Globalization, Union Influence and Self-Interested Labor Market Regulators

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Abstract

I examine how globalization affects sector-specific employment levels, wages and welfare in a general equilibrium model with partly oligopolistic and unionized markets. Employer federations and labor unions bargain over wages and influence self-interested regulators that determine union bargaining power. Labor market regulation can be at the national or international level. Globalization is modeled as reducing trade costs or opening up shielded sectors to trade. The former of these and international labor market regulation promote aggregate welfare. International labor market regulation and opening up shielded sectors to trade decrease open-sector and increase shielded-sector and competitive-sector wages.

Journal of Economic Literature: $C72$, $J53$, $O33$

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1. Introduction

The traditional way of considering globalization analyzes the impact of trade cost reductions or opening up to trade on bargained wages through the elasticity of labor demand. Huizinga (1993) and Driffill and Vander Ploeg (1995) claim that the integration of markets increase the elasticity of labor demand, decreasing bargained wages. Naylor (1998,1999) indicates the opposite. Bastos and Kreickemeier (2009) as well as Kreickemeier and Meland (2013) combine Neary's (2009) general oligopolistic equilibrium model with unionized labor markets, repeating Naylor's conclusion. All these papers, however, assume that relative union bargaining power is constant (e.g. monopoly unions). In this article, in contrast, I assume that labor and employer lobbies influence policy makers that regulate relative union bargaining power and thereby the level of wages in the economy.

Unionization has declined in most OECD countries since the 1980s (Nickell et al. 2005, pp. 6-7). In particular, in the years 1975-2000, labor markets have been rapidly deregulated in the US and UK (Acemoglu et al. 2001). Globalization has undermined union bargaining power (cf. Abraham et al. 2009, Dumont at al. 2006, 2012, Boulhol et al. 2011). Protection of regular employment contracts was diminished when globalization was proceeding rapidly (Potrafke 2010). Acemoglu et al. (2001) explain declining unionization by skill-biased technological change which increases the outside option of skilled workers, undermining the coalition among skilled and unskilled workers in support of unions, but I provide an alternative explanation by globalization and the political economy of labor market regulation.

The political economy can be modeled either by *majority voting* (cf. Saint-Paul 2002a, 2002b), *all-pay auctioning*, in which the lobbyist making the greater effort wins with certainty (cf. Johal and Ulph 2002), or *menu actioning*, in which the lobbyists announce their bids contingent on the policy maker's actions (cf. Dixit et al 1997). With all-pay auctioning, lobbying expenditures are incurred by all the lobbyists before the policy maker takes an action. This is the case e.g. when interest groups spend money to increase the probability of getting their favorite type of government elected. With menu auctioning, it is not possible for a lobbyist to spend money and effort on lobbying without getting what he lobbied for. Because menu auctioning fits best for the case where employers and labor unions obtain marginal improvements for their position by lobbying, I take it as a starting point.

Palokangas (2003) uses the political economy model with menu auctioning to show that distorting taxation can cause labor market regulation: if employers and workers bargain over wages and lobby the government over taxation and labor market regulation, and if it is much easier to tax wages than profits, then the government has incentives to protect union power. Palokangas (2014) introduces several regulators into a growth model where oligopolists perform R&D, showing that a greater number of regulators tend to decrease union power. In this article, I combine the political economy model of labor market regulation with Neary's (2009) general oligopolistic equilibrium model of open economies. This challenges results based on the assumption that relative union bargaining power is exogenous.

I organize the remainder of this article as follows. The structure of the economy is presented in section 2. The specific models of the households, firms and labor markets are constructed in 3, 4 and 5. A common agency game where employers and labor unions lobby regulators is presented in 6. The political equilibrium of that game is established in 7. Finally, the general equilibrium and welfare effects of globalization are considered in 8.

2. The economy

I examine two identical countries, home and foreign, with fixed amount L of labor and a "continuum" of oligopolistic sectors $i \in [0, 1]$ which produce one unit of output from one unit of labor. In line with Brander and Krugman (1983), there are segmented markets and a specific unit tariff $\tau > 0$ for traded goods. Because this tariff characterizes implicit trade barriers rather than the government's revenue-raising, I assume that tariff revenues from foreign firms accrue to home firm owners in the same sector i, for simplicity. I denote the variables associated with the foreign country by superscript $(^*)$.

The equilibrium conditions of the home and foreign labor markets are

$$L = \int_0^1 l(i)di, \quad L = L^* = \int_0^1 l^*(i)di. \tag{1}$$

A constant proportion γ of the sectors $i \in [0,1]$ is *competitive*. The remainder of the sectors contain a given number n of oligopolistic firms. A constant proportion α of the sectors $i \in [0,1]$ is *open*, producing traded goods. The remainder proportion $\beta = 1 - \gamma - \alpha$ the sectors $i \in [0,1]$ is *shielded*, producing non-traded goods. Thus,

$$\int_{i \in M} di = \gamma, \quad \int_{i \in O} di = \alpha, \quad \int_{i \in S} di = \beta = 1 - \gamma - \alpha, \tag{2}$$

where M, O and S are the sets of competitive, open and shielded sectors, respectively.[1] The tariff $\tau > 0$ prevents any trade of the competitive goods $i \in M$ between the two identical countries. Opening up shielded sectors to trade is equivalent to increasing α holding γ constant.

In each oligopolistic sector $i \in O \cup S$, the rents are divided between workers and employers in *wage bargaining*, where a labor union represents the former and an employer federation the latter. In each country, there is a *regulator* that determines relative union bargaining power. I assume that the regulator can discriminate between the open and shielded sectors. The unions and employer federations influence the regulator by their political contributions. To consider the international coordination of labor market regulation, I assume that the home and foreign regulators are strategically

[1]The structure of the economy follows Kreickemeier and Meland (2013), but with the following exceptions. The competitive sectors in the model of this article provide a reservation wage for labor unions. KM introduce non-unionized (but oligopolistic) sectors into their model for the same purpose, but assuming exogenous union power. Because union power is determined by political process in this article, it would be implausible to assume that union power is allowed in some, but not in the other sectors. If there is no union in a sector, then the best explanation is that there are no rents to be bargained over.

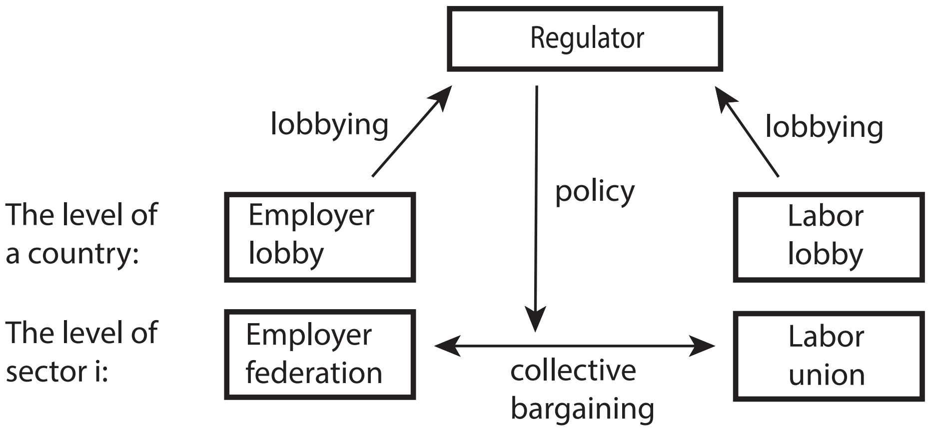

Figure 1: The political equilibrium in a country.

interdependent, forming expectations on each other's responses.

The political equilibrium is established by the common agency model (c.f. Bernheim and Whinston 1986 and Dixit et al.1997), cf. Fig. 1. The players are households, firms, labor unions, labor and employer lobbies, and regulators. They act in an *extensive form game* as follows:

(i) Employer and union lobbies influence regulators, relating their prospective political contributions to the latter's decisions.

(ii) Regulators set relative union bargaining power for all oligopolistic sectors $i \in O \cup S$ and collect political contributions.

(iii) The competitive wage adjusts to balance the labor market.

(iv) Firms and labor unions bargain over wages.

(v) Firms employ labor.

(vi) The households decide on consumption.

This game is solved by backward induction: stage (vi) is examined in section 3, stage (v) in 4, stages (iv) and (iii) in 5, stage (ii) in 6 and stage (i) in 7. At each stage, I consider first the behavior of the home agents and then generalize the results for the foreign agents.

3. The households

Following Neary (2009), I assume that the representative home household derives utility U from the consumption $c(i)$ of the goods $i \in [0,1]$ as follows:

$$u \doteq \int_0^1 \left[ac(i) - \frac{b}{2} c(i)^2 \right] di, \tag{3}$$

where a and b are positive constants. Denoting income by I and the price for good i by $p(i)$, the home budget constraint can be written as follows:

$$I = \int_0^1 p(i)c(i)di. \tag{4}$$

The maximization of utility (3) by consumption $c(i)$ subject to the budget constraint (4) leads to the *inverse demand functions* $p(i) = [a - bc(i)]/\lambda$, where λ is the marginal utility of income. Following Neary (2009), I normalize λ at one. The inverse demand functions take then the form

$$p(i) = a - bc(i). \tag{5}$$

The index of the prices (5) is given by

$$\mu_1 \doteq \int_0^1 p(i)di = a - \int_0^1 c(i)di. \tag{6}$$

Because one unit of each good i is produced from one unit of labor, consumption $\int_0^1 [c(i) + c^*(i)]di$ must be equal to employment $\int_0^1 [l(i) + l^*(i)]di = 2L$ in the two countries taken together [cf. (1)]. Because the countries are identical, then, $c^*(i) = c(i)$ and $\int_0^1 c(i)di = L$ hold true in equilibrium, and it follows from (6) that the price index $\mu_1 = a - bL$ is constant in equilibrium.

Plugging the direct demand functions $c(i) = [a - p(i)]/b$ [cf. (5)] into the budget (4) and the utility function (3) yields the uncentred variance of prices, μ_2, and indirect utility as follows:

$$\mu_2 \doteq \int_0^1 p(i)^2 di = a\mu_1 - bI, \quad u = \frac{a^2}{2b} - \frac{\mu_2}{2b} = \frac{a^2}{2b} - \frac{a\mu_1}{2b} + \frac{I}{2}.$$

Because utility U depends linearly on I only, *income I can be used as a proxy for utility U* at all levels of aggregation.

4. Production

In competitive sectors $i \in M$, the prices are equal to the competitive wage w_m and home consumption $c(i)$ is equal to home output $l(i)$ [cf. (5)]:

$$p(i) = w_m \text{ and } l_m = l(i) = c(i) = \frac{a - p(i)}{b} = \frac{a - w_m}{b} \text{ for } i \in M. \tag{7}$$

In shielded sectors, $i \in S \cup N$, consumption $c(i)$ equals employment $l(i)$:

$$c(i) = l(i) = \sum_{j=1}^{n} l_j(i), \tag{8}$$

where $l_j(i)$ is the labor input of firm j. Noting the inverse demand function (5) and technology (8), the profit of home firm j can be written as follows:

$$\pi_j(i) \doteq [p(i) - w(i)] l_j(i) = \left[a - b \sum_{\kappa=1}^{n} l_\kappa(i) - w(i)\right] l_j(i). \tag{9}$$

Home firm j maximizes profit (9) by its input $l_j(i)$, given the wage $w(i)$ and the inputs of the other firms, $\sum_{\kappa \neq j}^{n} l_\kappa(i)$. Cournot competition between the

n identical firms yields

$$c(i) = l(i) = nl_j(i) = n\frac{a - w(i)}{(n+1)b} \text{ and } p(i) = \frac{a + nw(i)}{n+1} \text{ for } i \in S \cup N. \tag{10}$$

In open sectors $i \in O$, the employment of home firm j equals its output for the home markets, $x_j(i)$, and that for the foreign markets, $y_j(i)$,

$$l_j(i) = x_j(i) + y_j(i). \tag{11}$$

The consumption of good $i \in O$, $c(i)$, equals home production of that good, $x_j(i)$, plus imports from abroad, $y_j^*(i)$:

$$c(i) = \sum_{i=1}^{n}[x_j(i) + y_j^*(i)]. \tag{12}$$

Noting the inverse demand function (5) and technology (11) and (12), the profit of home firm j can be written as follows:

$$\begin{aligned} \pi_j(i) &\doteq [p(i) - w(i)]x_j(i) + [p^*(i) - w(i) - \tau]y_j(i) \\ &= \left\{a - b\sum_{i=1}^{n}[x_j(i) + y_j^*(i)] - w(i)\right\}x_j(i) \\ &\quad + \left\{a - b\sum_{\kappa=1}^{n}[x_j^*(i) + y_j(i)] - w(i) - \tau\right\}y_j(i). \end{aligned} \tag{13}$$

Home firm j in sector $i \in O$ maximizes its profit (13) by its inputs $x_j(i)$ and $y_j(i)$, given the wage $w(i)$ and the inputs of the other firms, $x_\kappa(i)$ and $y_\kappa(i)$ for $\kappa \neq j$ and $x_\kappa^*(i)$ and $y_\kappa^*(i)$ for all j. Foreign firm j behaves accordingly.[2] Kreickemeier and Meland (2013) prove that if the tariff τ is low enough for having trade in the open sectors, there is Cournot competition between n identical home and n identical foreign firms, where the latter have higher effective (trade-cost inclusive) marginal cost. This competition yields

$$\begin{aligned}
&x(i) = nx_j(i) = n\frac{a-(n+1)w(i)+n[w^*(i)+\tau]}{(2n+1)b},\\
&y(i) = ny_j(i) = n\frac{a-(n+1)[w(i)+\tau]+nw^*(i)}{(2n+1)b},\\
&y^*(i) = n\frac{a-(n+1)[w^*(i)+\tau]+nw(i)}{(2n+1)b}, \quad y^*(i)-y(i) = \frac{n}{b}[w(i)-w^*(i)],
\end{aligned} \tag{14}$$

$$\begin{aligned}
&l(i) = nl_j(i) = n[x_j(i)+y_j(i)] = n\frac{2[a+nw^*(i)-(n+1)w(i)]-\tau}{(2n+1)b},\\
&c(i) = c^*(i) = n[x_j(i)+y_j^*(i)] = n\frac{2a-w(i)-w^*(i)-\tau}{(2n+1)b} \quad \text{and}\\
&p(i) = p^*(i) = \frac{1}{2n+1}\big\{(n+1)a+n[w(i)+w^*(i)+\tau]\big\} \text{ for } i \in O,
\end{aligned} \tag{15}$$

where $w(i)$ and $w^*(i)$ are the home and foreign wages in sector $i \in O$.

5. The determination of the wages

In each sector i at home, there is a labor union and an employer federation that bargain over the wage $w(i)$. These observe labor demands (10) or (15), but, with a large number of industries $i \in [0,1]$, they take the competitive wage w_m and the foreign wage $w^*(i)$ as given. The union attempts to

[2] This is equivalent to the reciprocal dumping model of Brander and Krugman (1983). Exports occur if and only if the tariff τ is below a critical level that is implicitly given by the condition that effective marginal cost of serving the export market, $w(i)+\tau$, equals the price in this market in the absence of trade, $[a+nw(i)]/(n+1)$, which is also the marginal revenue of the exporting firm for the first unit sold abroad.

maximize the workers' rents over and above the competitive wage w_m,

$$v(i) = [w(i) - w_m]l(i), \tag{16}$$

while the employer federation attempts to maximize the sum of profits [(9) or (13)] and tariff revenues $\tau y^*(i)$ in the sector,

$$\begin{aligned}\pi(i) &\doteq \sum_{j=1}^{n} \pi_j(i) + \tau y^*(i) = [p(i) - w(i)]l(i) + \tau[y^*(i) - y(i)] \text{ for } i \in O,\\ \pi(i) &\doteq \sum_{j=1}^{n} \pi_j(i) = [p(i) - w(i)]l(i) \text{ for } i \in S.\end{aligned} \tag{17}$$

I assume that the tariff τ is small enough to yield $\frac{\partial \pi(i)}{\partial w(i)} < 0$ for $i \in O \cup S$.

The outcome of wage bargaining is obtained by maximizing the *Generalized Nash Product* of the parties' utilities, $\Theta(i) \doteq \log v(i) + [1/\delta(i) - 1]\pi(i)$, by the home wage $w(i)$, given v, $w^*(i)$ and relative union bargaining power $\delta(i)$. The first-order and second-order conditions of this maximization are

$$\frac{\partial \Theta(i)}{\partial w(i)} = \frac{1}{v(i)}\frac{\partial v(i)}{\partial w(i)} + \left[\frac{1}{\delta(i)} - 1\right]\frac{1}{\pi(i)}\frac{\partial \pi(i)}{\partial w(i)} = 0, \quad \frac{\partial^2 \Theta(i)}{\partial w(i)^2} < 0. \tag{18}$$

Because the open and shielded sectors are uniform, respectively, the regulator sets the same relative union bargaining power for them, respectively: $\delta(i) = \delta_o$ for $i \in O$ and $\delta(i) = \delta_s$ for $i \in S$. Differentiating the first-order condition (18), one can see that the wage is an increasing function of relative union bargaining power in each home sector $i \in [0, 1]$:

$$w(i) = \begin{cases} w_s = \widetilde{w}_s(\delta_s, w_m) & \text{for } i \in S \\ w_o = \widetilde{w}_o(\delta_o, w_m, w_o^*) & \text{for } i \in O \end{cases} \tag{19}$$

with

$$\frac{\partial \widetilde{w}_\ell}{\partial \delta_\ell} = -\frac{\partial^2 \Theta^\ell}{\partial w(i) \partial \delta_\ell} \Bigg/ \frac{\partial^2 \Theta^\ell}{\partial w(i)^2} = \underbrace{\frac{\delta_\ell^{-2}}{\pi(i)}}_{+} \underbrace{\frac{\partial \pi(i)}{\partial w(i)}}_{-} \Bigg/ \underbrace{\frac{\partial^2 \Theta^\ell}{\partial w(i)^2}}_{-} > 0, \quad \ell \in \{s, o\}. \tag{20}$$

Noting (7), (10), (15) and (19), I can define the sector-specific prices, demands and employment levels as follows:

$$\begin{aligned} &p(i) = p_s = \frac{a + nw_s}{n+1} \text{ and } c(i) = c_s = l(i) = l_s = \frac{n(a - w_s)}{(n+1)b} \text{ for } i \in S; \\ &p(i) = p_o = \frac{1}{2n+1}\{(n+1)a + n[w_o + w_o^* + \tau]\},\ c(i) = c_o = \frac{a - p_o}{b} \\ &\text{and } l(i) = l_o = n\frac{2[a + nw_o^* - (n+1)w_o] - \tau}{(2n+1)b} \text{ for } i \in O. \end{aligned} \tag{21}$$

Given (2), (7) and (21), the full-employment constraint (1) takes the form

$$L = \int_{i \in M} l(i)di + \int_{i \in S} l(i)di + \int_{i \in O} l(i)di = \alpha l_o + \beta L_s + \gamma l_m, \tag{22}$$

where the market-clearing competitive wage w_m is given by

$$w_m = a - bl_m = a + \frac{b}{\gamma}(\alpha l_o + \beta l_s - L) \doteq \widetilde{w}_m(w_s, w_o, w_o^*, \tau, \alpha). \tag{23}$$

6. Lobbies and regulators

In the home country, all unions belong to the union lobby and the employers to the employer lobby. These influence the regulator over relative union bargaining power δ_o and δ_s for the open and shielded sectors, respectively. They pay political contributions to the regulator and distribute these over their members. I assume that the direct effect of δ_ℓ on the wage w_ℓ outweighs the indirect effect through the competitive wage w_m through (20), so that w_ℓ

is an increasing function δ_ℓ for the regulator and the lobbies. In that case, it is equivalent to replace relative union bargaining power δ_ℓ by the wage w_ℓ as the control variable in the political process: the home lobbies behave as if they influenced the home regulator over the home wages w_o and w_s.

Noting (14), (16) and (17), I obtain the workers' rents W and aggregate profits Π as functions of the shielded sector wage w_s, the home and foreign open-sector wages w_o and w_o^*, the tariff τ and the mass of open sectors, α:

$$W(w_s, w_o, w_o^*, \tau, \alpha) \doteq \int_{i \in O \cup S} v(i) di = \int_{i \in O \cup S} [w(i) - w_m] l(i) di, \tag{24}$$

$$\begin{aligned} \Pi(w_s, w_o, w_o^*, \tau, \alpha) &\doteq \int_{i \in O \cup S} \pi(i) di \\ &= \int_{i \in O \cup S} [p(i) - w(i)] l(i) di + \tau \int_{i \in O} [y^*(i) - y(i)] di \\ &= \int_{i \in O \cup S} [p(i) - w(i)] l(i) di + \frac{n}{b} \tau \int_{i \in O} [w(i) - w^*(i)] di. \end{aligned} \tag{25}$$

Aggregate income I is then equal to the workers' rents W, aggregate profits Π plus the competitive wages for the whole labor force L:

$$I \doteq W + \Pi + w_m L. \tag{26}$$

The union lobby attempts to maximize the workers' rents W minus its political contributions R_W, $I_W \doteq W - R_W$, while the employer lobby attempts to maximize total profits Π minus its political contributions R_Π to the regulator, $I_\Pi \doteq \Pi - R_\Pi$. Following Dixit et al. (1997), I assume that the regulator's utility G is an increasing function of the utilities of both lobbies,

I_W and I_Π, and the total contributions $R_P + R_W$ it receive:

$$I_W(w_s, w_o, w_o^*, \tau, \alpha, R_W) \doteq W - R_W, \quad I_\Pi(w_s, w_o, w_o^*, \tau, \alpha, R_\Pi) \doteq \Pi - R_\Pi,$$
$$G(I_W, I_\Pi, R_W + R_\Pi), \quad \frac{\partial G}{\partial I_W} > 0, \quad \frac{\partial G}{\partial I_\Pi} > 0, \quad \frac{\partial G}{\partial (R_W + R_\Pi)} > 0. \tag{27}$$

Following Dixit (1986), I assume that the home regulator and the home lobbies anticipate their foreign counterparts to follow their choice of the open-sector wage w_o according to the *conjectural variation relation*

$$\frac{dw_o^*}{dw_o} = \varphi \in \{0, 1\}. \tag{28}$$

This incorporates two cases into the same framework: *national labor market regulation* ($\varphi = 0$), where the regulators behave in Cournot manner, taking each other's wages as given; and *international labor market regulation* ($\varphi = 1$), where the regulators fully cooperate.

7. Political Equilibrium

According to proposition 1 of Dixit et al. (1997), a subgame perfect Nash equilibrium for the game between the employer lobby, the union lobby and the regulator is a set of contribution schedules $R_\Pi(w_s, w_o, w_o^*)$ and $R_W(w_s, w_o, w_o^*)$ and policy (w_s, w_o) that satisfy the following conditions $(i) - (iv)$:[3]

(i) With a feasible strategy $R_\Pi(w_s, w_o, w_o^*)$ $\big(R_W(w_s, w_o, w_o^*)\big)$, the employer (labor) lobby maximizes its utility I_Π (I_W) by wages (w_s, w_o) s.t. (28):

$$(w_s, w_o) = \arg \max_{\substack{(w_s, w_o) \\ s.t.(28)}} I_\kappa(w_s, w_o, w_o^*, \tau, \alpha, R_\kappa), \quad \kappa \in \{\Pi, W\}. \tag{29}$$

[3]It is also required that the contributions of the lobbies, R_Π and R_W, are non-negative but no more than the contributor's income. This is however evident in the model.

(ii) Wages (w_s, w_o) maximize the regulator's welfare (27) s.t. (28) [cf. (29)]:

$$
\begin{aligned}
(w_s, w_o) &= \arg \max_{\substack{(w_s, w_o)\\ \text{s.t. } (28)}} G\big(\max_{\substack{(w_s, w_o)\\ \text{s.t. } (28)}} I_\Pi, \max_{\substack{(w_s, w_o)\\ \text{s.t. } (28)}} I_W, R_\Pi(w_s, w_o) + R_W(w_s, w_o)\big) \\
&= \arg \max_{(w_s, w_o) \text{ s.t. } (28)} \big[R_\Pi(w_s, w_o, w_o^*) + R_W(w_s, w_o, w_o^*)\big]. \qquad (30)
\end{aligned}
$$

(iii) The employer (labor) lobby provides the regulator at least with the level of utility than in the case where it offers nothing $R_W = 0$ $(R_\Pi = 0)$, and where the regulator responds optimally given the other lobby's contribution function.

The equilibrium conditions (29) are then equivalent to [cf. (27)]

$$
\begin{aligned}
0 &= \frac{\partial I_\kappa}{\partial w_o} + \frac{\partial I_\kappa}{\partial w_o^*}\frac{dw_o^*}{dw_o} - \frac{\partial I_\kappa}{\partial R_\kappa}\frac{\partial R_\kappa}{\partial w_o} = \frac{\partial \kappa}{\partial w_o} + \frac{\partial \kappa}{\partial w_o^*}\varphi - \frac{\partial R_\kappa}{\partial w_o}, \\
0 &= \frac{\partial I_\kappa}{\partial w_s} - \frac{\partial I_\kappa}{\partial R_\kappa}\frac{\partial R_\kappa}{\partial w_s} = \frac{\partial \kappa}{\partial w_s} - \frac{\partial R_\kappa}{\partial w_s}, \quad \kappa \in \{\Pi, W\}.
\end{aligned}
$$

Thus, in equilibrium the change in the contributions of the employer (labor) lobby, R_Π (R_W), due to a change in a wage equals the effect of that wage on the welfare of that lobby, Π (W):

$$
\frac{\partial R_\kappa}{\partial w_o} = \frac{\partial \kappa}{\partial w_o} + \frac{\partial \kappa}{\partial w_o^*}\varphi, \; \frac{\partial R_\kappa}{\partial w_s} = \frac{\partial \kappa}{\partial w_s}, \quad \kappa \in \{\Pi, W\}. \qquad (31)
$$

In other words, the contribution schedules are locally truthful. This concept can be extended to a globally truthful contribution schedule that represents the preferences of the employer (labor) lobby at all policy points (cf. Berhheim and Whinston 1997 or Dixit et al. 1994). Given (31), this truthful contribution function takes the form [cf. (27)]

$$R_\Pi = \max[\Pi - \underline{\Pi}, 0], \quad R_W = \max[W - \underline{W}, 0], \tag{32}$$

where $\underline{\Pi}$ ($\underline{W}$) is total profits (total wages) when the employer (labor) lobby does not pay contributions but the regulator chooses its best response, given the contribution schedule of the labor (employer) lobby.

The threat points $\underline{\Pi}$ and $\underline{W}$ are determined as follows. If the employer lobby does not pay contributions to the regulator, $R_\Pi = 0$, then the latter retaliates by increasing union power δ to unity. In that case, $\underline{\Pi} \doteq \Pi\big|_{\delta=1,\, R_\Pi=0}$. If the union lobby does not pay contributions to the regulator, $R_W = 0$, then the latter retaliates by decreasing union power δ to zero. In that case, $\underline{W} \doteq W\big|_{\delta=0,\, R_W=0}$. Thus, $\underline{\Pi}$ and $\underline{W}$ are given for the lobbies. Given (24), (25) and (32), the regulator's equilibrium conditions (30) become

$$(w_s, w_o) = \arg \max_{(w_s, w_o) \text{ s.t. } (28)} (W + \Pi). \tag{33}$$

This result can be rephrased as follows:

Proposition 1. *In equilibrium, the home regulator maximizes total income in the unionized sectors, $W + \Pi$, subject to its expectations* (28) *on the foreign regulator's response.*

8. Employment and aggregate welfare

Because the two countries are identical and one unit of each open-sector good $i \in O$ is made of one unit of labor, then, in equilibrium, it is true that

$$\begin{aligned} &I^* = I,\ \ w_o^* = w_o,\ \ w_s^* = w_s,\ \ w_m^* = w_m,\ \ p_o^* = p_o,\ \ p_s^* = p_s,\ \ p_m^* = p_m, \\ &c_s = l_s = l_s^* = c_s^*,\ \ c_o = l_o = l_o^* = c_o^*. \end{aligned} \tag{34}$$

In that equilibrium, the regulator's equilibrium conditions (33) define aggregate income I and sector-specific employment levels l_m, l_s and l_o as functions of the globalization parameters φ, τ and α (cf. Appendix A):

$$(p_o - p_s)_{\varphi=1} = 0, \quad (p_o - p_s)_{\varphi=0} > 0, \tag{35}$$

$$I(\varphi,\tau,\alpha), \quad l_s(\varphi,\tau,\alpha), \quad l_m(\varphi,\tau,\alpha), \quad l_o(\varphi,\tau,\alpha), \tag{36}$$

$$\left(\frac{\partial I}{\partial \alpha} - \frac{\partial I}{\partial \beta}\right)_{\varphi=1} = \left.\frac{\partial l_\ell}{\partial \tau}\right|_{\varphi=1} = \left(\frac{\partial l_\ell}{\partial \alpha} - \frac{\partial l_\ell}{\partial \beta}\right)_{\varphi=1} \quad \text{for } \ell \in \{m,s,o\}, \tag{37}$$

$$\frac{\partial I}{\partial \varphi} > 0, \quad \frac{\partial I}{\partial \tau} < 0, \tag{38}$$

$$\begin{aligned}&\frac{\partial l_m}{\partial \varphi} < 0, \ \left.\frac{\partial l_m}{\partial \tau}\right|_{\varphi=0} > 0, \ \left(\frac{\partial l_m}{\partial \alpha} - \frac{\partial l_m}{\partial \beta}\right)_{\varphi=0} < 0, \ \frac{\partial l_s}{\partial \varphi} < 0, \ \left.\frac{\partial l_s}{\partial \tau}\right|_{\varphi=0} > 0,\\ &\left(\frac{\partial l_s}{\partial \alpha} - \frac{\partial l_s}{\partial \beta}\right)_{\varphi=0} < 0, \ \frac{\partial l_o}{\partial \varphi} > 0, \ \left.\frac{\partial l_o}{\partial \tau}\right|_{\varphi=0} < 0, \ \left(\frac{\partial l_o}{\partial \alpha} - \frac{\partial l_o}{\partial \beta}\right)_{\varphi=0} > 0.\end{aligned} \tag{39}$$

Differentiating the employment functions l_m, l_s and l_o [cf. (7) and (21)] totally and noting (39) and $w_o^* = w_o$ [cf. (34)], I obtain the wage functions

$$\begin{aligned}&\frac{\partial w_m}{\partial \varphi} > 0, \ \left.\frac{\partial w_m}{\partial \tau}\right|_{\varphi=0} < 0, \ \left(\frac{\partial w_m}{\partial \alpha} - \frac{\partial w_m}{\partial \beta}\right)_{\varphi=0} > 0, \ \frac{\partial w_s}{\partial \varphi} > 0, \ \left.\frac{\partial w_s}{\partial \tau}\right|_{\varphi=0} > 0,\\ &\left(\frac{\partial w_s}{\partial \alpha} - \frac{\partial w_s}{\partial \beta}\right)_{\varphi=0} > 0, \ \frac{\partial w_o}{\partial \varphi} < 0, \quad \left(\frac{\partial w_o}{\partial \alpha} - \frac{\partial w_o}{\partial \beta}\right)_{\varphi=0} < 0,\\ &\left.\frac{\partial w_o}{\partial \tau}\right|_{\varphi=0} = -\frac{1}{2n}\Bigg[1 + \underbrace{(2n+1)b}_{+}\underbrace{\left.\frac{\partial l_o}{\partial \tau}\right|_{\varphi=0}}_{-}\Bigg].\end{aligned} \tag{40}$$

The results (37) can be rephrased as follows:

Proposition 2. *With international labor market regulation $\varphi = 1$,*

(a) a decrease in trade cost τ and opening up shielded sectors to trade have no effect on sector-specific employment levels l_m, l_s and l_o, and

(b) opening up shielded sectors to trade (i.e. an increase in α with an equal decrease in β) has no effect on aggregate income and aggregate welfare.

Each regulator behaves as if it maximized total rents in its jurisdiction (cf. proposition 1). When labor market regulation is common for the two identical countries, the common regulator maximizes total rents in the countries taken together. Consequently, there is no distortion due to mutual trade and the output prices are uniform in the open and shielded sectors [cf. (35)]. In that case, trade policy has no effect on employment levels and opening up shielded sectors has no effect on welfare.

The results (38) can be rephrased as follows:

Proposition 3. *International labor market regulation (i.e. an increase of φ from 0 to 1) and a decrease in the trade cost τ promote aggregate income I and aggregate welfare.*

A a decrease in the trade cost $\tau > 0$ improves efficiency for the two regulators taken together. International labor market regulation improves efficiency as well, because it eliminates the Cournot competition between the regulators of the two countries. The regulators limit the bargaining power of the open-sector labor unions to ensure that the welfare losses due to high open-sector wages do not outweigh their efficiency benefits.

The results (40) can be rephrased as follows:

Proposition 4. *Starting from the initial point of national labor market regulation $\varphi = 0$, international labor market regulation (i.e. an increase of φ from 0 to 1) and opening up shielded sectors to trade (i.e. an increase in α with an equal decrease in β) decrease the open-sector wage w_o and increase shielded-sector and the competitive-sector wages, w_s and w_m.*

The Cournot competition between the regulators of the two countries increases the open-sector wages w_o and w_o^* too high from the welfare of the two regulators taken together. International labor market regulation eliminates this. The resulting fall in the open-sector wage w_o increases employment in the open sectors. This causes a migration of workers from the the shielded and competitive to the open sectors, increasing the wages in the former.

9. Conclusions

In this article, I examine two identical integrated countries in which some sectors are oligopolistic and unionized. The lobbies representing unions and employers influence regulators for revising labor market rules in their favor. Traditionally, globalization is examined through the general equilibrium effects of trade cost reductions and opening up shielded sectors to trade. In this article, international labor market regulation is analyzed as the third aspect of globalization. The main results are the following.

First, when shielded sectors are opened up to trade or labor market regulation becomes internationally coordinated, the open-sector wages decrease, but the shielded-sector and competitive-sector wages increase.[4] In the model of Kreickemeier and Meland (2013), wages are set by monopoly labor unions which are microeconomic agents: these take the other wages in the economy as given. Union wages are then set as a mark up over and above the competitive wage so that all wages change proportionally.

In this article, the level of wages is ultimately determined by the regulators that are macroeconomic agents: these take into account also the effects through the competitive wages. Consequently, globalization can change the open-sector wages in the opposite direction than the shielded-sector and competitive-sector wages. The Cournot competition between the regulators of the two countries increases open-sector wages too high from the welfare of these regulators taken together. International labor market regulation eliminates this. The resulting fall in open-sector wages decreases employment

[4]This explains the observation that union power has been declining for many years in several countries (cf. the introductory section). The open-sector union wages fall. The shielded-sector union wages rise, but the scope of this decreases, because shielded sectors are at the same time converted into open sectors.

in the open sectors. This makes workers to migrate from the shielded and competitive into the open sectors, increasing the wages in the former.

The second result is that when trade costs are reduced or labor market regulation becomes internationally coordinated, aggregate welfare increases. In Kreickemeier and Meland (2013), trade cost decreases lead to lower welfare, because consumption levels become more unequal and this reduces welfare through the concavity of the utility function. In the model of this document, the regulators limit the bargaining power of the open-sector labor unions to ensure that the welfare losses due to high open-sector wages do not outweigh their efficiency benefits from trade cost decreases. As a result of this, welfare increases also for the economy as a whole.

Appendix A. Results (36)-(39)

Because there must be positive demand $c(i) = [a - p(i)]/b$ and a positive marginal product $\frac{\partial}{\partial c(i)}[p(i)c(i)] = p(i) + c(i)\frac{\partial p(i)}{\partial c(i)} = p(i) - bc(i) = 2p(i) - a > 0$ in all sectors $i \in [0, 1]$, the supports of the prices and the demands are

$$\frac{a}{2} < p(i) < a, \quad 0 < c(i) = \frac{a - p(i)}{b} < \frac{a}{2b} \tag{A.1}$$

Noting (21) and (23), I obtain

$$\begin{aligned}
&\frac{\partial \widetilde{w}_m}{\partial w_s} = b\frac{\beta}{\gamma}\frac{dl_s}{dw_s} = -\frac{\beta}{\gamma}\frac{n}{n+1}, \quad \frac{\partial \widetilde{w}_m}{\partial w_o} = b\frac{\alpha}{\gamma}\frac{\partial l_o}{\partial w_o} = -2\frac{\alpha}{\gamma}\frac{(n+1)n}{2n+1}, \\
&\frac{\partial \widetilde{w}_m}{\partial w_o^*} = b\frac{\alpha}{\gamma}\frac{\partial l_o}{\partial w_o^*} = 2\frac{\alpha}{\gamma}\frac{n^2}{2n+1}, \quad \frac{\partial \widetilde{w}_m}{\partial \tau} = b\frac{\alpha}{\gamma}\frac{\partial l_o}{\partial \tau} = -\frac{\alpha}{\gamma}\frac{n}{2n+1}, \\
&\left.\frac{\partial \widetilde{w}_m}{\partial \alpha}\right|_{d\beta=-d\alpha} = \frac{b}{\gamma}(l_o - l_s).
\end{aligned} \tag{A.2}$$

Noting (21), (24), (25) and (26), I define total rents:

$$
\begin{aligned}
J &\doteq W + \Pi = \int_{i \in O \cup S} [p(i) - w_m] l(i) di + \tau \int_{i \in O} [w(i) - w^*(i)] di \\
&= \alpha \Big[(p_o - w_m) c_o + \tau \frac{n}{b} (w_o - w_o^*) \Big] + \beta (p_s - w_m) l_s \\
&= \frac{\alpha}{b} \big[(p_o - w_m)(a - p_o) + \tau n (w_o - w_o^*) \big] + \frac{\beta}{b} (p_s - w_m)(a - p_s) \\
&= \frac{\alpha}{b} \big[(a + w_m) p_o - p_o^2 - a w_m + \tau n (w_o - w_o^*) \big] + \frac{\beta}{b} [(a + w_m) p_s - p_s^2 - a w_m].
\end{aligned} \tag{A.3}
$$

Given (21) and (A.2), the function (A.3) has following partial derivatives:

$$
\begin{aligned}
\frac{\partial J}{\partial w_s} &= \frac{\beta}{b} (a + w_m - 2p_s) \frac{dp_s}{dw_s} + \left[\frac{\alpha}{b} (p_o - a) + \frac{\beta}{b} (p_s - a) \right] \frac{\partial \widetilde{w}_m}{\partial w_s} \\
&= \beta \frac{n/\gamma}{n+1} \big[\gamma (2 l_s - l_m) + \alpha c_o + \beta l_s \big], \qquad (A.4) \\
\frac{\partial J}{\partial w_o} &= \frac{\alpha}{b} \left[(a + w_m - 2p_o) \frac{\partial p_o}{\partial w_o} + \tau n \right] + \left[\frac{\alpha}{b} (p_o - a) + \frac{\beta}{b} (p_s - a) \right] \frac{\partial \widetilde{w}_m}{\partial w_o} \\
&= \frac{\alpha}{\gamma} \frac{n/b}{2n+1} \Big[\gamma (2c_o - l_m) + (2n+1) \frac{\gamma}{b} \tau + 2(n+1)(\alpha c_o + \beta l_s) \Big], \\
\frac{\partial J}{\partial w_o^*} &= \frac{\alpha}{b} \left[(a + w_m - 2p_o) \frac{\partial p_o}{\partial w_o^*} - \tau n \right] + \left[\frac{\alpha}{b} (p_o - a) + \frac{\beta}{b} (p_s - a) \right] \frac{\partial \widetilde{w}_m}{\partial w_o^*} \\
&= \frac{\alpha}{\gamma} \frac{n/b}{2n+1} \Big[\gamma (2c_o - l_m) - (2n+1) \frac{\gamma}{b} \tau - n(\alpha c_o + \beta l_s) \Big], \qquad (A.5) \\
\frac{\partial J}{\partial w_o} + \varphi \frac{\partial J}{\partial w_o^*} &= \frac{\alpha}{\gamma} \frac{n/b}{2n+1} \Big\{ (1 + \varphi) \gamma (2c_o - l_m) + (1 - \varphi)(2n+1) \frac{\gamma}{b} \tau \\
&\qquad + 2[(1 - \varphi) n + 1](\alpha c_o + \beta l_s) \Big\}, \qquad (A.6) \\
\frac{\partial J}{\partial \tau} &= \frac{\alpha}{b} (a + w_m - 2p_o) \frac{\partial p_o}{\partial \tau} + \left[\frac{\alpha}{b} (p_o - a) + \frac{\beta}{b} (p_s - a) \right] \frac{\partial \widetilde{w}_m}{\partial \tau} \\
&= \frac{\alpha}{\gamma} \frac{n}{2n+1} \big[\gamma (2c_o - l_m) + \alpha c_o + \beta l_m \big], \qquad (A.7)
\end{aligned}
$$

$$
\begin{aligned}
\left.\frac{\partial J}{\partial \alpha}\right|_{d\beta=-d\alpha} &= (p_o - w_m)c_o + \tau\frac{n}{b}(w_o - w_o^*) - (p_s - w_m)l_s \\
&= (l_m - l_o)bc_o + \tau\frac{n}{b}(w_o - w_o^*) - (l_m - l_s)bl_s \\
&\quad - (\alpha c_o + \beta l_s)\frac{b}{\gamma}(l_o - l_s). \qquad \text{(A.8)}
\end{aligned}
$$

Given (28), (31), (A.4) and (A.6), the first-order conditions corresponding to maximization (30) are

$$
0 = \frac{\partial(R_\Pi + R_W)}{\partial w_s} = \frac{\partial J_\Pi}{\partial w_s} + \frac{\partial J_W}{\partial w_s} = \frac{\partial \Pi}{\partial w_s} + \frac{\partial W}{\partial w_s} = \frac{\partial(\Pi + W)}{\partial w_s} = \frac{\partial J}{\partial w_s}, \tag{A.9}
$$

$$
\begin{aligned}
0 &= \frac{\partial R_\Pi}{\partial w_o} + \frac{\partial R_W}{\partial w_o} = \frac{\partial J_\Pi}{\partial w_o} + \frac{\partial J_\Pi}{\partial w_o^*}\frac{dw_o^*}{dw_o} + \frac{\partial J_W}{\partial w_o} + \frac{\partial J_W}{\partial w_o^*}\frac{dw_o^*}{dw_o} \\
&= \frac{\partial J_\Pi}{\partial w_o} + \varphi\frac{\partial J_\Pi}{\partial w_o^*} + \frac{\partial J_W}{\partial w_o} + \varphi\frac{\partial J_W}{\partial w_o^*} = \frac{\partial \Pi}{\partial w_o} + \varphi\frac{\partial \Pi}{\partial w_o^*} + \frac{\partial W}{\partial w_o} + \varphi\frac{\partial W}{\partial w_o^*} \\
&= \frac{\partial(\Pi + W)}{\partial w_o} + \frac{\partial(\Pi + W)}{\partial w_o^*}\varphi = \frac{\partial J}{\partial w_o} + \varphi\frac{\partial J}{\partial w_o^*}. \qquad \text{(A.10)}
\end{aligned}
$$

I assume that the second-order condition holds for $\varphi \in \{0, 1\}$.

Because the countries are identical, $w_o^* = w_o$ and $c_o = l_o$ hold true in equilibrium [cf. (34)]. Inserting these, (A.4) and (A.6) into the first-order conditions (A.9) and (A.10), I obtain the equations

$$
0 = \alpha l_o + \beta l_s + \gamma(2l_s - l_m), \tag{A.11}
$$

$$
0 = 2[(1-\varphi)n + 1](\alpha l_o + \beta l_s) + (1+\varphi)\gamma(2l_o - l_m) + (1-\varphi)(2n+1)\frac{\gamma}{b}\tau. \tag{A.12}
$$

From (A.11), (A.12) and $0 \le \varphi \le 1$, I obtain

$$
\begin{aligned}
l_s - \frac{l_m}{2} &= -\frac{\alpha l_o + \beta l_s}{2\gamma} < 0, \\
l_o - l_s &= \frac{l_m}{2} - l_s - \frac{(1-\varphi)n+1}{(1+\varphi)\gamma}(\alpha l_o + \beta l_s) - (1-\varphi)\left(n + \frac{1}{2}\right)\frac{\tau}{b} \\
&= \left[\frac{1}{2} - \frac{(1-\varphi)n+1}{(1+\varphi)\gamma}\right](\alpha l_o + \beta l_s) - (1-\varphi)\left(n + \frac{1}{2}\right)\frac{\tau}{b}, \\
(l_o - l_s)_{\varphi<1} &= \left[\frac{1}{2} - \underbrace{\frac{(1-\varphi)n+1}{(1+\varphi)\gamma}}_{>\frac{1}{2}}\right](\underbrace{\alpha l_o + \beta l_s}_{+}) - (\underbrace{1-\varphi}_{>0}) \underbrace{\left(n + \frac{1}{2}\right)\frac{\tau}{b}}_{+} < 0, \\
(l_o - l_s)_{\varphi=1} &= 0, \qquad \text{(A.13)}
\end{aligned}
$$

$$
l_o \le l_s < \frac{l_m}{2}, \quad p_o \ge p_s > w_m, \quad (p_o - p_s)_{\varphi=1} = 0, \quad (p_o - p_s)_{\varphi=0} > 0. \qquad \text{(A.14)}
$$

From (A.7), (A.10), (A.11), (A.14), $w_o^* = w_o$ and $c_o = l_o$ it follows that

$$
\frac{\partial J}{\partial \tau} = \frac{\alpha}{\gamma}\frac{n}{2n+1}\left[\gamma(2l_o - l_m) + \alpha c_o + \beta l_m\right], \qquad \text{(A.15)}
$$

$$
\frac{\partial J}{\partial \alpha} = (l_m - l_o)bl_o - (l_m - l_s)bl_s - (\alpha l_o + \beta l_s)\frac{b}{\gamma}(l_o - l_s), \qquad \text{(A.16)}
$$

$$
\begin{aligned}
&\frac{\partial J}{\partial w_o} + \frac{\partial J}{\partial w_o^*} = (1-\varphi)\frac{\partial J}{\partial w_o^*} \\
&= \frac{\alpha}{\gamma}\frac{n/b}{2n+1}(1-\varphi)\left[\gamma(2c_o - l_m) - (2n+1)\frac{\gamma}{b}\tau - n(\alpha c_o + \beta l_s)\right]. \qquad \text{(A.17)}
\end{aligned}
$$

Noting $w_o^* = w_o$, (A.3) and (A.9), I can transform the income constraint (26) and the full-employment constraint (22) into the form:

$$
\begin{aligned}
0 &= \alpha p_o l_o + \beta p_s l_s + \gamma w_m l_m - I \\
&= \alpha(a - bl_o)l_o + \beta(a - bl_s)l_s + \gamma(a - bl_m)l_m - I, \qquad \text{(A.18)}
\end{aligned}
$$

$$0 = \alpha l_o + \beta l_s + \gamma l_m - L. \tag{A.19}$$

The system of four equations, (A.18), (A.19), (A.11) and (A.12), has four unknown variables – income I and employment levels l_m, l_s and l_o – and three parameters φ, τ and α. Differentiating this system totally and noting $d\beta = -d\alpha$ [cf. (2)], I obtain the matrix equation

$$\begin{bmatrix} -1 & \gamma(a-2bl_m) & \beta(a-2bl_s) & \alpha(a-2bl_o) \\ 0 & \gamma & \beta & \alpha \\ 0 & -\gamma & \beta+2\gamma & \alpha \\ 0 & -(1+\varphi)\gamma & 2\beta[(1-\varphi)n+1] & {\scriptstyle 2\alpha[(1-\varphi)n+1] \atop +2(1+\varphi)\gamma} \end{bmatrix} \begin{bmatrix} dI \\ dl_m \\ dl_s \\ dl_o \end{bmatrix}$$
$$+ \begin{bmatrix} 0 & 0 & [a-b(l_o+l_s)](l_o-l_s) \\ 0 & 0 & l_o-l_s \\ 0 & 0 & l_o-l_s \\ \vartheta & (1-\varphi)(2n+1)\frac{\gamma}{b} & 2[(1-\varphi)n+1](l_o-l_s) \end{bmatrix} \begin{bmatrix} d\varphi \\ d\tau \\ d\alpha - d\beta \end{bmatrix} = 0, \tag{A.20}$$

where, by (A.14), it holds true that

$$\vartheta \doteq \gamma(\underbrace{2l_o - l_m}_{-}) - \underbrace{2\varphi(\alpha l_o + \beta l_s)}_{+} - \underbrace{(2n+1)\frac{\gamma}{b}}_{+}\tau < 0. \tag{A.21}$$

The Jacobian of this system is

$$K = -2\gamma^2\left\{2\alpha[(\underbrace{1-\varphi}_{+})n+1] + 2(1+\varphi)\gamma + \alpha\left(2\frac{\beta}{\alpha}+1\right)(1+\varphi)\right\} < 0. \tag{A.22}$$

Noting (A.13)-(A.17), I can write the matrix equation (A.20) in terms of partial derivatives:

$$\begin{aligned}
\frac{\partial I}{\partial \varphi} &= \underbrace{\frac{4}{K}}_{-} b \underbrace{\vartheta}_{-} \alpha\gamma[\gamma(\underbrace{l_m - l_o}_{+}) + \beta(\underbrace{l_s - l_o}_{\geq 0})] > 0, \\
\frac{\partial I}{\partial \tau} &= \underbrace{\frac{4}{K}}_{-} b \underbrace{(1-\varphi)(2n+1)\frac{\gamma}{b}}_{+} \alpha\gamma[\gamma(\underbrace{l_m - l_o}_{+}) + \beta(\underbrace{l_s - l_o}_{\geq 0})] < 0, \\
\frac{\partial I}{\partial \alpha} - \frac{\partial I}{\partial \beta} &= 2\frac{\gamma^2}{K}(l_o - l_s)b\big\{(1+\varphi)\big[\gamma(l_o + l_s - 2l_m) + 2\beta(l_o - l_s)\big] \\
&\qquad + \alpha(l_s - l_o)\left[(1-\varphi)n + 1 + (1+\varphi)\left(\frac{1}{2}+\frac{\beta}{\alpha}\right)\right]\bigg\}, \\
\left(\frac{\partial I}{\partial \alpha} - \frac{\partial I}{\partial \beta}\right)_{\varphi=1} &= \left(\frac{\partial I}{\partial \alpha} - \frac{\partial I}{\partial \beta}\right)_{\varphi=1\,\&\,l_s=l_o} = 0, \\
\frac{\partial l_m}{\partial \varphi} &= -2\gamma\alpha \underbrace{\frac{1}{K}}_{-} \underbrace{\vartheta}_{-} < 0, \\
\frac{\partial l_m}{\partial \tau} &= -2\gamma\alpha \underbrace{\frac{1}{K}}_{-} \underbrace{(2n+1)\frac{\gamma}{b}}_{+}(1-\varphi)\begin{cases} = 0 & \Leftrightarrow \varphi = 1, \\ > 0 & \Leftrightarrow \varphi = 0, \end{cases} \\
\frac{\partial l_m}{\partial \alpha} - \frac{\partial l_m}{\partial \beta} &= -2\gamma\alpha \underbrace{\frac{1}{K}}_{-} \underbrace{\vartheta}_{-} < 0, \\
\frac{\partial l_s}{\partial \varphi} &= -2\gamma\alpha \underbrace{\frac{1}{K}}_{-} \underbrace{\vartheta}_{-} < 0,
\end{aligned}$$

$$\frac{\partial l_s}{\partial \tau} = -2\gamma\alpha \underbrace{\frac{1}{K}}_{-} \underbrace{(2n+1)\frac{\gamma}{b}}_{+}(1-\varphi) \begin{cases} = 0 & \Leftrightarrow \varphi = 1, \\ > 0 & \Leftrightarrow \varphi = 0, \end{cases}$$

$$\frac{\partial l_s}{\partial \alpha} - \frac{\partial l_s}{\partial \beta} = 4\gamma \underbrace{\frac{1}{K}}_{-} (l_o - l_s)(1+\varphi)\gamma \begin{cases} = 0 & \Leftrightarrow l_0 = l_s \Leftrightarrow \varphi = 1, \\ > 0 & \Leftrightarrow l_0 < l_s \Leftrightarrow \varphi = 0, \end{cases}$$

$$\frac{\partial l_o}{\partial \varphi} = \underbrace{\frac{\gamma}{K}}_{-} \underbrace{\vartheta}_{-}(2\gamma + \beta) > 0,$$

$$\frac{\partial l_o}{\partial \tau} = 2 \underbrace{\frac{\gamma}{K}}_{-} \underbrace{(2n+1)\frac{\gamma}{b}}_{+}(\gamma + \beta)(1-\varphi) \begin{cases} = 0 & \Leftrightarrow \varphi = 1, \\ < 0 & \Leftrightarrow \varphi = 0, \end{cases}$$

$$\frac{\partial l_o}{\partial \alpha} - \frac{\partial l_o}{\partial \beta} = 2 \underbrace{\frac{\gamma}{K}}_{-} \underbrace{(l_o - l_s)}_{-} \{\underbrace{2\gamma[(1-\varphi)n + 1] + 1 + \varphi}_{+}\} \begin{cases} = 0 & \Leftrightarrow \varphi = 1, \\ > 0 & \Leftrightarrow \varphi = 0. \end{cases}$$

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