Economic Integration, Union Power, and Growth with Creative Destruction

Tapio Palokangas*
University of Helsinki, HECER and IZA

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Abstract

We construct a Schumpeterian growth model of a common market with following properties. Households can stay as workers or become researchers at some cost. Workers are employed in production and researchers in R&D. Workers are unionized. Intermediate goods are substitutes and their producers are strategically interdependent. The main findings are as follows. Both union power and economic integration promote growth. A common market should accept new members as long as this increases consumption per capita. If economic integration intensifies international competition very much (only a little), then there is political pressure to weaken (strengthen) union power for the elimination of excessive (deficient) growth.

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Corresponding author:

Tapio Palokangas, Department of Economics, P.O. Box 17 (Arkadiankatu 7), FIN-00014 University of Helsinki, Finland. Phone +358 9 191 28735, Fax +358 9 191 28736, Email: Tapio.Palokangas@helsinki.fi

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1 Introduction

At the time labour unions were established, economies were in many respect more closed than nowadays. In a couple of decades, unions' position have been dramatically weakened and wage inequality has increased.[1] The governments in many countries have deregulated the labour market to undermine or reduce union power in wage bargaining. We examine here the relationship of governments, unions, technological change and economic integration.

Labour unions and employer federations have two roles which are often mixed in economic debates: (*i*) they bargain over wages and (*ii*) lobby the government for a number of issues (e.g. pension schemes, hiring and firing costs, hours of work). To avoid confusion in this matter, this study concentrates wholly on role (*i*) and assumes that labour unions and employer federations attempt to improve their members' welfare through wage settlement. Political lobbying is ignored here and the author considers it elsewhere.[2]

Although it is widely known that deunionization removes the wage compression imposed by unions and increase inequality among workers,[3] there is still no theory of deunionization. We take the 'Schumpeterian' growth model,[4] in which firms can step forward in the quality ladders of technology by R&D, as a starting point, but replace the competitive labour market by wage bargaining in which unions and employers observe the effect of wages on both employment and investment. We also assume that the government can influence union power e.g. by legislation or compulsory intermediation. Our results suggest that intensified competition in the goods markets due to economic integration is the likely cause for the observed deunionization.

Many papers show that the relationship of labour unions and economic

[1]In the US, in 1980 the ratio of the 90th to the 10th percentile of the distribution of male weekly wages was 2.7, and 24% of all private sector workers were unionized. By 1990, the ratio has risen to 3.5 and only 12% of the private sector workers were unionized (Juhn et. al., 1993, Farber and Krueger 1992). In the UK, the ratio of the 90-10 wage differential was 2.4 and increased to 3.1 in 1990, while union density among male workers was 54% in 1980, and fell to 3.1 in 1990 (Gosling and Machin 1995). Cf. also Acemoglu et. al. (2001).

[2]Using a common agency framework, Palokangas (2003) considers unions and employers as lobbies trying to influence the self-interested government.

[3]There is a lot of evidence that unions compress the structure of wages (cf. DiNardo et. al. (1996), Card 1996, and Fortin and Lemieux 1997). Cf. also Acemoglu et. al. (2001).

[4]Cf. e.g. Grossman and Helpman (1991) (in ch. 4), Aghion and Howitt (1998), and Wälde (1999).

growth depends significantly on the production structure of the economy. Peretto (1998) examines the growth effects of union bargaining power by a product-variety model. His main result is that a fall in union power promotes R&D and growth through a higher profit margin. Peretto however assumes that (*i*) labour is employed only in production, (*ii*) final goods can be directly converted into R&D, (*iii*) labour unions completely ignore the effect of their wages on productivity through R&D, and (*iv*) union power is exogenous. We, on the contrary, assume that labour is used both in production and R&D, unions take into account also the effects through R&D, and union power can be changed through labour market reforms.

Dinopoulos and Zhao (2003) examine the interaction of union power and globalization. They as well assume that labour unions ignore the effect of their wages on productivity through R&D. A salient feature of their model is that a union's utility is postulated as a geometric average of the wage and employment. They show that macroeconomic effects of globalization depend decisively on the relative weight of the wage in union preferences. We, on the contrary, prefer to stick to microfoundations and to derive union preferences from workers' preferences and seniority as follows. The workers differ in their probability of employment. The higher seniority a worker has, the less likely he loses his job when aggregate employment falls. Because union members vote for the management, the latter's utility is determined by the median member's preferences.

There are already many papers that suggest that expensive labour may speed up economic growth. Cahuc and Michel (1996) (using an OLG model), as well as Agell and Lommerud (1997) (using an extensive game framework) show that a minimum wage may create an incentive for workers to accumulate human capital. Palokangas (1996, 2000) introduces wage bargaining into Romer's (1990) product-variety model with skilled and unskilled workers. He shows that higher union bargaining power leads to higher wages for unskilled workers, higher unemployment for both skilled and unskilled workers in production, a lower wage for skilled workers. This decreases costs in R&D and promotes growth. All these papers, however, ignore the uncertainty that is embodied in technological change. To eliminate this shortcoming, we use here a Schumpeterian model of creative destruction.

The author uses a Schumpeterian model of creative destruction for problems of growth and trade also in two other papers. Palokangas (2004a) examines the growth and welfare effects of union power in a model where research firms learn from each other. It shows that the international coordination of labour market policy raises the workers' wages and promotes growth and welfare. Palokangas (2004b) examines the growth and welfare effects of the expansion of common markets when the labour markets are perfect but economies differ in the productivity of R&D. It shows that a small economy with low incentives to save do not growth at all, if left alone, but avoids stagnation if its R&D is productive enough to join a common market with a positive growth rate. In this study, we focus on two problems: the expansion strategy of a unionized common market and the effects of economic integration on the political economy of labour market regulation/deregulation.

The remainder of this paper is organized as follows. Section 2 explains the institutional background of the model. The basic structures of the model are presented in section 3. Section 4 considers a household's consumption and saving as a problem of stochastic dynamic programming. It results in the savings and investment functions for the economies.[5] Section 5 examines wage bargaining and Section 6 the growth and welfare effects of integration.

2 The setting

There is a common market with a given number J of member economies. Each of these economies contains one unit of land and a fixed number of similar households.[6] Competitive firms in the common market produce the consumption good from intermediate goods of all member economies. Intermediate-good firms in the common market are strategically interdependent. They are oligopolists which form expectations on each other's responses.

[5] The study focuses entirely on the households' stationary equilibrium in which the allocation of resources is invariable across technologies, and ignores the behaviour of the system during the transitional period before the equilibrium is reached. In this study, the growth model is based on a Poisson process. This means that if the initial state is chosen outside a stationary equilibrium, then the model would most likely generate cycles, which are technically extremely difficult to cope with.

[6] The purpose of this admittedly strong assumption is to allow us to make welfare comparisons, which would be extremely problematic with heterogeneous households.

All households are modelled as dynastic families which are risk averters and share identical preferences. The members of such a family can be either *workers*, who are employed in production, or *researchers*, who are employed in R&D. Family-optimization considerations determine the evolution of consumption expenditure over time, the allocation of savings across shares in different firms, and the decision whether a family member becomes a researcher or enters the labour force as a worker. A single family takes macroeconomic variables (e.g. prices, wages, profits and employment) as given.

In this framework, economic integration is equivalent to the increase in the size J of the common market. This increases the variety of products and intensifies the competition between the intermediate-good producers.

The structure of economy $j \in \{1, ..., J\}$ can be characterized as follows:

(i) One monopolist at a time produces the economy-specific intermediate good by workers. Several firms do R&D by using researchers and finance their expenditure by issuing shares. A research firm's technology is a random variable but the probability of its improvement in one unit of time is an increasing function of its investment in R&D. When a research firm in economy j is successful, it uses its new technology to drive the old producer out and starts producing good j itself. Its profits are then distributed among those who had financed it. When R&D is not successful for a firm, there is no profit and the *ex post* value of a share of the firm is zero.

(ii) The households decide their labour supply before entering the labour market. They save in shares in research firms of their home economies.

(iii) The workers are unionized and differ in seniority which affects the probability of employment. The labour union is able to control the whole of the intermediate good industry, including potential entrants, so that the change of the incumbent producer does not affect the union's bargaining position. Because the union's management is chosen by voting, its instantaneous utility is the median member's expected income. In wage bargaining, the labour union attempts to maximize the discounted value of the flow of its instantaneous utility and the employer federation the discounted value of the flow of the employers' profits.[7]

(iv) Direct subsidy to R&D is commonly non-feasible.[8] Given this, the government regulates union power as a second-best policy.

The growth model is based on a Poisson process. We focus entirely on the households' stationary equilibrium in which the allocation of resources is invariable across technologies, and ignore the behaviour of the system during the transitional period before the equilibrium is reached. If the initial state is chosen outside a stationary equilibrium, then the model would most likely generate cycles, which are technically extremely difficult to cope with.

3 The model

(a) Consumption-good firms. There is one consumption good in the common market and its price is normalized at unity. The representative consumption-good firm in the common market makes its output C from the quantity n_k of the intermediate goods and the quantity a_k of land throughout all economies k by CES technology as follows:

$$C = \left[\sum_{k=1}^{J} B_k^{1-1/\theta} \left(n_k^{1-1/\theta} + \gamma a_k^{1-1/\theta} \right) \right]^{\theta/(\theta-1)}, \tag{1}$$

where $\theta > 1$ is the constant elasticity of substitution and B_k the productivity parameter in economy k. The firm maximizes its profit taking the prices of

[7]Some papers assume that the expected wage outside the firm is the union's reference point, but this is not quite in line with the microfoundations of the alternating offers game. Binmore, Rubinstein and Wolinsky (1986) state (pp. 177, 185-6) that the the reference income should not be identified with the outside option point. Rather, despite the availability of these options, it remains appropriate to identify the reference income with the income streams accruing to the parties in the course of the dispute. For example, if the dispute involves a strike, these income streams are the employee's income from temporary work, union strike funds, and similar sources, while the employer's income might derive from temporary arrangements that keeps the business running.

[8]It is commonly suggested that in order to eliminate the externality due to R&D, the government should directly subsidize R&D. In reality, however, R&D is mostly carried out by research departments of companies that are also producing other goods, so that the government cannot completely distinguish between inputs being used in R&D and production. If R&D were subsidized, then it were in the interests of both employers and labour unions to hide costs of production under R&D expenditure and share the subsidy. For this discussion, see Palokangas (2000), chapter 8.

intermediate goods, p_k, and rents R_k throughout all economies k as given. This yields the equilibrium conditions

$$p_j = \partial C/\partial n_j = B_j^{1-1/\theta}(C/n_j)^{1/\theta}, \quad R_j/p_j = \gamma(n_j/a_j)^{1/\theta}. \tag{2}$$

Because economy j contains one unit of land, in equilibrium there must be

$$a_j = 1. \tag{3}$$

(b) Intermediate-good firms. There is one firm at a time as the incumbent producer of good j. It anticipates the reaction of the producers of the other goods $k \neq j$ by the function

$$C = \Phi(n_j, J), \quad \phi(J) \doteq \frac{n_j}{\Phi}\frac{\partial \Phi}{\partial n_j} < 1, \quad \phi' > 0. \tag{4}$$

The more there are competitors (i.e. the higher J), the more difficult it is to raise the price above unit cost (i.e. the higher the elasticity ϕ). One unit of intermediate good j is produced from one labour unit. The incumbent firm takes workers' wage w_j, aggregate consumption in the common market, C, and the productivity B_j as given and maximizes its profit

$$\pi_j \doteq p_j n_j - w_i n_j \tag{5}$$

by its labour input n_j subject to the inverse demand function in (2) and its expectations (4). Without potential competition from new entrants, the first-order condition of this maximization is given by

$$w_j = p_j + n_j \frac{\partial p_j}{\partial n_j} = p_j + \frac{p_j}{\theta}\Big(\frac{y_j}{\Phi}\frac{\partial \Phi}{\partial y_j} - 1\Big) = \Big[1 + \frac{\phi(J) - 1}{\theta}\Big]p_j.$$

This yields the monopoly price $p_j^m \doteq \theta/[\theta + \phi(J) - 1]$. Each new generation of good j provides constant $\varepsilon > 1$ times as many services as the product of the generation before it. if the previous incumbent, whose productivity is $1/\varepsilon$ times the productivity of the current incumbent, makes a positive profit $\pi_j = (1/\varepsilon)p_j^m n_j - w_j n_j > 0$ for the monopoly price p_j^m, then the current incumbent sets $p_j = \varepsilon w_j$ to prevent the others from entering the market. Hence, the firm applies the mark-up rule with

$$\varphi(J) \doteq \min\Big[\varepsilon, \frac{\theta}{\theta + \phi(J) - 1}\Big] > 1, \quad \varphi' < 0 \text{ for } \varphi < \varepsilon.$$

Economic integration (i.e. a higher J) decreases the mark-up factor φ through heavier international competition. From this and (2)-(5) it follows that

$$w_j = p_j/\varphi(J) = C^{1/\theta} B_j^{1-1/\theta} n_j^{-1/\theta} \varphi(J), \quad R_j = \gamma n_j^{1/\theta} p_j,$$
$$\pi_j = \big[\varphi(J) - 1\big] w_j n_j, \quad \varphi(J) > 1, \quad \varphi' < 0 \text{ for } \varphi < \varepsilon. \tag{6}$$

(c) Technological change. Economy j is subject to technological change which is characterized by a Poisson process q_j as follows. During a short time interval $d\tau$, there is an innovation $dq_j = 1$ with probability $\Lambda_j d\tau$, and no innovation $dq_j = 0$ with probability $1 - \Lambda_j d\tau$, where Λ_j is the arrival rate of innovations in the research process. We assume that the arrival rate Λ_j is in fixed proportion λ to the employment of researchers in the economy j, l_j:

$$\Lambda_j = \lambda l_j, \quad \lambda > 0. \tag{7}$$

We denote the serial number of technology in economy k by t_k. The level of productivity in the production of intermediate good k, $B_k(t_k)$, is determined by the currently most advanced technology t_k. The invention of a new technology raises t_k by one and the level of productivity $B_k(t_k)$ by $\varepsilon > 1$. This implies

$$B_k(t_k) = B_k(0)\varepsilon^{t_k}. \tag{8}$$

Because the average growth rate in economy k is in fixed proportion $(\log \varepsilon)$ to the arrival rate $\Lambda_k = \lambda l_k$ and l_k,[9] we can use research input l_k as a proxy of the growth rate of economy k.

(d) Employment and labour supply. Because each family can change its members' occupation from a worker to an researcher at some cost and the abilities of all individuals in economy j differ, there is a decreasing and convex transformation function between the supply of workers, N_j, and the supply of researchers, L_j, as follows:

$$N_j = N(L_j), \quad N' < 0, \quad N'' < 0. \tag{9}$$

Hence, more and more workers must be transformed in order to create one more research input. A worker's expected wage is equal to the wage w_j times

[9] For this, see Aghion and Howitt (1998), p. 59.

the likelihood of employment, n_j/N_j:

$$w_j^e \doteq (n_j/N_j)w_j, \tag{10}$$

Because researchers are not unionized, they are always fully employed,

$$l_j = L_j, \tag{11}$$

and their expected wage is equal to the wage v_j.

Because households must choose their combination (L_j, N_j) of labour supply before entering the labour market, this choice is based on the transformation function (9) and the expected wages (v_j, w_j^e) which the household takes as given. This equilibrium is found by maximizing expected income $v_jL_j + w_j^eN_j = v_jL_j + w_j^eN(L_j)$ by L_j, which yields the first order condition $v_j/w_j^e = -N'(L_j)$. This condition, (9), (10) and (11) yield

$$-\frac{N'(l_j)}{N(l_j)} = -\frac{N'(L_j)}{N(L_j)} = \frac{v_j}{w_j^e N_j} = \frac{v_j}{w_j n_j}. \tag{12}$$

4 Consumption and saving

Economy j contains a fixed number κ of similar households that are dynastic families. Each family consist of both workers and researchers.[10] The utility for household $\ell \in \{1, ..., \kappa\}$ in economy j from an infinite stream of consumption beginning at time T is given by

$$U_j(C_{j\ell}, T) = E\int_T^\infty C_{j\ell}^\sigma e^{-\rho(\tau-T)}d\tau \text{ with } 0 < \sigma < 1 \text{ and } \rho > 0, \tag{13}$$

where τ is time, E the expectation operator, $C_{j\ell}$ consumption, ρ the rate of time preference and $1/(1-\sigma)$ is the constant rate of relative risk aversion.

Because only researchers are used in R&D, investment expenditure in economy j is equal to labour cost v_jl_j, where l_j is the researchers' employment and v_j their wage. We assume, for simplicity, that households purchase only shares of the firms operating in the same economy:

$$\sum_{\ell=1}^{\kappa} S_{j\ell} = v_jl_j, \tag{14}$$

[10] See footnote 6.

where $S_{j\ell}$ is saving by household ℓ in economy j. When household ℓ has financed a successful R&D project, it acquires the right to a certain share of profits the successful firm earns in the production of final goods. Since the old producer is driven out of the market, all shares held in it lose their value. We denote by $s_{j\ell}$ the true profit share of household ℓ when the uncertainty of the outcome of the projects are taken into account. These shares throughout all households in economy j sum up to one:

$$\sum_{\ell=1}^{\kappa} s_{j\ell} = 1. \tag{15}$$

Following Wälde (1999), we assume that the change in this share, $ds_{j\ell}$, is a function of the increment dq_j of a Poisson process q_j as:

$$ds_{j\ell} = (i_{j\ell} - s_{j\ell})dq_j \text{ with } i_{j\ell} \doteq S_{j\ell}/(v_j l_j), \tag{16}$$

where $v_j l_j$ total investment expenditure in economy j and $i_{j\ell}$ the true investment share of household ℓ. When a household does not invest in the upcoming vintage, its share holdings are reduced to zero in the case of research success $dq_j = 1$. If it invests, then the amount of share holdings depends on its relative investment in the vintage.

Labour income in economy j is equal to wages paid in production and R&D, $w_j n_j + v_j l_j$. The total income of household $\ell \in \{1, ..., \kappa\}$ in economy j, $A_{j\ell}$, consists of an equal share $1/\kappa$ of wages and rents $w_j n_j + v_j l_j + R_j a_j$ and the share $s_{j\ell}$ of the profits of the intermediate-good firm, π_j:[11]

$$A_{j\ell} \doteq (v_j l_j + w_j n_j + R_j a_j)/\kappa + s_{j\ell}\pi_j. \tag{17}$$

Because the price of the consumption good is normalized at unity, the budget constraint of household ℓ in economy j is given by

$$A_{j\ell} = C_{j\ell} + S_{j\ell}, \tag{18}$$

where $C_{j\ell}$ is consumption and $S_{j\ell}$ saving.

We denote the value of receiving a share $s_{j\ell}$ of the profits of the monopolists using current technology t_j by $\Omega(s_{j\ell}, t_j)$, and the value of receiving a share $i_{j\ell}$ of the profits of the monopolists of the next generation by

[11] Because the consumption-good firms are subject to technology (1) with constant returns to scale, in equilibrium they have no profits to be distributed to households.

$\Omega(i_{j\ell}, t_j + 1)$. Household ℓ maximizes its utility (13) subject to stochastic process (16) and the budget constraint (18) by its saving $S_{j\ell}$, given wages (w_j, v_j), profits π_j, employment (n_j, l_j) and the arrival rate of innovations Λ_j. This maximization leads to the Bellman equation[12]

$$\rho\Omega(s_{j\ell}, t_j) = \max_{S_{j\ell}} \big\{ C_{j\ell}^{\sigma} + \Lambda_j [\Omega(i_{j\ell}, t_j + 1) - \Omega(s_{j\ell}, t_j)] \big\}, \tag{19}$$

where $C_{j\ell} = A_{j\ell} - S_{j\ell}$ and Λ_j is determined by (7). The first order condition associated with the Bellman equation (19) is given by

$$\Lambda_j \frac{d}{dS_{j\ell}} [\Omega(i_{j\ell}, t_j + 1) - \Omega(s_{j\ell}, t_j)] = \sigma C_{j\ell}^{\sigma-1}. \tag{20}$$

We try the solution that consumption expenditure $C_{j\ell}$ is a share $0 \leq c_{j\ell} \leq 1$ out of income $A_{j\ell}$, and the value function is of the form $\Omega = (c_{j\ell} A_{j\ell})^{\sigma} / r_{j\ell}$, where the consumption-income ratio $c_{j\ell}$ and the (subjective) interest rate $r_{j\ell}$ are independent of income $A_{j\ell}$. Inserting that solution into (19) and (20), we obtain the following results for economy j (Appendix A). First, every innovation that replaces technology t_j by $t_j + 1$ raises consumption C_j and domestic output y_j in economy j as follows:

$$C^{t_j+1} / C^{t_j} = \varepsilon^{1-1/\theta} > 1. \tag{21}$$

Second, workers' employment n_j is determined by

$$n_j = n(l_j, J), \quad \frac{\partial n}{\partial J} < 0, \quad \frac{\partial}{\partial J}\left[\frac{1}{n_j}\frac{\partial n}{\partial l_j}\right] > 0 \;\Leftrightarrow\; \frac{\partial n}{\partial l_j} < 0. \tag{22}$$

Economic integration (i.e. the increase in J) intensifies competition from abroad and thereby reduces workers' employment n_j.

5 Wage bargaining

In each economy j, the workers' wage w_j is determined by bargaining between a union representing workers in economy j and a federation representing employers of these workers. These control the whole intermediate-good industry inclusive of the possible entrants. We assume, for simplicity, that both the

[12] Cf. Dixit and Pindyck (1994).

labour union and the employed federation are risk neutral, have the same rate of time preference $\varrho > 0$, and their reference income is zero.[13]

Because workers differ in seniority, they face different probability of employment. The probability that a worker of seniority β is employed, when the total rate of employment is n_j/N_j, is therefore given by (see figure 1)

$$f(\beta)\frac{n_j}{N_j}, \quad f' < 0, \quad f(0) > 1, \quad f(N_j) < 1, \quad \int_0^{N_j} f(\beta)d\beta = N_j. \tag{23}$$

The property $f' < 0$ tells that the more senior a worker (i.e. the smaller β), the less likely he loses his job when the total rate of employment, n_j/N_j, falls. If all workers were homogeneous (i.e. $f(\beta) \equiv 1$), they all would have the same probability n_j/N_j of employment, as characterized by line aa. Because senior workers (with a small β) have a higher probability of employment than junior workers (with a high β), the function f must be decreasing. Because the employment probability for a worker cannot be above one, the function SS must be below one.

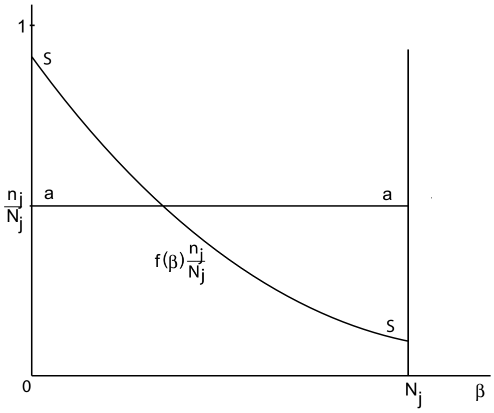

Figure 1: A worker's expected employment.

If all N_j workers are unionized, then the median member of the union is the worker of seniority $N_j/2$, his probability of employment is given by $f(N_j/2)n_j/N_j$, and his expected income by $w_j f(N_j/2)n_j/N_j$, which is also the union's instantaneous utility. The union attempts then to maximize the expected value $\mathcal{U}_j$ of the stream of $w_j f(N_j/2)n_j/N_j$, while the federation

[13]See footnote 7.

attempts to maximize the expected value $\mathcal{F}_j$ of the stream of employers' profits π_j, taking total consumption in the common market, C, as given. Given the result (6) and (21) and the stochastic technological progress (see section 3c), these targets take the form:[14]

$$\mathcal{U}_j(l_j, C) \doteq E\int_0^\infty e^{-\varrho\tau} w_j f(N_j/2)\frac{n_j}{N_j}d\tau = \frac{B_j(0)^{1-1/\theta} w_j f(N_j/2) n_j/N_j}{B_j^{1-1/\theta}\left[\varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j\right]} > 0,$$

$$\mathcal{F}_j(l_j, C) \doteq E\int_0^\infty e^{-\varrho\tau}\pi_j d\tau = \frac{B_j(0)^{1-1/\theta}\pi_j}{B_j^{1-1/\theta}\left[\varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j\right]} > 0. \tag{24}$$

There is one-to-one correspondence from w_j to l_j through (6) and (22) as

$$w_j = C^{1/\theta} B_j^{1-1/\theta} n(l_j, J)^{-1/\theta}\varphi(J).$$

Hence, in the model of bargaining, w_j can be replaced by l_j as the instrument of bargaining. The outcome of bargaining is then obtained through maximizing the Generalized Nash Product $\mathcal{U}_j^{\alpha_j}\mathcal{F}_j^{1-\alpha_j}$, where constant $\alpha_j \in (0,1)$ is relative union bargaining power, by l_j, keeping C constant. This maximization proves (Appendix B):

Proposition 1 *Workers' and researchers' employment are negatively dependent, $\partial n/\partial l_j < 0$. Higher union power α_j and economic integration (i.e. a bigger J) promote R&D and growth, $l_j = \Theta(\alpha_j, J)$, $\partial\Theta/\partial\alpha_j > 0$, $\partial\Theta/\partial J > 0$.*

Union power raises workers' wage w_j but lowers their employment n_j and expected wage (= the wage times the employment rate) w_j^e. With a lower relative expected wage for a worker, more households choose to become researchers rather than workers (i.e. l_j increases). A higher number of researchers promotes R&D and growth. Economic integration (i.e. a higher J) decreases workers' employment n_j and their expected wage, more households choose to become researchers (i.e. l_j increases) and the growth rate increases.

6 Social welfare

The average level of productivity in the consumption-good sector is given by

$$B \doteq \left[\frac{1}{J}\sum_{k=1}^{J} B_k^{1-1/\theta}\right]^{\theta/(\theta-1)}. \tag{25}$$

[14]For this, see e.g. Aghion and Howitt (1998), p. 61.

Because there is symmetry throughout economies $j = 1, .., J$, there exists an equilibrium with $\alpha_j = \alpha$, $l_j = l$ and $B_j = B$. In that equilibrium, noting (7), the average growth rate of consumption (= the arrival rate of jumps $\varepsilon > 1$ in the level of productivity in the consumption-good sector) is given by

$$\Lambda \doteq \frac{\partial B}{\partial B_k}\Lambda_k\bigg|_{B_k=B} = \frac{1}{J}\sum_{k=1}^{J}\left(\frac{B}{B_k}\right)^{1/\theta}\bigg|_{B_k=B}\Lambda_k = \frac{1}{J}\sum_{k=1}^{J}\Lambda_k = \lambda l.$$

We denote the serial number of consumption technology by t. Choosing $B(0) = 1$, we then obtain $B = \varepsilon^t$. Noting this, proposition 1 and results (1), (3), (22) and (25), we can define consumption per economy in the common market as follows:

$$\frac{C}{J} = \chi(l,J)\left[\frac{1}{J}\sum_{k=1}^{J}B_k^{1-1/\theta}\right]^{\theta/(\theta-1)} = J^{1/(\theta-1)}\chi(l,J)B = J^{1/(\theta-1)}\varepsilon^t\chi(l,J),$$
$$\chi(l,J) \doteq \left[n(l,J)^{1-1/\theta}+\gamma\right]^{\theta/(\theta-1)} > n, \quad \frac{\partial\chi}{\partial J} = \left(\frac{\chi}{n}\right)^{1/\theta}\frac{\partial n}{\partial J} < 0,$$
$$\frac{\partial\chi}{\partial l} = \left(\frac{\chi}{n}\right)^{1/\theta}\frac{\partial n}{\partial l} < 0, \quad \frac{1}{\chi}\frac{\partial\chi}{\partial l} = \left(\frac{\chi}{n}\right)^{1/\theta-1}\frac{1}{n}\frac{\partial n}{\partial l}. \tag{26}$$

Differentiating the logarithm of the last equation and noting (22), we obtain

$$\frac{\partial}{\partial J}\left[\frac{1}{\chi}\frac{\partial\chi}{\partial l}\right] = \overbrace{\left(1-\frac{1}{\theta}\right)}^{+}\left[\frac{1}{n}\frac{\partial n}{\partial J} - \overbrace{\frac{1}{\chi}}^{+}\frac{\partial\chi}{\partial J}\right]\overbrace{\frac{1}{\chi}}^{+}\overbrace{\frac{\partial\chi}{\partial l}}^{-} + \overbrace{\frac{1}{\chi}\left(\frac{\chi}{n}\right)^{1/\theta-1}}^{+}\overbrace{\frac{\partial}{\partial J}\left[\frac{1}{n}\frac{\partial n}{\partial l}\right]}^{+}$$
$$> \left(1-\frac{1}{\theta}\right)\left[\frac{1}{n}\frac{\partial n}{\partial J} - \frac{1}{\chi}\left(\frac{\chi}{n}\right)^{1/\theta}\frac{\partial n}{\partial J}\right]\frac{1}{\chi}\frac{\partial\chi}{\partial l}$$
$$= \underbrace{\left(1-\frac{1}{\theta}\right)}_{+}\left[1-\underbrace{\left(\frac{n}{\chi}\right)^{1-1/\theta}}_{<1}\right]\underbrace{\frac{1}{n}}_{+}\underbrace{\frac{\partial n}{\partial J}}_{-}\frac{1}{\chi}\underbrace{\frac{\partial\chi}{\partial l}}_{-} > 0. \tag{27}$$

Because the number of households in the whole common market is constant $J\kappa$, then, given (13) and (26), the utility of the representative consumer in the common market can be written as follows [cf. $C_{j\ell} = C/(J\kappa)$]:

$$U = E\int_T^\infty\left(\frac{C}{J\kappa}\right)^\sigma e^{-\rho(\tau-T)}d\tau = \kappa^{-\sigma}E\int_T^\infty J^{\sigma/(\theta-1)}\chi(l,J)^\sigma\varepsilon^{\sigma t}e^{-\rho(\tau-T)}d\tau. \tag{28}$$

Following Blanchard and Giavazzi (2003), we assume that the common market is able to fully control union power α in its jurisdiction (e.g. through compulsory meadiation). The social planner in the common market then maximizes social welfare (28) by α. Because the number of researchers l depends on union power α through proposition 1, α can be replaced by $l_j = l$ (which also proxies the growth rate) as the instrument of maximization.

To examine the optimal policy of integration, assume first that the common market can expand smoothly by taking small new members in. In such a case, the social planner can use both l_j and the size of the common market, J, as policy instruments. Denoting the value of the state of technology t for this planner by $\Upsilon(t)$, and noting proposition 1 and results (7) and (26), we obtain the Bellman equation for integration policy as (constant $\kappa^{-\sigma}$ omitted):

$$\begin{aligned}&\rho\Upsilon(t,J) = \max_{J,l} \mathcal{Q}(l,J,t), \text{ where} \\ &\mathcal{Q} \doteq J^{\sigma/(\theta-1)}\chi(l,J)^{\sigma}\varepsilon^{\sigma t} + \lambda l[\Upsilon(t+1) - \Upsilon(t)].\end{aligned} \tag{29}$$

We define $(J^*, l^*) = \arg\max_{J,l} \mathcal{Q}(l,J,t)$. This, (26) and (29) yield

$$J^* = \arg\max_J \mathcal{Q}(l^*,J,t) = \arg\max_J \left[J^{\sigma/(\theta-1)}\chi(l^*,J)\right] = \arg\max_J [C/(J\kappa)]_{l=l^*}.$$

This result can be rephrased as follows:

Proposition 2 *A common market should expand as long as this increases consumption per capita, $C/(J\kappa)$.*

If the common market can control its growth rate through union power, then the integration of new members can be wholly determined by the maximization of current consumption with no concern of economic growth.

Second, consider labour union policy in an expanding common market. We can then exploit the model above on the assumption that the size J of the common market is exogenous. The Bellman equation for this policy is

$$\rho\Upsilon(t,J) = \max_l \mathcal{Q}(l,J,t). \tag{30}$$

Noting (29), the first-order condition corresponding to (30) is given by

$$\frac{\partial \mathcal{Q}}{\partial l}(l,J,t) = \sigma J^{\sigma/(\theta-1)}\chi^{\sigma}\varepsilon^{\sigma t}\frac{1}{\chi}\frac{\partial \chi}{\partial l} + \lambda[\Upsilon(t+1) - \Upsilon(t)] = 0. \tag{31}$$

We consider the situation in the neighbourhood of the optimal common market for which

$$J = \arg\max_J \mathcal{Q} = \arg\max_J \left[J^{\sigma/(\theta-1)} \chi^\sigma(l,J) \right]. \tag{32}$$

The interpretation of this is the following. The common market adjusts first its size J to the optimal level by accepting new members. After this, it starts to consider what to do with union power.

From (26), (27), (31) and (32) it follows that

$$\frac{\partial^2 \mathcal{Q}}{\partial l \partial J} = \sigma \varepsilon^{\sigma t} \frac{1}{\chi} \frac{\partial \chi}{\partial l} \underbrace{\frac{\partial}{\partial J} \left[J^{\sigma/(\theta-1)} \chi^\sigma \right]}_{\approx 0} + \underbrace{\sigma J^{\sigma/(\theta-1)} \chi^\sigma \varepsilon^{\sigma t}}_{+} \underbrace{\frac{\partial}{\partial J} \left[\frac{1}{\chi} \frac{\partial \chi}{\partial l} \right]}_{+} > 0.$$

Given this and the second-order condition $\partial^2 \mathcal{Q}/\partial l^2 < 0$, the comparative statics of the first-order condition (31) yields:

Proposition 3 *If the common market is close to its optimal size, then its expansion (i.e. a bigger J) promotes R&D and speeds up growth:*

$$\frac{dl}{dJ} = -\frac{\partial^2 \mathcal{Q}}{\partial l \partial J} \bigg/ \frac{\partial^2 \mathcal{Q}}{\partial l^2} > 0. \tag{33}$$

Intensified competition with integration decreases the demand for workers' labour (cf. (22)). There are then more resources for R&D and growth.

Finally, noting proposition 1 and result (33), we obtain

$$\frac{d\alpha}{dJ} = \left(\frac{dl}{dJ} - \frac{\partial \Theta}{\partial J} \right) \bigg/ \frac{\partial \Theta}{\partial \alpha_j} < 0 \quad \Leftrightarrow \quad \frac{dl}{dJ} > \frac{\partial \Theta}{\partial J} \quad \Leftrightarrow \quad \frac{J}{l} \frac{dl}{dJ} > \frac{J}{l} \frac{\partial \Theta}{\partial J}, \tag{34}$$

where $(J/l)dl/dJ$ is the elasticity of R&D with respect to the variety of products when union power α is not used as a control variable, and $(J/l)\partial\Theta/\partial J$ is the elasticity of R&D with respect to the variety of products when union power α is used as a control variable. These results can be rephrased as:

Proposition 4 *If the competition effect of integration (i.e. the direct effect of J on Θ) is strong enough, $\partial\Theta/\partial J > dl/dJ$, then integration causes political pressure to weaken labour unions (i.e. to decrease α). If it is weak enough, $\partial\Theta/\partial J < dl/dJ$, then there is political pressure to strengthen labour unions.*

If the increase in international competition due to economic integration increases R&D more than what is desirable from the social point of view, then excess R&D must be eliminated by weakening labour unions. If vice versa, then R&D must be raised to the socially desirable level by strengthening labour unions. The elasticity rule (34) can be used to specify the necessity of labour market regulation/deregulation, if there are good empirical proxies for union power α and the variety of products, J.[15]

7 Conclusions

This paper examines a common market with the following properties. First, the expansion of the common market increases the variety of products and intensifies competition in the goods market. Second, growth is generated by creative destruction. A firm creating the latest technology through a successful R&D project crowds the other firms with older technologies out of the market so that they lose their value. Third, households save by buying shares in R&D projects. Fourth, households decide whether their members are researchers who are used in R&D, or workers who are employed in production. A change of occupation involves a cost. Fifth, direct subsidy to R&D is commonly non-feasible. Sixth, wages are determined by union-employer bargaining. Seventh, workers differ in seniority. The results are as follows.

Union power has a positive impact on the growth rate, but a negative impact on current income. With higher union power, workers' wages increase, but their employment and expected wage falls, and more households choose to become researchers rather than workers. With lower employment for workers, current output and income is smaller. On the other hand, with a larger

[15] The following papers proxy α by the unionization rate (i.e. the ratio of unionized to all workers). Addison and Wagner (1994) find a positive cross-sectional correlation, but Menezes-Filho et.al. (1998) find little correlation in a panel of firms, between $R\&D$ and the unionization rate in the UK. On the other hand, Connolly et.al. (1986), Hirsch (1990, 1992), Bronars et.al. (1994) find a negative cross-sectional correlation between these in the USA, and Betts et.al. (2001) in Canada. Hence, the results seem to be institution-specific. There are, however, good reasons to believe that unionization rate is not a proper proxy for union power in wage bargaining. In many (mainly European) countries, the contract made by the representative union is extended to cover the whole industry. In such a case, the unionization rate is insignificant. In some other countries (e.g. USA, Canada), unions can make agreements only for their members and a unionized worker can be easily replaced by a non-unionized worker. In such a case, the unionization rate may affect $R\&D$.

number of researchers, there will be more innovations and a higher growth rate in future. The welfare effect of union power is positive (negative) if the latter effect through growth dominates (is dominated by) the former effect through employment. Union power and the growth rate are socially optimal when the growth and employment effects exactly outweigh each other. When the common market takes new members, R&D and the growth rate increase. In such a case, workers' expected wage falls, more households choose to become researchers rather than workers, and R&D increases.

The stronger the unions, the more there is R&D and the higher the growth rate. Union power raises workers' wage but decreases their employment. Employment however falls so much relative to the wage increase that workers' expected wage (= the wage times the employment rate) falls, more households choose to become researchers rather than workers and a higher number of researchers promotes R&D and economic growth.

If a common market can fully control union power in its jurisdiction, it should expand as long as this increases its consumption per capita. Because it can control its growth rate through union power, the integration of new members can be wholly judged by the maximization of current consumption with no concern of economic growth.

If economic integration intensifies competition in the product markets much enough, then integration causes political pressure to labour market deregulation. In such a case, R&D after integration is higher than what is desirable from the social point of view, and excess R&D must be eliminated by weakening labour unions. If economic integration intensifies competition only very moderately, then there is political pressure to labour market regulation. In such a case, R&D must be raised to the socially desirable level by strengthening labour unions. If there are good empirical proxies for union power and the variety of products, then there is an elasticity rule by which the decision between deregulation and regulation in the labour market can be judged.

By the results of this paper, we can judge the following. Intensified competition in the goods markets due to economic integration is the likely cause for the observed deunionization during the last two decades.

Appendix A

Let us denote variables depending on technology t_j by superscript t_j. Since according to (17) income $A^{t_j}_{j\ell}$ depends directly on the share $s^{t_j}_{j\ell}$, we denote $A^{t_j}_{j\ell}(s^{t_j}_{j\ell})$. Guessing that $c_{j\ell}$ is invariant across technologies, we obtain

$$C^{t_j}_{j\ell} = c_{j\ell} A^{t_j}_{j\ell}(s^{t_j}_{j\ell}), \quad S^{t_j}_{j\ell} = (1 - c_{j\ell}) A^{t_j}_{j\ell}(s^{t_j}_{j\ell}). \tag{35}$$

The share in the next producer $t_j + 1$ is determined by investment under technology t_j, $s^{t_j+1}_{j\ell} = i^{t_j}_{j\ell}$. The value functions are then given by

$$\Omega(s^{t_j}_{j\ell}, t_j) = (C^{t_j}_{j\ell})^{\sigma}/r_{j\ell}, \quad \Omega(i^{t_j}_{j\ell}, t_j + 1) = (C^{t_j+1}_{j\ell})^{\sigma}/r_{j\ell}. \tag{36}$$

Given this, we obtain

$$\partial\Omega(s^{t_j}_{j\ell}, t_j)/\partial S^{t_j}_{j\ell} = 0. \tag{37}$$

From (16), (17), (35) and (36) it follows that

$$\begin{gathered}
\frac{\partial i^{t_j}_{j\ell}}{\partial S^{t_j}_{j\ell}} = \frac{1}{v^{t_j}_j l^{t_j}_j}, \quad \frac{\partial[A^{t_j+1}_{j\ell}(i^{t_j}_{j\ell})]}{\partial i^{t_j}_{j\ell}} = \frac{\partial[A^{t_j+1}_{j\ell}(s^{t_j+1}_{j\ell})]}{\partial s^{t_j+1}_{j\ell}} = \pi^{t_j+1}_j, \\
\frac{\partial\Omega(i^{t_j}_{j\ell}, t_j + 1)}{\partial S^{t_j}_{j\ell}} = \frac{\sigma}{r_{j\ell}}(C^{t_j+1}_{j\ell})^{\sigma-1} \frac{\partial C^{t_j+1}_{j\ell}}{\partial A^{t_j+1}_{j\ell}} \frac{\partial A^{t_j+1}_{j\ell}}{\partial i^{t_j}_{j\ell}} \frac{\partial i^{t_j}_{j\ell}}{\partial S^{t_j}_{j\ell}} = \sigma \frac{c_{j\ell}(C^{t_j+1}_{j\ell})^{\sigma-1}\pi^{t_j+1}_j}{r_{j\ell} v^{t_j}_j l^{t_j}_j}.
\end{gathered} \tag{38}$$

We focus on a stationary equilibrium where the allocation of labour, $(l^{t_j}_j, n^{t_j}_j)$, is invariant across technologies. Given (9), this implies

$$l^{t_j}_j = l_j, \quad n^{t_j}_j = n_j, \quad N_j = N(L_j) = N(l_j). \tag{39}$$

We assume that households in economy j take aggregate consumption in the whole common market, C, as exogenously given. Given this and (6), it then follows that

$$w^{t_j+1}_j / w^{t_j}_j = (B^{t_j+1}_j / B^{t_j}_j)^{1-1/\theta}.$$

Noting this, (8), (17), (35) and (39), we obtain

$$\begin{aligned}
C^{t_j+1}_{j\ell}/C^{t_j}_{j\ell} &= A^{t_j+1}_{j\ell}/A^{t_j}_{j\ell} = v^{t_j+1}_j/v^{t_j}_j = \pi^{t_j+1}_j/\pi^{t_j}_j \\
&= w^{t_j+1}_j/w^{t_j}_j = (B^{t_j+1}_j/B^{t_j}_j)^{1-1/\theta} = \varepsilon^{1-1/\theta} > 1.
\end{aligned} \tag{40}$$

Inserting (7), (36) and (40) into the equation (19), we obtain

$$\begin{aligned}
0 &= (\rho+\Lambda_j)\Omega(s_{j\ell}^{t_j}, t_j) - (C_{j\ell}^{t_j})^\sigma - \Lambda_j \Omega(i_{j\ell}^{t_j}, t_j+1) \\
&= (\rho+\Lambda_j)(C_{j\ell}^{t_j})^\sigma / r_{j\ell} - (C_{j\ell}^{t_j})^\sigma - \Lambda_j (C_{j\ell}^{t_j+1})^\sigma / r_j \\
&= (C_{j\ell}^{t_j})^\sigma [\rho + \Lambda_j - r_{j\ell} - \varepsilon^{(1-1/\theta)\sigma}\Lambda_j]/r_{j\ell} \\
&= (C_{j\ell}^{t_j})^\sigma \big\{\rho - r_{j\ell} + [1-\varepsilon^{(1-1/\theta)\sigma}]\lambda l_j\big\}/r_{j\ell}.
\end{aligned}$$

This implies

$$r_j = r_{j\ell} = \rho + [1-\varepsilon^{(1-1/\theta)\sigma}]\lambda l_j > 0. \tag{41}$$

From (12) it follows that

$$v_j^{t_j}/(w_j^{t_j} n_j) = -N'(l_j)/N(l_j). \tag{42}$$

Inserting (6), (7) and (37)-(42) into (20) yields

$$\begin{aligned}
0 &= \lambda l_j \frac{\partial \Omega(i_{j\ell}^{t_j}, t_j+1)}{\partial S_{j\ell}^{t_j}} - \sigma (C_{j\ell}^{t_j})^{\sigma-1} = \lambda l_j \sigma c_{j\ell} \frac{(C_{j\ell}^{t_j+1})^{\sigma-1}\pi_j^{t_j}}{r_j v_j^{t_j} l_j} - \sigma (C_{j\ell}^{t_j})^{\sigma-1} \\
&= \sigma (C_{j\ell}^{t_j})^{\sigma-1}\Big[\lambda c_{j\ell}\varepsilon^{(1-1/\theta)(\sigma-1)}\frac{\pi_j^{t_j}}{r_j v_j^{t_j}} - 1\Big]
\end{aligned}$$

and

$$\begin{aligned}
c_{j\ell} &= \varepsilon^{(1/\theta-1)(\sigma-1)}\frac{r_j v_j^{t_j}}{\lambda \pi_j^{t_j}} = \varepsilon^{(1/\theta-1)(\sigma-1)}\frac{\rho/\lambda + [1-\varepsilon^{(1-1/\theta)\sigma}]l_j}{(\varepsilon-1)N(l_j)/[-N'(l_j)]} \doteq c(l_j), \\
\frac{dc}{dl} &= \Bigg\{\underbrace{\frac{1-\varepsilon^{(1-1/\theta)\sigma}}{\rho/\lambda + [1-\varepsilon^{(1-1/\theta)\sigma}]l_j}}_{-} + \underbrace{\frac{N''}{N'} - \frac{N'}{N}}_{+}\Bigg\} c_j \gtrless 0.
\end{aligned} \tag{43}$$

Given (6), (14), (15), (17), (35), (42) and (43), we obtain

$$\begin{aligned}
\frac{v_j l_j}{1-c(l_j)} &= \frac{1}{1-c(l_j)}\sum_{\ell=1}^{\kappa} S_{j\ell} = \sum_{\ell=1}^{\kappa}\frac{S_{j\ell}}{1-c(l_j)} = \sum_{\ell=1}^{\kappa}\frac{S_{j\ell}}{1-c_{j\ell}} = \sum_{\ell=1}^{\kappa} A_{j\ell} \\
&= v_j l_j + w_j n_j + R_j a_j + \pi_j = v_j l_j + (1+\gamma n_j^{1/\theta-1})\varphi(J) w_j n_j,
\end{aligned}$$

which is equivalent to $v_j l_j = [1/c(l_j) - 1]\varphi(J)(1+\gamma n_j^{1/\theta-1}) w_j n_j$. From this and (12) it follows that

$$\varphi(J)\underbrace{(1+\gamma n_j^{1/\theta-1})}_{>1} = \frac{v_j l_j/(w_j n_j)}{1/c(l_j)-1} = \frac{-(N'/N) l_j}{1/c(l_j)-1} = \frac{c_j(l_j) l_j[-N'(l_j)]}{[1-c_j(l_j)]N(l_j)} \doteq \delta(l_j),$$

where, given (43), the sign of the derivative δ' is ambiguous. This equation and (6) show that $\delta > \varphi > 1$. Solving for n_j, we obtain

$$n_j = n(l_j, J) = \gamma^{1/(1-1/\theta)}[\delta(l_j) - \varphi(J)]^{1/(1/\theta-1)}\varphi(J)^{1/(1-1/\theta)}.$$

Differentiating the logarithm of this equation totally, we obtain

$$\frac{dn_j}{n_j} = \frac{1}{1-1/\theta}\left[\frac{\varphi'(J)}{\varphi(J)}dJ - \frac{\delta'(l_j)dl_j - \varphi'(J)}{\delta(l_j) - \varphi(J)}\right].$$

Noting this and (6), we obtain partial derivatives

$$\frac{\partial n}{\partial l_j} = \underbrace{\frac{1}{1/\theta - 1}}_{-}\underbrace{\frac{n(l_j, J)}{\delta(l_j) - \varphi(J)}}_{+}\delta'(l_j) < 0 \;\;\Leftrightarrow\;\; \delta' > 0,$$

$$\frac{\partial n}{\partial J} = \underbrace{\frac{\varphi'(J)}{1 - 1/\theta}}_{-}\underbrace{n(l_j, J)}_{+}\left[\underbrace{\frac{1}{\varphi(J)}}_{+} + \underbrace{\frac{1}{\delta(l_j) - \varphi(J)}}_{+}\right] < 0,$$

$$\frac{\partial}{\partial J}\left[\frac{1}{n_j}\frac{\partial n}{\partial l_j}\right] = \underbrace{\frac{\varphi'}{1/\theta - 1}}_{+}\underbrace{\frac{1}{(\delta - \varphi)^2}}_{+}\delta' > 0 \;\;\Leftrightarrow\;\; \delta' > 0 \;\;\Leftrightarrow\;\; \frac{\partial n}{\partial l_j} < 0.$$

Appendix B

Given this, (6), (9), (11), (22) and (24), the logarithm of the Generalized Nash product $\mathcal{U}_j^\alpha \mathcal{F}_j^{1-\alpha}$ takes the form

$$\begin{aligned}
\Gamma_j(l_j, C, \alpha_j, \theta) &\doteq \log\big[\mathcal{U}_j^\alpha \mathcal{F}_j^{1-\alpha}\big] = \alpha_j \log \mathcal{U}_j + (1-\alpha_j)\log \mathcal{F}_j \\
&= \alpha_j \log\big[w_j f(N_j/2)(n_j/N_j)B_j^{1/\theta-1}\big] + (1-\alpha_j)\log\big[\pi_j B_j^{1/\theta-1}\big] \\
&\quad - \log\big[\varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j\big] \\
&= \alpha_j \log\big[w_j f(N_j/2)(n_j/N_j)B_j^{1/\theta-1}\big] + (1-\alpha_j)\log\big[w_j n_j B_j^{1/\theta-1}\big] \\
&\quad - \log[\varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j] + \Delta \\
&= \log\big[w_j n_j B_j^{1/\theta-1}\big] + \alpha_j \log\, f(N_j/2) - \alpha_j \log\, N_j \\
&\quad - \log\big[\varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j\big] + \Delta \\
&= (1-1/\theta)\log\, n_j + \alpha_j \log\, f(N_j/2) - \alpha_j \log\, N_j \\
&\quad - \log\big[\varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j\big] + \Delta
\end{aligned}$$

$$
\begin{aligned}
&= (1-1/\theta)\log n(l_j,J) + \alpha_j \log f\big(N(l_j/2)\big) - \alpha_j \log N(l_j) \\
&\quad - \log\big[\varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j\big] + \Delta \\
&\text{with } \varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j > 0, \qquad (44)
\end{aligned}
$$

where Δ denotes terms that are independent of n_j and l_j. Because a logarithm is an increasing transformation, the outcome of bargaining is obtained through maximizing the function (44) by l_j, taking C as given. Given (9), (23), (44), $\varepsilon > 1$ and $\theta > 1$, this leads to the first-order condition

$$
\begin{aligned}
\frac{\partial \Gamma_j}{\partial l_j} &= \alpha_j \left[\overbrace{\frac{1}{2}\frac{f'(N(l_j)/2)}{f(N(l_j)/2)} - \frac{1}{N(l_j)}}^{-}\right] \overbrace{N'(l_j)}^{-} + \overbrace{\frac{(\varepsilon^{1-1/\theta}-1)\lambda}{\varrho + (1-\varepsilon^{1-1/\theta})\lambda l_j}}^{+} \\
&\quad + \underbrace{\left(1-\frac{1}{\theta}\right)}_{+} \underbrace{\frac{1}{n(l_j,J)}}_{+} \frac{\partial n}{\partial l_j}(l_j,J) = 0. \qquad (45)
\end{aligned}
$$

This implies $\partial n/\partial l_j < 0$. Furthermore, the equation (45) defines the function $l_j = \Theta(\alpha_j, J)$. Given (9), (22), (23) and $\theta > 1$, it shows that

$$
\frac{\partial^2 \Gamma_j}{\partial l_j \partial \alpha_j} = \underbrace{\left(\frac{1}{2}\frac{f'}{f} - \frac{1}{N}\right)}_{-} \underbrace{N'}_{-} > 0, \qquad \frac{\partial^2 \Gamma_j}{\partial l_j \partial J} = \underbrace{\left(1-\frac{1}{\theta}\right)}_{+} \underbrace{\frac{\partial}{\partial J}\left[\frac{1}{n_j}\frac{\partial n}{\partial l_j}\right]}_{+} > 0.
$$

Given this and the second-order condition $\partial^2 \Gamma_j/\partial l_j^2 < 0$, the comparative statics of the first-order condition (45) yields the function $l_j = \Theta(\alpha_j)$ with

$$
\frac{\partial \Theta}{\partial \alpha_j} = -\frac{\partial^2 \Gamma_j}{\partial l_j \partial \alpha_j} \Big/ \frac{\partial^2 \Gamma_j}{\partial l_j^2} > 0 \text{ and } \frac{\partial \Theta}{\partial J} = -\frac{\partial^2 \Gamma_j}{\partial l_j \partial J} \Big/ \frac{\partial^2 \Gamma_j}{\partial l_j^2} > 0.
$$

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