^c p^u\right] \leq \alpha\left[(1-\alpha)K + (2-\alpha)p^c p^u\right]$ if $2(1-\alpha) \leq \alpha$, or, equivalently, if $\alpha \geq 2/3$. Furthermore, we find that (with $a > 9bL/4$)

$$(1-\alpha)\left[8(a-bL)(p^c)^2(2-\alpha)^2 + \frac{bL}{2}\alpha^2(p^u)^2\right] < \alpha\left[8(a-bL)(p^u)^2(2-\alpha)^2 + \frac{bL}{2}(1-\alpha)^2(p^c)^2\right] \quad (22)$$

is equivalent to $(1-\alpha)(p^c)^2 < \alpha(p^u)^2$, which, in view of $p^c < p^u$, definitely holds for any $\alpha > 1/2$. Putting together, we can therefore safely conclude that $\Gamma(\alpha) < 0$ holds for any $\alpha \geq 2/3$, implying that $\alpha \geq 2/3$ is inconsistent with an extremum.

We now show that there exists a unique $\hat{\alpha} \in (0, 2/3)$ which fulfills condition $\Gamma(\hat{\alpha}) = 0$ and that s^w reaches a maximum at this α-level. For this purpose, we show that[23]

$$\frac{d\Gamma(\hat{\alpha})}{d\alpha} = \frac{\partial\Gamma}{\partial p^c}\frac{dp^c}{d\alpha} + \frac{\partial\Gamma}{\partial p^u}\frac{dp^u}{d\alpha} + \frac{\partial\Gamma}{\partial\alpha} < 0 \quad (23)$$

holds. Let us first partially differentiate Γ with respect to α and evaluate the resulting expression at $\alpha = \hat{\alpha}$. This gives $\partial\Gamma/\partial\alpha = -\Gamma_1\big(\Phi_1 - \Phi_2 + \Phi_3 + \Phi_4\big)$, with

$$\Phi_1 \equiv \frac{\alpha K + 2(4-\alpha)p^c p^u}{\alpha\left[\alpha K + 2(2-\alpha)p^c p^u\right]}, \qquad \Phi_2 \equiv \frac{2\left[8(a-bL)(p^u)^2(2-\alpha) + (1-\alpha)(p^c)^2 bL/2\right]}{8(a-bL)(p^u)^2(2-\alpha)^2 + (1-\alpha)^2(p^c)^2 bL/2},$$

$$\Phi_3 \equiv \frac{(1-\alpha)K + (3-\alpha)p^c p^u}{(1-\alpha)\left[(1-\alpha)K + (2-\alpha)p^c p^u\right]}, \quad \Phi_4 \equiv \frac{2\left[8(a-bL)(p^c)^2(2-\alpha) - \alpha(p^u)^2 bL/2\right]}{8(a-bL)(p^c)^2(2-\alpha)^2 + \alpha^2(p^u)^2 bL/2}.$$

It is straightforward that $\Phi_1 + \Phi_3 > 2$. Furthermore, noting that $a > 9bL/4$ ensures both $a - bL > bL/2$ and $2p^c - p^u > 0$, we can further conclude that $0 < \Phi_2 < 2$ and $\Phi_4 > 0$. Putting together, this proves $\partial\Gamma/\partial\alpha < 0$.

We now turn to the indirect effect of an α-adjustment on Γ through changes in the price levels p^u, p^c. Taking into account that $dp^c/d\alpha = 2dp^u/d\alpha$ and evaluating the derivative at

[23] Strictly speaking, the second-order condition for a maximum of s^w at $\alpha = \hat{\alpha}$ is given by $d^2 s^w/d\alpha^2\big|_{\alpha=\hat{\alpha}} = \phi'(\hat{\alpha})\Gamma(\hat{\alpha}) + \phi(\hat{\alpha})\Gamma'(\hat{\alpha}) < 0$. However noting that $\Gamma(\hat{\alpha}) = 0$, while $\phi(\hat{\alpha}) > 0$, we can safely conclude that $d^2 s^w/d\alpha^2\big|_{\alpha=\hat{\alpha}} >, =, < 0$ is equivalent to $\Gamma'(\hat{\alpha}) >, =, < 0$, so that a maximum is reached if $\Gamma'(\hat{\alpha}) < 0$.

$\alpha = \hat{\alpha}$, we obtain

$$\frac{\partial \Gamma}{\partial p^c}\,\frac{dp^c}{d\alpha} + \frac{\partial \Gamma}{\partial p^u}\,\frac{dp^u}{d\alpha} = \Gamma_1 \Psi \frac{dp^u}{d\alpha}, \tag{24}$$

with

$$\Psi \equiv \frac{(2-3\alpha)K(2-\alpha)\,(2p^u + p^c)}{[\alpha K + 2(2-\alpha)p^c p^u]\,[(1-\alpha)K + (2-\alpha)p^c p^u]} + \frac{2p^u p^c(2p^u - p^c)\,\left[\rho^2 - \alpha^2(1-\alpha)^2(bL/2)^2\right]}{[\rho(p^c)^2 + \alpha^2(p^u)^2(bL/2)]\,[\rho(p^u)^2 + (1-\alpha)^2(p^c)^2(bL/2)]} \tag{25}$$

and $\rho \equiv 8(a-bL)(2-\alpha)^2$. Noting that $\Psi > 0$ holds for any $\alpha \leq 2/3$, recollecting from above that $\alpha \geq 2/3$ is inconsistent with an extremum, and taking into account that $dp^u/d\alpha < 0$, it follows that

$$\frac{\partial \Gamma}{\partial p^c}\,\frac{dp^c}{d\alpha} + \frac{\partial \Gamma}{\partial p^u}\,\frac{dp^u}{d\alpha} < 0 \tag{26}$$

holds in the relevant α-interval. Together with our insights regarding the sign of $\partial\Gamma/\partial\alpha$, this proves that $d\Gamma(\hat{\alpha})/d\alpha < 0$, implying that s^w has a maximum at $\alpha = \hat{\alpha}$. However, since $d\Gamma(\hat{\alpha})/d\alpha < 0$ holds for any possible $\hat{\alpha}$, we can furthermore safely conclude that s^w does not have an interior minimum on the relevant parameter domain, so that $\Gamma(\hat{\alpha}) = 0$ must characterize a unique maximum, when taking into account that s^w is twice continuously differentiable in α. This also confirms that the relationship between s^w and α is hump-shaped. *QED.*

Proof of a hump-shaped relationship between v_1 and α

Substituting $\mu_1 = 2(a-bL)$,

$$\mu_2 = 4(a-bL)^2 + \frac{b^2L^2\kappa}{4} \tag{27}$$

and

$$I_1 = \left[2(a-bL) + \frac{bL\kappa}{4}\right] L, \tag{28}$$

with $\kappa \equiv \alpha(1-\alpha)/(2-\alpha)^2$, into $\lambda_1 = \big(a\mu_1 - bI_1\big)/\mu_2$ and considering the resulting expression in $v_1 = -\lambda_1^2\mu_2$, we obtain

$$v_1 = -\frac{1}{4}\frac{\left[8(a-bL)^2 - b^2L^2\kappa\right]^2}{[16(a-bL)^2 + b^2L^2\kappa]} \tag{29}$$

Differentiating the latter with respect to α, then gives

$$\frac{dv_1}{d\alpha} = \frac{b^2L^2(2-3\alpha)\left[40(a-bL)^2+b^2L^2\kappa\right]\left[8(a-bL)^2-b^2L^2\kappa\right]}{4\left[16(a-bL)^2+b^2L^2\kappa\right]^2(2-\alpha)^3}.$$

Accounting for $a > 9bL/4$, it is thus immediate that $\text{sign}(dv_1/d\alpha) = \text{sign}(2-3\alpha)$, implying that v_1 is hump-shaped in α with a unique maximum at $\alpha = 2/3$. *QED.*

Proof of a u-shaped relationship between v_2 and α

Substituting $\mu_1 = 2(a - bL)$ and μ_2 from Eq. (27) into $\lambda_2 = \big(a\mu_1 - bI_2\big)/\mu_2$, considering $\kappa = \alpha(1-\alpha)/(2-\alpha)^2$, and accounting for

$$I_2 = \left[2(a-bL) - \frac{bL\kappa}{2}\right]L, \tag{30}$$

we can calculate

$$v_2 = -\lambda_2^2\mu_2 = -\frac{\left[4(a-bL)^2+b^2L^2\kappa\right]^2}{\left[16(a-bL)^2+b^2L^2\kappa\right]}. \tag{31}$$

Differentiating the latter with respect to α, gives

$$\frac{dv_2}{d\alpha} = \frac{b^2L^2(3\alpha-2)\left[28(a-bL)^2+b^2L^2\kappa\right]\left[4(a-bL)^2+b^2L^2\kappa\right]}{\left[16(a-bL)^2+b^2L^2\kappa\right]^2(2-\alpha)^3}.$$

It is thus immediate that $\text{sign}(dv_1/d\alpha) = \text{sign}(3\alpha - 2)$, implying that v_2 is u-shaped in α with a unique minimum at $\alpha = 2/3$. *QED.*

Proof of a u-shaped relationship between $\tilde{v}$ and α

Noting that with $\lambda = 1$, we have $\tilde{v} = -\mu_2/2$. Substituting (27) and differentiating with respect to α, we obtain $d\tilde{v}/d\alpha = -(1/2)d\mu_2/d\alpha$, where

$$\frac{d\mu_2}{d\alpha} = \frac{b^2L^2}{2}\frac{2-3\alpha}{(2-\alpha)^2}. \tag{32}$$

Thus, it follows that $\text{sign}(d\tilde{v}/d\alpha) = \text{sign}(3\alpha - 2)$, implying that the relationship between $\tilde{v}$ and α is u-shaped and reaches a unique minimum at $\alpha = 2/3$. *QED.*

Proof of positive welfare effects when the two countries open up for trade

Regarding welfare levels under autarky, we can first note that the respective result for country 1 can be inferred from (29), when setting $\alpha = 0$. In this limiting case, both countries are symmetric, and hence trade does not affect welfare. This is well known from Neary (2009), implying that $v_1^{aut} = -(a - bL)^2$, where superscript *aut* refers to autarky. Noting from above that in the open economy v_1 is hump-shaped in α, with $v_1|_{\alpha=0} = v_1|_{\alpha=1} = v_1^{aut}$, it is immediate that country 1 must benefit from opening up for trade with country 2 if $\alpha \in (0, 1)$.

To determine the autarky welfare of country 2, we can first note that in the absence of trade firms are monopolists, choosing $q_2^{aut}(z) = \left[a - \lambda_2^{aut} w_2^{aut}(z)\right]/(2b)$. Unions then optimally choose $\lambda_2^{aut} w_2^{aut}(z) = [a + \lambda_2^{aut} w_2^{c,aut}]/2$. Thus the full employment condition reduces to $\lambda_2^{aut} w_2^{c,aut} = a - 4bL/(2-\alpha)$. It is then easily confirmed that the first and the second (uncentered) moment of the price distribution in country 2 are given by $\mu_1^{2,aut} = (a - bL)/\lambda_2^{aut}$ and $\mu_2^{2,aut} = \left[(a - bL)^2 + b^2L^2\kappa\right] / \left(\lambda_2^{aut}\right)^2$, respectively, if there is no trade with country 1. Thereby, $\kappa = \alpha(1-\alpha)/(2-\alpha)^2$ has been used from above. Accordingly, we can calculate $v_2^{aut} = -(a - bL)^2 - b^2L^2\kappa$. Comparing v_1^{aut} and v_2^{aut}, we obtain the intuitive result that the unionized country has the lower welfare under autarky (except in the special cases of $\alpha = 0$ and $\alpha = 1$, where welfare levels are equal). Finally, subtracting v_2^{aut} from (31), we obtain

$$v_2 - v_2^{aut} = \frac{9(a - bL)^2 b^2 L^2 \kappa}{16(a - bL)^2 + b^2 L^2 \kappa} > 0, \tag{33}$$

which proves that country 2 benefits from free trade with country 1. This completes the proof. *QED.*

Supplement

(Not intended for publication)

Derivation of T^w and s^w if $N > 1$

Substituting $x_2(z) = \big(a - \lambda_2 p^u(z)\big)/b$ from (3) into $T_2 = \int_0^\alpha |Nq_2(z) - x_2(z)|\, p(z)dz$, we obtain $T_2 = \alpha p^u\big(a - \lambda_2 p^u - bNq_2^u\big)/b$. Noting further that $\lambda_2 = \big(a\mu_1 - bI_2\big)/\mu_2$ and that $\mu_1 = \alpha p^u + (1-\alpha)p^c$, $\mu_2 = \alpha(p^u)^2 + (1-\alpha)(p^c)^2$, $I_2 = N\left[\alpha p^u q_2^u + (1-\alpha)p^c q_2^c\right]$, the latter can be reformulated as

$$T_2 = \frac{\alpha(1-\alpha)p^c p^u}{b}\frac{a(p^c - p^u) + bN(p^u q_2^c - p^c q_2^u)}{\alpha(p^u)^2 + (1-\alpha)(p^c)^2}. \tag{S.1}$$

Accounting for

$$p^c = 2a - bL\frac{(2N+1)(2-\alpha)+2}{(N+1)(2-\alpha)}, \qquad p^u = 2a - bL\frac{(2N+1)(2-\alpha)+1}{(N+1)(2-\alpha)}, \tag{S.2}$$

we can calculate

$$p^c - p^u = -\frac{bL}{(N+1)(2-\alpha)}, \qquad N\left[p^u q_2^c - p^c q_2^u\right] = \frac{L}{2-\alpha}\left(2a - bL\frac{2N+1}{N+1}\right), \tag{S.3}$$

when considering $Nq_2^c = 2L/(2-\alpha)$ and $Nq_2^u = L/(2-\alpha)$. Then, substituting (S.3) into (S.1), we can calculate

$$T_2 = L(a - bL)\frac{(2N+1)(2-\alpha)\kappa p^c p^u}{(N+1)\left[\alpha(p^u)^2 + (1-\alpha)(p^c)^2\right]}, \tag{S.4}$$

with $\kappa \equiv \alpha(1-\alpha)/(2-\alpha)^2$. Finally, substituting T_i into $T^w = 2T_i$ gives

$$T^w = \frac{2L(a-bL)(2N+1)(2-\alpha)\kappa p^c p^u}{(N+1)\left[\alpha(p^u)^2 + (1-\alpha)(p^c)^2\right]}, \tag{S.5}$$

which coincides with (11) if $N = 1$.

To determine the trade share, s^w, we have to divide world-wide exports T^w by world-wide GDP, $I^w = I_1 + I_2$. Noting that $I_i = N\left[phap^u q_i^u + (1-\alpha)p^c q_i^c\right]$ and accounting for (S.2) and

$$q_1^c = L\frac{(2N+1)(2-\alpha) - 2N}{N(N+1)(2-\alpha)} \qquad q_1^u = L\frac{(2N+1)(2-\alpha) - N}{N(N+1)(2-\alpha)} \tag{S.6}$$

$$q_2^c = L\frac{2}{N(2-\alpha)} \qquad q_2^u = L\frac{1}{N(2-\alpha)}, \tag{S.7}$$

we can calculate

$$I_1 = 2L(a - bL) + bL^2 \frac{N\kappa}{(N+1)^2}, \tag{S.8}$$

$$I_2 = 2L(a - bL) - bL^2 \frac{\kappa}{N+1}. \tag{S.9}$$

It is then immediate that

$$I^w = 4L(a - bL) - bL^2 \frac{\kappa}{(N+1)^2}. \tag{S.10}$$

Hence, dividing T^w by I^w yields

$$s^w = \frac{2(a - bL)(2N+1)(2-\alpha)\kappa p^c p^u}{(N+1)\left[\alpha(p^u)^2 + (1-\alpha)(p^c)^2\right]} \left\{4(a - bL) - bL\frac{\kappa}{(N+1)^2}\right\}^{-1}. \tag{S.11}$$

Comparative-static effects of changes in N on T^w and s^w

In a first step, we study the impact of an increase in N on T^w. For this purpose, it is useful to define

$$A(N) \equiv \frac{p^c p^u}{\left[\alpha(p^u)^2 + (1-\alpha)(p^c)^2\right]}. \tag{S.12}$$

Differentiating the latter with respect to N gives

$$A'(N) = \frac{1}{\mu_2^2}\left\{\left[\alpha(p^u)^2 - (1-\alpha)(p^c)^2\right]\left(p^u\frac{dp^c}{dN} - p^c\frac{dp^u}{dN}\right)\right\} \tag{S.13}$$

Noting that

$$\frac{dp^c}{dN} = bL\frac{\alpha}{(N+1)^2(2-\alpha)}, \qquad \frac{dp^u}{dN} = -bL\frac{1-\alpha}{(N+1)^2(2-\alpha)} \tag{S.14}$$

and thus

$$p^u\frac{dp^c}{dN} - p^c\frac{dp^u}{dN} = \frac{2bL(a - bL)}{(N+1)^2(2-\alpha)}, \tag{S.15}$$

we further obtain

$$A'(N) = \frac{\mu_1}{\mu_2^2}\frac{bL}{(N+1)^2(2-\alpha)}\left[\alpha(p^u)^2 - (1-\alpha)(p^c)^2\right]. \tag{S.16}$$

Using the latter in

$$\frac{dT^w}{dN} = 2(2-\alpha)\kappa L(a - bL)\left[A'(N)\frac{2N+1}{N+1} + A(N)\frac{1}{(N+1)^2}\right], \tag{S.17}$$

where $\kappa = \alpha(1-\alpha)/(2-\alpha)^2$ has been used from above, we can calculate

$$\frac{dT^w}{dN} = \frac{2(2-\alpha)\kappa L(a-bL)}{\mu_2(N+1)^2} \underbrace{\left[\frac{\mu_1}{\mu_2}\frac{bL}{(2-\alpha)}\left[\alpha(p^u)^2 - (1-\alpha)(p^c)^2\right]\frac{2N+1}{N+1} + p^c p^u\right]}_{\equiv\psi}, \quad \text{(S.18)}$$

Noting that $\alpha\,(p^u)^2 - (1-\alpha)\,(p^c)^2 > -\,(p^c)^2$, it is straightforward to show that

$$\psi > p^u p^c - \frac{\mu_1}{\mu_2}\frac{bL}{2-\alpha}\frac{2N+1}{N+1}\,(p^c)^2\,.$$

Defining

$$g(N) \equiv p^u - \frac{\mu_1}{\mu_2}\frac{bL}{(2-\alpha)}\frac{2N+1}{N+1}p^c \quad \text{(S.19)}$$

we can thus safely conclude that $p^c g(N) > 0$ – and thus $g(N) > 0$ – is sufficient for $dT^w/dN > 0$.

Differentiation of $g(N)$ yields

$$g'(N) = \frac{dp^u}{dN} - \frac{\mu_1}{\mu_2}\frac{bL}{2-\alpha}\left[\frac{p^c}{(N+1)^2} + \frac{2N+1}{N+1}\frac{dp^c}{dN} - \frac{2N+1}{N+1}\frac{d\mu_2}{dN}\frac{p^c}{\mu_2}\right]$$

Substituting $dp^u/dN < 0$, $dp^c/dN > 0$ from above, and noting that

$$\frac{d\mu_2}{dN} = 2\alpha p^u\frac{dp^u}{dN} + 2(1-\alpha)p^c\frac{dp^c}{dN} = -\frac{2\kappa}{N+1}\left(\frac{bL}{N+1}\right)^2 < 0, \quad \text{(S.20)}$$

it is immediate that $g'(N) < 0$. Noting that $\lim_{N\to\infty} p^u = \lim_{N\to\infty} p^c = \mu_1$ and $\lim_{N\to\infty}\mu_2 = \mu_1^2$ we can further calculate

$$\lim_{N\to\infty} g(N) = 2\left(a - bL\frac{3-\alpha}{2-\alpha}\right),$$

which is positive if $a > 9bL/4$. This proves that $g(N) > 0$ and thus $dT^w/dN > 0$ hold in the relevant parameter domain.

In a second step, we can now evaluate ds^w/dN. According to the definition of s^w, we get

$$\frac{ds^w}{dN} = \frac{1}{(I^w)^2}\left[\frac{dT^w}{dN}I^w - T^w\frac{dI^w}{dN}\right] \quad \text{(S.21)}$$

Substituting from above, gives

$$\frac{ds^w}{dN} = \frac{2(2-\alpha)\kappa L(a-bL)}{(I^w)^2\mu_2(N+1)^2}\left[\psi I^w - \frac{2(2N+1)\alpha(1-\alpha)p^c p^u bL^2}{(N+1)^2(2-\alpha)^2}\right]. \quad \text{(S.22)}$$

From above, we know that $\psi > p^c g(N)$. Furthermore, we also know that $p^u > p^c$ implies

$$p^c g(N) > \left(1 - \frac{bL}{2-\alpha}\frac{\mu_1}{\mu_2}\frac{2N+1}{N+1}\right) p^c p^u.$$

Defining[24]

$$\gamma(N) \equiv \frac{\mu_1}{\mu_2}\frac{2N+1}{N+1}, \quad \text{with} \quad \gamma'(N) = -\frac{\mu_1}{\mu_2^2}\frac{d\mu_2}{dN}\frac{2N+1}{N+1} + \frac{\mu_1}{\mu_2}\frac{1}{(N+1)^2} > 0 \tag{S.23}$$

and $\lim_{N\to\infty}\gamma(N) = (a-bL)^{-1}$, it is immediate that

$$\psi > p^c g(N) > \left[1 - \frac{bL}{(a-bL)(2-\alpha)}\right] p^c p^u. \tag{S.24}$$

must hold.

Considering the latter inequality in ds^w/dN and substituting I^w , we can conclude that

$$G(a) \equiv \left(1 - \frac{bL}{(a-bL)(2-\alpha)}\right)\left(4L(a-bL) - bL^2\frac{\kappa}{(N+1)^2}\right) - \frac{2(2N+1)\kappa bL^2}{(N+1)^2} > 0 \tag{S.25}$$

is sufficient for $ds^W/dN > 0$. Accounting for $G'(a) > 0$ and noting that

$$G(9bL/4) = bL^2\left[\left(1 - \frac{4}{5(2-\alpha)}\right)\left(5 - \frac{\kappa}{(N+1)^2}\right) - \frac{2(2N+1)\kappa}{(N+1)^2}\right], \tag{S.26}$$

we can furthermore conclude that

$$\sigma(N) \equiv \left(5 - \frac{4}{2-\alpha}\right)\left[5(N+1)^2 - \kappa\right] - 10(2N+1)\kappa > 0 \tag{S.27}$$

is sufficient for $ds^W/dN > 0$ in the relevant parameter domain. Differentiating $\sigma(N)$ yields $\sigma'(N) = [5 - 4/(2-\alpha)]\,10(N+1) - 20\kappa$, which, in view of $5 - 4/(2-\alpha) \geq 1$ and $\kappa \leq 1/4$, is strictly positive for any N. Accounting for

$$\sigma(1) = \left(5 - \frac{4}{2-\alpha}\right)(20-\kappa) - 30\kappa \geq 20 - 31\kappa > 0, \tag{S.28}$$

finally proves that $\sigma(N) > 0$ and thus $ds^w/dN > 0$ must hold if $a > 9bL/4$. *QED*

[24]Note that $\gamma'(N) > 0$ can be inferred from our previous insight that $d\mu_2/dN < 0$ (see (S.20)).

The impact of an increase in N on v_1, v_2 and $\tilde{v}$

Noting from the discussion in the main text that $\tilde{v} = -\mu_2/2$, it follows from (S.20) that $d\tilde{v}/dN > 0$. Furthermore, we can note that $v_1 = -\lambda_1^2\mu_2$. Substituting $\lambda_1 = (a\mu_1 - bI_1)/\mu_2$ and noting that $\mu_1 = 2(a - bL)$ is a constant, we obtain

$$v_1 = -\frac{[2a(a-bL) - bI_1]^2}{\mu_2}. \tag{S.29}$$

Accounting for[25] $dI_1/dN < 0$, according to (S.8), and $d\mu_2/dN < 0$, according to (S.20), it is straightforward to show that $dv_1/dN < 0$. In a final step, we now analyze the impact of an increase in N on

$$v_2 = -\frac{[2a(a-bL) - bI_2]^2}{\mu_2}. \tag{S.30}$$

Substituting (S.9), the latter can be rewritten in the following way:

$$v_2 = -\frac{\left[2(a-bL)^2 + b^2L^2\kappa/(N+1)\right]^2}{\mu_2}, \tag{S.31}$$

where $\kappa = \alpha(1-\alpha)/(2-\alpha)^2$. Accounting for $d\mu_2/dN < 0$, it is thus immediate that an increase in N exerts two counteracting effects on v_2. Differentiating v_2 gives

$$\frac{dv_2}{dN} = -\frac{2\lambda_2\kappa b^2L^2}{\mu_2(N+1)^2}Z(N), \tag{S.32}$$

with

$$Z(N) = -\mu_2 + \frac{2(a-bL)^2}{N+1} + \frac{b^2L^2\kappa}{(N+1)^2} = -2\frac{(2N+1)(a-bL)^2}{N+1} < 0. \tag{S.33}$$

This implies $dv_2/dN > 0$. *QED*

Non-satiation and participation of representative consumers if $N \geq 1$

All our results have been derived under the assumption that both the non-satiation and participation conditions are fulfilled for both representative consumers. We now check, whether this assumption is consistent with the chosen parameter configurations. For

[25] Differentiating I_1 with respect to N gives $-bL^2\kappa(N-1)/(N+1)^3$, which is strictly negative for any $N > 1$.

this purpose, we first study the condition for non-satiation, which, for the representative consumer in country $i = 1, 2$, is given by $\lambda_i > 0$. From inspection of (S.8) and (S.9), we can conclude that $I_1 \geq I_2$ for all possible α (and $I_1 > I_2$ if $\alpha \in (0,1)$). Since all consumers face the same price levels, we can thus conclude that non-satiation is guaranteed for the representative consumer in country 2 if it is fulfilled for the representative consumer in country 1. Furthermore, we can conclude that condition $\lambda_1 > 0$ is equivalent to condition $a\mu_1 - bI_1 > 0$. Substituting for I_1 and accounting for $\mu_1 = 2(a - bL)$, we can conclude that $\lambda_1 > 0$ is guaranteed if

$$2(a - bL)^2 - b^2L^2 \frac{N\kappa}{(N+1)^2} > 0, \tag{S.34}$$

which is always fulfilled if $a > 9bL/4$.

Let us now consider the condition for participation, which can only be binding for the products with the highest prices, i.e. for the products from the unionized industries. Noting from above that the representative consumer in country 2 has the lower income, it follows from (3) that $a - \lambda_2 p^u > 0$ is sufficient for participation of both representative agents in the consumption of both goods. Substituting for λ_2, recollecting the definitions of μ_1 and μ_2 and accounting for (S.2), we can calculate

$$x_2^u = \frac{1}{b\mu_2}\left[-\frac{a(1-\alpha)bL}{(N+1)(2-\alpha)}p^c + bI_2p^u\right] > \frac{p^c}{b\mu_2}\omega(a), \tag{S.35}$$

with

$$\begin{aligned}\omega(a) &= bI_2 - \frac{a(1-\alpha)bL}{(N+1)(2-\alpha)} \\ &= 2bL(a-bL) - b^2L^2\frac{\kappa}{N+1} - \frac{a(1-\alpha)bL}{(N+1)(2-\alpha)}.\end{aligned} \tag{S.36}$$

Thus, $\omega(a) > 0$ is sufficient for $x_2^u > 0$. Noting that $\omega'(a) > 0$ and that

$$\omega(9bL/4) = b^2L^2\left[\frac{5}{2} - \frac{\kappa}{(N+1)} - \frac{9(2-\alpha)\kappa}{4(N+1)}\right] \tag{S.37}$$

must be strictly positive, as $\kappa \leq 1/4$ and $(2-\alpha)\kappa < 1/2$, we can safely conclude that $x_2^u > 0$ holds in the the relevant parameter domain. Thus either representative agent participates in the consumption of the two commodities. *QED.*

Non-satiation and participation of individual workers if $N \geq 1$

Noting that due to our linear demand structure, total profits in country i can be written as $\Pi_i = bN\int_0^1 \left(q_i(z)\right)^2 dz$. Substituting (S.6) and (S.7), gives

$$\Pi_1 = \frac{bL^2}{N(N+1)^2}\frac{(2N+1)(2-\alpha)^2 + N^2(4-3\alpha)}{(2-\alpha)^2}, \qquad \Pi_2 = \frac{bL^2}{N}\frac{4-3\alpha}{(2-\alpha)^2}. \tag{S.38}$$

With profits being uniformly distributed among domestic production workers, per capita income is given by

$$\rho_1^c = 2(a-bL) + bL\frac{N\alpha(1-\alpha)}{(N+1)^2(2-\alpha)^2}, \tag{S.39}$$

$$\rho_2^c = 2(a-bL) - bL\frac{N\alpha(1-\alpha)+\alpha(2N+1)}{N(N+1)(2-\alpha)^2}, \tag{S.40}$$

and

$$\rho_2^u = 2(a-bL) + bL\frac{2(1-\alpha)+N(4-\alpha)(1-\alpha)}{N(N+1)(2-\alpha)^2}, \tag{S.41}$$

according to (8′), (9′) and (S.38). It is easily confirmed that $\rho_2^c < \rho_1^c < \rho_2^u$ if $\alpha \in (0,1)$, so that the ranking of workers' income is preserved when accounting for a lump-sum distribution of profit income within each economy. Hence, we can conclude that if non-satiation is fulfilled for unionized workers in country 2, it is fulfilled for all income groups. For unionized workers in country 2, the marginal utility of income is given by[26]

$$\lambda_{\rho_2^u} = \frac{(a/L)\mu_1 - b\rho_2^u}{\mu_2}, \tag{S.42}$$

and these workers are non-satiated if $\lambda_{\rho_2^u} > 0$ or, equivalently, if $a\mu_1 > bL\rho_2^u$. Substituting for ρ_2^u and μ_1, we can rewrite the condition for non-satiation in the following way:

$$\zeta(a) = 2(a-bL)^2 - b^2L^2\frac{2(1-\alpha)+N(4-\alpha)(1-\alpha)}{N(N+1)(2-\alpha)^2} > 0. \tag{S.43}$$

Noting that $\zeta'(a) = 4\,(a-bL) > 0$ if $a > bL$ and accounting for $\zeta(9bL/4) > 0$, it is immediate that $a > 9bL/4$ is sufficient for non-satiation of all income groups.

[26] When writing (S.42), we have assumed that all agents have identical preferences that are described by a utility function similar to the one in (1), with a/L assuming the role of a.

We now turn to the issue of participation. Noting from above that non-unionized workers in country 2 have the lowest income, we can safely conclude that all workers consume all goods, if the non-unionized workers in country 2 consume the most expensive ones, i.e. commodity 2. Hence, in order to show that participation is no problem in our setting, we can look at the individual demand function $x^u_{\rho_2^c} = \left(a/L - \lambda_{\rho_2^c} p^u\right)/b$, where $\lambda_{\rho_2^c}$ is defined in analogy to $\lambda_{\rho_2^u}$ with ρ_2^c assuming the role of ρ_2^u. Participation is no problem if $x^u_{\rho_2^c} > 0$, i.e. if $a/L - \lambda_{\rho_2^c} p^u > 0$. The respective condition can be reformulated to

$$\xi(a) \equiv \rho_2^c p^u - \frac{a}{bL}(1-\alpha)\left(p^u - p^c\right)p^c > 0. \tag{S.44}$$

Substituting for $p^u - p^c$ and ρ_2^c, according to (S.2) and (S.40), further gives

$$\xi(a) = \left[2(a-bL) - bL\frac{N\alpha(1-\alpha)+\alpha(2N+1)}{N(N+1)(2-\alpha)^2}\right]p^u - \frac{a}{N+1}\frac{1-\alpha}{2-\alpha}p^c > 0. \tag{S.45}$$

In view of $p^u \geq p^c$, we can also conclude that

$$\tilde{\xi}(a) = 2(a-bL) - bL\frac{N\alpha(1-\alpha)+\alpha(2N+1)}{N(N+1)(2-\alpha)^2} - \frac{a}{N+1}\frac{1-\alpha}{2-\alpha} > 0 \tag{S.46}$$

is sufficient for $x^u_{\rho_2^c} > 0$. It is easily confirmed that $\tilde{\xi}'(a) > 0$, while $\tilde{\xi}(9bL/4) > 0$, implying that $a > 9bL/4$ is also sufficient for participation of all consumers in our setting. *QED*