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The welfare effects of economic integration when products are patented*

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Abstract

This paper presents a model of economic growth where products are invented and patented, and where production involves fixed costs at the location of the plant. The model is used to assess the effects of instantaneous integration of a small, autarkic country into a larger economy on *a)* consumer welfare and *b)* the distribution of income.

Consumer welfare in the small country rises immediately because of newly available products. Additionally, the welfare of *all* consumers rises due to economies of scale at the firm level. These latter benefits are gradually replaced by benefits stemming from newly invented products.

The distribution of income changes due to *a)* the asymmetric distribution of patent ownership and *b)* changes in the ratio's of skilled to unskilled workers.

Keywords: Economic integration; Income distribution; Product variety
JEL classification: F12, F15, O41

1 Introduction

During the Uruguay round, the members of the WTO reached an agreement on the trade related aspects of intellectual property rights (TRIPS). The objective of TRIPS is stated in article 7 of the agreement:

> The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations. (World Trade Organization 1994, Annex 1C)

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The principle way by which this objective is to be pursued is stated in article 3, paragraph 1 of the treaty.

> Each Member shall accord to the nationals of other Members treatment no less favourable than that it accords to its own nationals with regard to the protection of intellectual property (...) (World Trade Organization 1994, Annex 1C)

Given the controversies about the protection of foreign intellectual property rights (IPRs) in developing countries, the suggested relation between the enforcement of IPRs and the level of welfare deserves a closer look. This paper assesses the effects of economic integration on welfare when IPRs are strictly enforced. It shows that aggregate welfare increases in response to economic integration but also that it may severely affect the short and medium term distribution of income within and between countries.

Protection of intellectual property ensures economic growth by the standard argument that it provides firms with an incentive to develop new products. Economic integration temporarily strengthens this incentive as producers suddenly see the market for their products increase. Technological change and thus economic growth are stimulated by economic integration in much of the same way as they are stimulated by population growth.

Economic integration may have a substantial impact on the distribution of income when IPRs are enforced irrespective of the country of invention as envisaged in paragraph 3.1 of TRIPS. The principle argument can be easily explained. Suppose there exist two autarkic countries of a different size. Within each country each product is patented and is manufactured by just one firm. Then it is not unreasonable to assume that the number of product types in the large country is larger than that in the small country, and that many of the types in the small country are similar to some type in the large country.

When the two countries decide to form an economic union, some comparable patents will have been registered in both countries. These patents will only be valid for the country of origin; the other patents will become valid for the entire economic union. Clearly, the value of the patents with limited validity will be lower than the value of the other patents.

Because the majority of firms with a fully valid patent will be located in the large country, the average value of firms in the large country will rise more than the average value of firms in the small country. Many firms in the large country will see the market for their products expand, while this unlikely for small country firms.

The asymmetric effect of economic integration on the value of firms implies that the benefits of integration will be larger for shareholders in the large country than they will be for shareholders in the small country. The shareholders in the large country get a 'free lunch' in the form of market expansion, which is not enjoyed by shareholders in the other country. In this way, the international protection of IPRs will contribute to the proliferation of income inequality without stimulating economic growth.

In this paper, a model of semi-endogenous growth is presented that illustrates this and other consequences of economic integration. In the model, production involves fixed costs at the location of the plant. The economies of scale that arise from these fixed cost provide an incentive for international trade à la Krugman (1979). What distinguishes this model from other models of international trade is that new product types have to be invented before they can be produced – a feature due to Judd (1985). Two exceptions to this rule are the models by Grossman and Helpman (1989) and Peretto (2003). In the former model, however, there are no fixed costs of production, which leads to substantially different conclusions about the structure of trade. In the latter model, all research is directed towards quality improvements while product variety is determined by the size of the market relative to fixed costs – the standard Dixit and Stiglitz (1977) result.

Normally, product variety in trade models is determined by the Dixit-Stiglitz mechanism. Because in the current model products first have to be invented, economic integration does not cause an immediate rise in the number of firms. Rather, the initial advantage of economic integration lies in the increased scale of production. Over time, the number of products gradually increases as the enhanced profitability of firms induces research. In a nutshell, the model presented here unifies the approaches to product variety by Dixit and Stiglitz (1977) and Judd (1985).

Two sacrifices have been made to keep the model tractable. First, trade is assumed to be costless. The introduction of trading costs appears to be difficult when profits are positive.[1] Second, intertemporal knowledge spillovers are not easily combined with fixed costs and are therefore omitted. Consequentially, the model is restricted to semi-endogenous growth (i.e. economic growth that ultimately depends on population growth). Factor immobility is preserved throughout this paper.

Each product is manufactured with skilled and unskilled labor. As all products are symmetric this brings up the question of how factor price equalization (FPE) is achieved. The route to FPE that is followed here is that of vertical specialization by multinational enterprises (MNEs) in the spirit of Helpman and Krugman (1985, chaps. 12 and 13). If factor proportions differ across countries, a firm will have an incentive to split up its production process into a part that uses skilled labor and a part that uses unskilled labor. A consequence of this strategy is the existence of and trade in intermediate products. Whether these intermediate trade flows are intrafirm or whether they take place between two firms (one of which a subcontractor) does not matter here. So, in stead of moving factors of production to the place where they are relatively scarce, production processes are located in such a way that the costs of production are minimal.

The paper is structured as follows. Section 2 presents a model of an (integrated) economy with patented products and fixed production costs. The effects on aggregate welfare of two autarkic countries of unequal size forming an economic union are discussed in section 3. Section 4 treats the implications for the distribution of income. Concluding remarks can be found in section 5.

[1] Peretto (2003) did find a way to combine quality R&D in the presence of trading costs.

2 The model

The economy is inhabited by two dynastic households.[2] One household comprises all unskilled workers, L, and one household has all skilled workers, H, as its members. The most important difference between skilled and unskilled labor is that the former has an alternative use. The amount of skilled labor in the economy is partly employed for production, H_y, and partly for research, H_R. 'Lifetime' utility of the households is the discounted sum of 'instantaneous' utility u with subjective discount factor ρ.

$$U = \int_{\tau=t}^{\infty} \Lambda_\tau u_{\Lambda,\tau} \exp\left[\rho\left(t-\tau\right)\right] \mathrm{d}\tau, \quad \forall \Lambda \in \{L, H\} \tag{1}$$

Each household derives instantaneous utility from a consumption index C that depends on the quantities consumed of n different product types.

$$u_\Lambda = \ln\left(\frac{C_\Lambda}{\Lambda}\right), \quad \forall \Lambda \in \{L, H\} \tag{2}$$

$$C_L + C_H = C = \left[\int_0^n y\left(i\right)^\gamma \mathrm{d}i\right]^{\frac{1}{\gamma}} \tag{3}$$

Firms and product types are indexed by $i \in [0, n]$. Products are produced in two stages. The first stage involves only unskilled labor, l, and returns intermediate products. At the second stage, skilled labor, h, and stage 1 products, $\tilde{y}$, are used to produce stage 2 products. Products require fixed expenditure at both stages:

$$\tilde{y}\left(i\right) = \tilde{a} l\left(i\right) - \tilde{b} \tag{4}$$

$$\begin{aligned} y\left(i\right) &= \tilde{y}\left(i\right)\left(\frac{ah\left(i\right)-b}{\tilde{y}\left(i\right)}\right)^\beta = \tilde{y}\left(i\right)^{1-\beta}\left(ah\left(i\right)-b\right)^\beta \\ &= \left(\tilde{a} l\left(i\right) - \tilde{b}\right)^{1-\beta}\left(ah\left(i\right)-b\right)^\beta \end{aligned} \tag{5}$$

$\tilde{a}$ and a are parameters; $\tilde{b}$ and b are the fixed costs at the first and second stage of production, respectively.

Each product type is patented and is manufactured by only one firm, but the two stages of production do not necessarily take place in the same country. Firms can be 'binational'. The underlying idea is that a firm buys a patent on a product that is designed keeping in mind that it can be costly to gather all the inputs in a single place. More specifically, a part of the product is assumed to be producible separately and to require only unskilled labor. This intermediate product can be shipped without costs to any country within the economic region where it is 'upgraded' to a consumable good with the use of skilled labor.

[2] The absence of migration strictly implies that all members of a household are located in the same country. The shortcut taken here yields the same outcome as long as the growth rate of the population is the same for each country.

Profit maximization leads to prices being a mark-up over marginal costs.

$$p_y = \gamma^{-1} \frac{w\left(l_y - \frac{\tilde{b}}{\tilde{a}}\right) + \omega\left(h_y - \frac{b}{a}\right)}{y} \tag{6}$$

The wage rate of unskilled labor is denoted by w, the wage rate of skilled labor is ω. Because firms are symmetric the prices of all products are equal. The ratio of the wage rates is

$$\frac{w}{\omega} = \frac{1-\beta}{\beta} \frac{h_y - \frac{b}{a}}{l_y - \frac{\tilde{b}}{\tilde{a}}}. \tag{7}$$

The consumption index is taken to be the numeraire, implying that total expenditure is equal to C.

$$C = n^{\frac{1}{\gamma}} y = n p_y y \Rightarrow p_y = n^{\frac{1-\gamma}{\gamma}} \tag{8}$$

Although no trade and migration exists between autarkic economies, no autarkic economy is assumed to function in complete isolation from the rest of the world. In particular, a certain degree of knowledge spillovers occurs between economies. Researchers will imitate a product that has been invented in another economy rather than try to invent a product that is entirely new – simply because imitation is cheaper. The flow of patents, each representing a design of a new product type, depends on the number of researchers employed and on whether the product is an imitation or a true invention.[3] A researcher can produce one design at the time or he can produce $\delta > 1$ imitations. Imitation is only possible when the number of product types in the world, n_w, is strictly larger than the number of types available 'domestically'. Summarizing what has been stated above, the flow of new products is given by:

$$\dot{n} = \begin{cases} H_R & \text{if } n = n_w \\ \delta H_R & \text{if } n < n_w \end{cases} \tag{9}$$

The dot denotes the derivative with respect to time.

Entry and exit are free in the research sector thus profits in the research sector are zero. The value of a design, v, is limited by the wage a researcher receives.

$$v \leq \omega \tag{10}$$

The distribution of total revenues from production can be found using the wage ratio and both expressions for the price.

$$C = wL + \omega H_y + n\pi \tag{11}$$

$$wL = (1-\beta)\gamma C + wn\frac{\tilde{b}}{\tilde{a}} \tag{12}$$

$$\omega H_y = \beta\gamma C + \omega n \frac{b}{a} \tag{13}$$

$$n\pi = (1-\gamma) C - n\left(w\frac{\tilde{b}}{\tilde{a}} + \omega\frac{b}{a}\right) \tag{14}$$

[3]Knowledge spillovers from previous research efforts are omitted in order to keep the dynamic behavior of the model tractable.

Using these last results, the profit to skilled wage ratio can be expressed as

$$\frac{\pi}{\omega} = (1-\gamma)\frac{C}{n\omega} - \frac{w}{\omega}\frac{\tilde{b}}{\tilde{a}} - \frac{b}{a} \tag{15}$$

$$= \frac{(1-\gamma)}{\beta\gamma}\frac{\left(H_y - n\frac{b}{a}\right)}{n} - \frac{(1-\beta)\,\tilde{b}}{\beta\tilde{a}}\frac{H_y - n\frac{b}{a}}{L - n\frac{\tilde{b}}{\tilde{a}}} - \frac{b}{a} \tag{16}$$

where π represents the profits of a firm.

The Ramsey rule is the same for both households.

$$\hat{C}_L - \hat{L} = \hat{C}_H - \hat{H} = \hat{C} - g_P = \frac{\pi}{v} - \rho. \tag{17}$$

Variables wearing a hat are growth rates; the (constant) growth rate of the workforce is g_P. The total population, P, is the sum of L and H. Substitute for $\hat{C}$ and π/v in the Ramsey rule to get the optimal growth rate of consumption, provided that research is feasible ($v = \omega$).

$$\hat{C} = \frac{(1-\gamma)}{\beta\gamma}\frac{\left(H_y - n\frac{b}{a}\right)}{n} - \frac{(1-\beta)\,\tilde{b}}{\beta\tilde{a}}\frac{H_y - n\frac{b}{a}}{L - n\frac{\tilde{b}}{\tilde{a}}} - \frac{b}{a} - \rho + g_P \tag{18}$$

The total consumption can be written in terms of n, L, and H_y using equations 3 and 5.

$$C = n^{\frac{1}{\gamma}} y = n^{\frac{1-\gamma}{\gamma}} \left(\tilde{a}L - n\tilde{b}\right)^{1-\beta} (aH_y - nb)^{\beta} \tag{19}$$

The balanced growth rate can straightforwardly be found. The equations for consumption (19) and consumption growth (18) show that the growth rate of consumption can only be constant if $\hat{L} = \hat{H} = g_P$. Equations 9 and 19 reveal that the balanced growth rate of consumption is $\frac{1}{\gamma}g_P$. It immediately follows that per capita consumption growth is $\frac{1-\gamma}{\gamma}g_P$, even though knowledge spillovers are absent. The model is characterized by 'semi-endogenous' growth, that is, economic growth depends crucially on population growth. That the model is saddle path stable is shown in the appendix.

3 Aggregate welfare

The approach to economic integration adopted in this paper is that of a 'big bang' unification of two economies: a large one, labeled A, and a small one, labeled B. Before unification, both economies are autarkic. After unification, the two economies form a single integrated economy.

According to the model of the previous section, the number of products is linearly related to the size of the population in the steady state. This implies that, before unification, the large country has more product types than the small country. What happens to the number of types in each countries after unification depends on how similar the two sets of types are.

The larger size of country A ensures that the flow of new product designs is larger than in country B, assuming that both countries are in their steady state. This difference in the flow of new products (eventually) causes the number of products in A to exceed the number of products in B. For this reason, all researchers in country B will be busy imitating designs invented in country A. As a result, the products that are available in country B are a subset of the products available in A. After the economies of the two countries have integrated there will no longer be imitation in any of the two countries.

Throughout this paper, I assume that the order in which products are invented is the same for both economies. The idea behind this assumption is that new types of goods are generally more luxurious than existing types. The incentive for the invention of a luxurious good is supposedly lower than that for a less luxurious goods as the market for the latter is larger.

The consequence of this line of reasoning is that before unification, the set of types of the small country is completely contained in the large country's set of types. Immediately after unification, the set of types of the newly formed economy equals that of the large country. Consumers in the small country will see an immediate expansion in the number of types, whereas consumers in the large country will not see an immediate change.

There is a slight complication arising from the fact that a subset of product types is patented in both the large and the small country – presumably by different firms. The natural way of dealing with this situation is to preserve the rights attached to the patent only for the country it was valid for preceding the unification. Firms originally established in country B will still be allowed to sell their products domestically, but it will not be possible for them to sell in country A. Firms in country A can sell their products in both countries, provided that the product has not been patented in country B prior to unification.

The duopoly that arises for some products is not stable. Increasing returns to scale at the firm level provides an incentive for the shareholders of two firms owning a patent on the same product to force a merger of the two firms. Consequently, unification triggers an instantaneous wave of 'cross-border' mergers.

The occurrence of mergers raises the issue of how dividends should be distributed among shareholders from the two countries. The most neutral way of handling this problem is by assuming a 'fair deal' such that dividends are allocated according to the size of the future market of each country. In particular, if $n_{B,0}$ is number of firms that merge and κ_ι^* is the long term share of country ι in the aggregate income of the integrated economy, then the dividends received by country ι are $n_{B,0}\pi\kappa_\iota^*$.

Another issue concerns the effects of unification on the location of production. If the ratio of skilled to unskilled workers is the same in both countries, no plants will be relocated; only some of the redundant plants of merged firms will be closed. When the ratio of skilled to unskilled workers is not the same in both countries, some firms will find it profitable to engage in vertical specialization, separating the production of intermediates from that of final goods. A part of the production of intermediates will then be shifted to the country with a relative abundance

of unskilled workers, while a part of the production of final goods moves in the opposite direction.

The relocation of plants ensures that, given the type of labor, wage rates are identical across the entire integrated economy. If this would not be the case, a firm could increase its profits by relocating a part of its production activities. Hence, the integrated economy is truly integrated even though labor migration is absent. It is the movement of economic activity rather than the movement of production factors that ensures FPE.

Having settled the issues concerning property rights and FPE, we can now turn to the effects of economic integration on income and consumption. After the transition path of the integrated economy has been found (see appendix), the consumption paths of the households of the two countries have to be derived. According to the Ramsey rule (equation 17) consumption grows at the same pace in both countries. This implies that the allocation of consumption between the two countries is constant over time.

Ruling out unsustainable debts, each country's share in total consumption should not exceed its share in long-term income, $C_{\iota t}/C_t \leq \kappa_\iota^*$. Because this condition has to hold for all countries simultaneously, $C_{\iota t} = \kappa_\iota^* C_t$. Once we know κ_ι^*, we can solve for the consumption paths of both countries. Aggregate income in country ι is given by

$$Y_{\iota t} = \omega_t H_{\iota t} + w_t L_{\iota t} + \pi_t \left(W_{\iota 0} + \int_0^t \frac{Y_{\iota\tau} - C_{\iota\tau}}{Y_\tau - C_\tau} \dot{n}_\tau \mathrm{d}\tau \right), \tag{20}$$

where $W_{\iota 0}$ is the equivalent in number of firms of shareholdings by country ι immediately after the mergers. As $\lim_{t\to\infty} \frac{Y_{\iota t} - C_{\iota t}}{Y_t - C_t} = \lim_{t\to\infty} \frac{Y_{\iota t}}{Y_t} = \kappa_\iota^*$, we have

$$\kappa_\iota^* = \lim_{t\to\infty} \frac{\omega_t H_{\iota t} + w_t L_{\iota t}}{Y_t} + \lim_{t\to\infty} \frac{\pi_t \left(W_{\iota sd} + (n_t - n_{sd}) \kappa_\iota^* \right)}{Y_t}. \tag{21}$$

In the last term, sd is the period after which distribution of income is (approximately) stable. The first term is constant as soon as the integrated economy is in the steady state. In the second term, both $W_{\iota sd}$ and n_{sd} are asymptotically irrelevant as they are constants. What is left over, provides us with a solution for κ_ι^*:

$$\kappa_\iota^* = k_{0\iota} + \lim_{t\to\infty} \frac{\pi_t n_t \kappa_\iota^*}{Y_t} = k_{0\iota} + k_1 \kappa_\iota^* = \frac{k_{0\iota}}{1 - k_1} \tag{22}$$

The constants $k_{0\iota}$ and k_1 follow from the steady state solution for the integrated economy.

Figure 1 displays consumption per capita of the small country before, $t < 0$, and after, $t > 0$, the unification. Clearly, unification has an immediate and large impact on the consumption of the small country's inhabitants. Consumption rises for two reasons. First, unification yields immediate access to the product types that previously were only available in the large country. This is similar to the effect discussed by Romer (1994) and is clearly visible in figure 2. Second, the larger markets for products brought about by unification enables further exploitation of

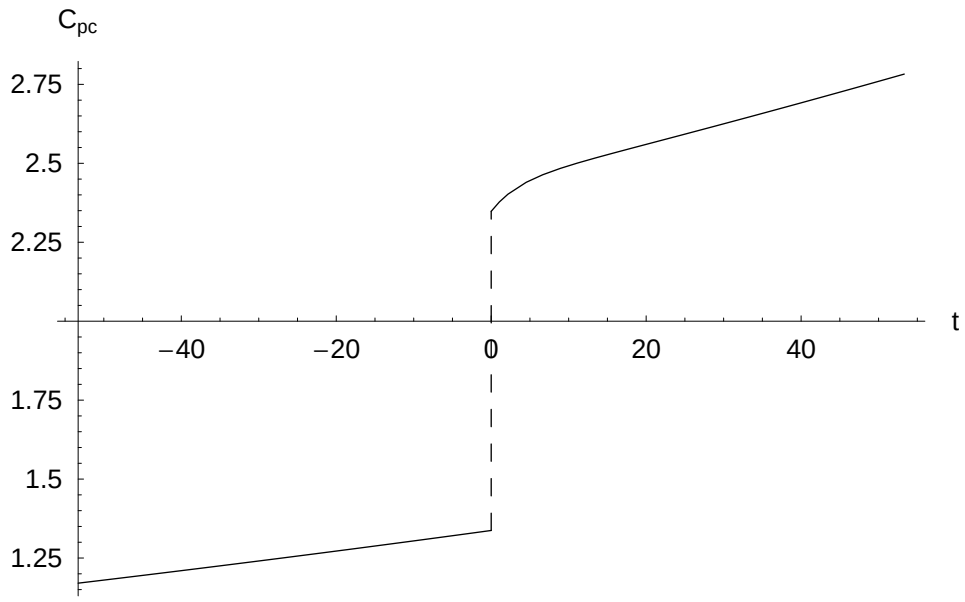

Figure 1: Per capita consumption – small country

economies of scale due to fixed costs. The increase in the scale of production is illustrated by figure 3.

Unlike the inhabitants of the small country, the inhabitants of the large country do not seem to have any immediate benefits from unification (figure 4). For the large country, unification does not bring about a spectacular expansion of the set of product types, although the growth of the number of types does temporarily accelerate as can be seen from figure 5.

The increase in scale caused by unification has an upward effect on profits. Higher profits, in turn, induce people to increase their savings rate – hence the initial decline in consumption in figure 4 – and causes the value of shares to inflate. High share prices make research more attractive and cause the rate of invention to accelerate.

The acceleration in the rate of introduction of new products is not sustainable. The high rate of invention has a depressing effect on the scale of production and, consequently, on profits. This causes the number of researchers relative to the size of the population to decline until the steady state is reached.

Concluding, unification leads to an immediate increase in product variety for the inhabitants of the small country while simultaneously raising the scale of production in both countries. The subsequent rise in profits stimulates research and induces the invention of new goods.

4 Income inequality

In the integrated economy, four groups of households can be distinguished: skilled workers in A, unskilled workers in A, skilled workers in B, and unskilled workers in

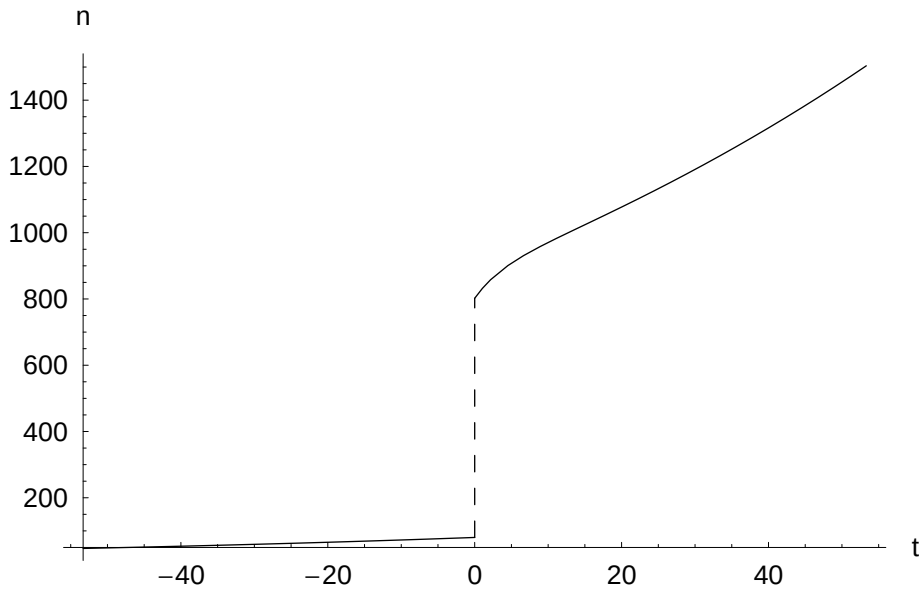

Figure 2: Number of types consumed – small country

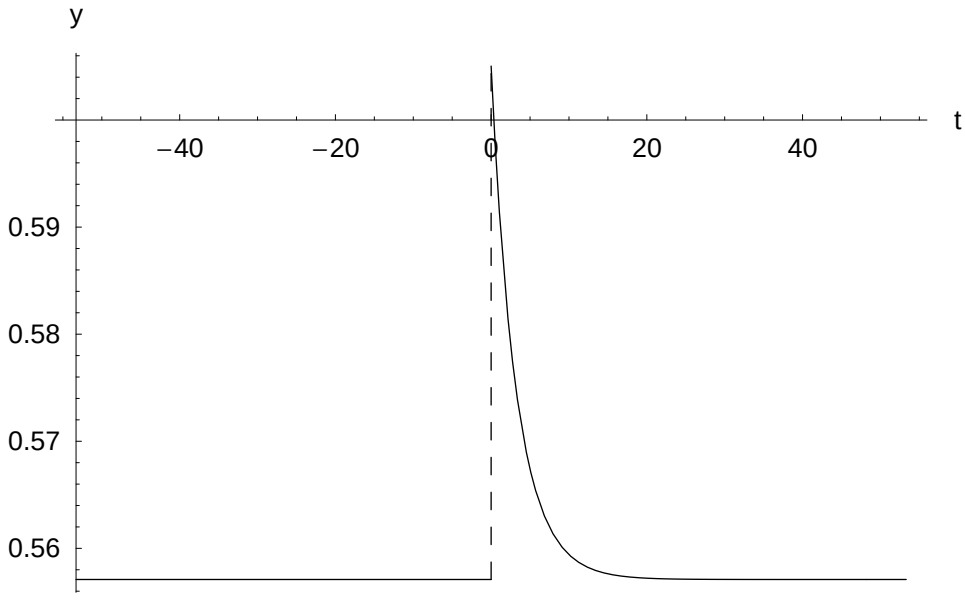

Figure 3: Scale of production – both countries

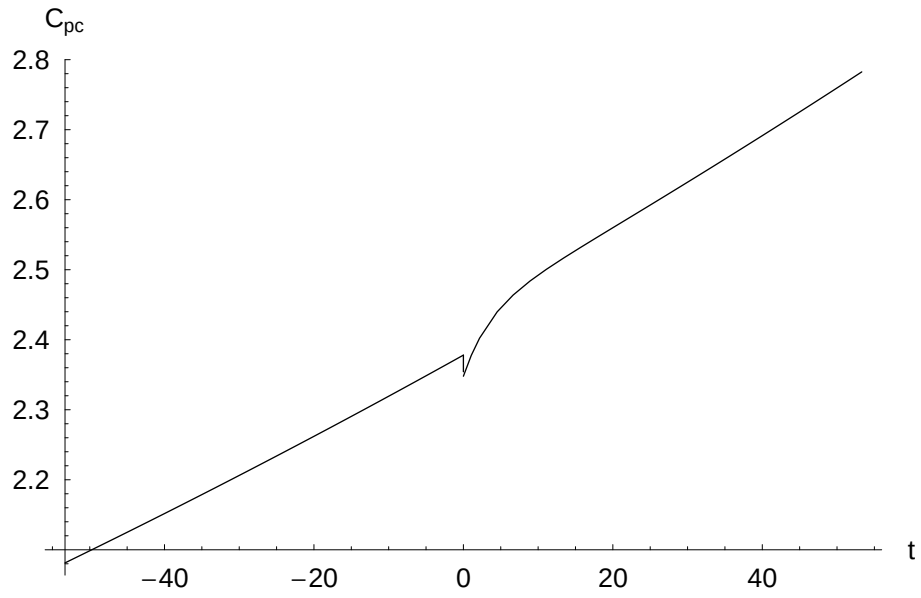

Figure 4: Per capita consumption – large country

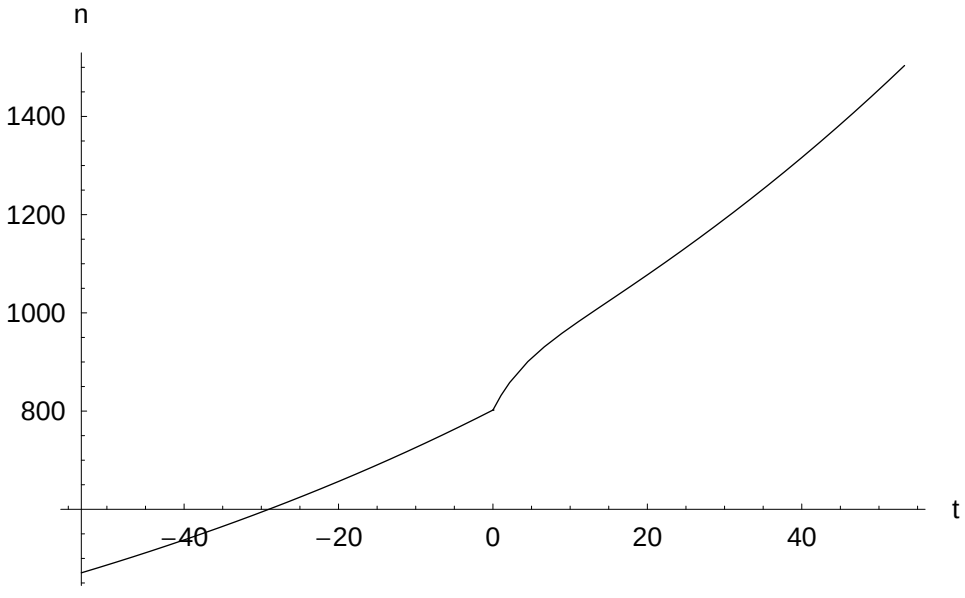

Figure 5: Number of types consumed – large country

B. Each of these groups can be affected in different ways by economic integration. In this section, the income and consumption of the four groups for two scenario's. The first scenario is that of the previous section where a small economy merges with a large economy that has the same ratio of skilled to unskilled workers. In the second scenario, the small economy has an abundance of unskilled labor relative to the large economy.

The consumption path for each group can be found in a manner analogous to the procedure that was used to find the consumption paths of the two countries. By the Ramsey rule the share in aggregate consumption of group j is constant over time, equalling κ_j^*. This property facilitates the derivation of the distribution of income.

Infinite horizon utility maximization causes consumption paths to be governed entirely by the long term distribution of income. This obscures some of the distributional effects of integration that would occur in real life. To get a better grasp of the short and medium term effects of unification it is useful to take a look at the income paths of the four groups.

Unfortunately, these income paths still have to be recovered. Income for the individual groups depends on wages, on initial shareholdings, and on shareholdings accumulated after $t = 0$.

$$
\begin{aligned}
Y_{H_A t} &= \omega_t H_{At} + \pi_t \left(\kappa^*_{0H_A} \left[\kappa^*_A n_{B0} + (n_{A0} - n_{B0}) \right] + \int_0^t \frac{Y_{H_A\tau} - C_{H_A\tau}}{Y_\tau - C_\tau} \dot{n}_\tau \mathrm{d}\tau \right) \\
Y_{L_A t} &= w_t L_{At} + \pi_t \left(\kappa^*_{0L_A} \left[\kappa^*_A n_{B0} + (n_{A0} - n_{B0}) \right] + \int_0^t \frac{Y_{L_A\tau} - C_{L_A\tau}}{Y_\tau - C_\tau} \dot{n}_\tau \mathrm{d}\tau \right) \\
Y_{H_B t} &= \omega_t H_{Bt} + \pi_t \left(\kappa^*_{0H_B} \kappa^*_B n_{B0} + \int_0^t \frac{Y_{H_B\tau} - C_{H_B\tau}}{Y_\tau - C_\tau} \dot{n}_\tau \mathrm{d}\tau \right) \\
Y_{L_B t} &= w_t L_{Bt} + \pi_t \left(\kappa^*_{0L_B} \kappa^*_B n_{B0} + \int_0^t \frac{Y_{L_B\tau} - C_{L_B\tau}}{Y_\tau - C_\tau} \dot{n}_\tau \mathrm{d}\tau \right)
\end{aligned}
$$

In the expression stated above, κ^*_{0j} is the long term share of group j in the aggregate income of the corresponding autarkic economy before unification. Patents ranging from n_{B0} to n_{A0} are only possessed by firms in country A.

As the level of income at $t > 0$ depends on the income of previous periods, income paths can only be derived recursively. For the simulation results presented below, $\int_0^t \frac{Y_{j\tau} - C_{j\tau}}{Y_\tau - C_\tau} \dot{n}_\tau \mathrm{d}\tau$ has been replaced by $\sum_{\tau=1}^t \frac{Y_{j\tau-1} - C_{j\tau-1}}{Y_{\tau-1} - C_{\tau-1}} \Delta n_\tau$.

Figure 6 illustrates the effects of unification on per capita income and consumption.[4] The ratio of skilled to unskilled workers is the same in both countries.

The figure clearly visualizes three phenomena. Without a doubt, the most important phenomenon is the increase in welfare for the inhabitants of country B caused by access to a wider set of products from $t = 0$ onwards. This has already been discussed in the previous section.

A second phenomenon is the jump in the income of skilled workers in country A. This group owns the majority of the shares in country A firms. After unification, most of these firms can suddenly sell to consumers in B because they own patents

[4]The parameter settings are the same as in the previous section.

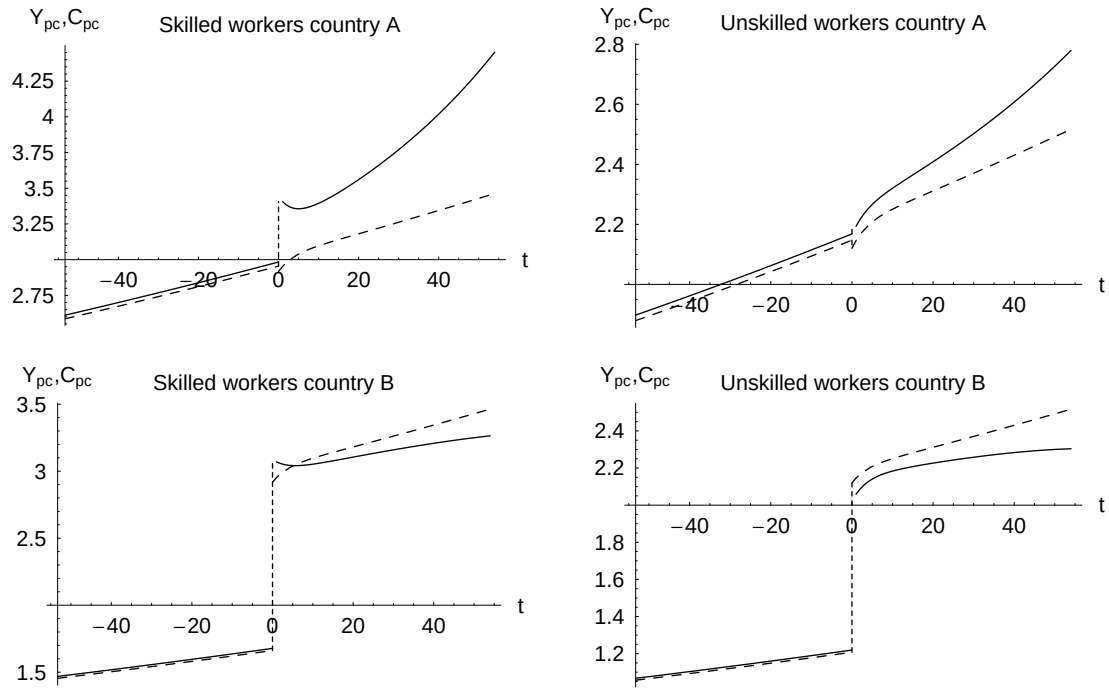

Figure 6: Y_{pc} (solid) and C_{pc} (dashed) by income group

on products that were not registered in country B. The corresponding rise in profits is mainly appropriated by skilled workers in A.

Third, consumption by households in country B exceeds their income. These households can lend from households in country A because their current share in income is below its long term value. This implies that the debt accumulated by country B will vanish asymptotically and is therefore sustainable.

Figure 7 shows net income from the possession of assets for all four groups. Especially skilled workers in A see their income from assets increase in response to the integration of the two economies. Unskilled workers in country B become net debtors very quickly (around $t = 5$).

As both countries have the same ratio of skilled to unskilled workers, the effects of unification on the ratio of wages, ω/w, are only transitory. This can be seen in figure 8. The temporary rise in the wages of skilled workers relative to the wages of unskilled workers is due to the increased attractiveness of research. Once the steady state has been reached, the ratio of wages has returned to the pre-unification level.

When the two integrating economies have an identically composed labor force, virtually all persistent changes in the distribution of income are due to the unequal distribution of shares between small country shareholders and large country shareholders. After unification, the shareholders of the small country suddenly have a minority stake in just a handful of firms. This contrasts sharply with the pre-unification era during which domestic shareholders controlled all the firms selling products on the domestic market. It also contrasts sharply with gains from

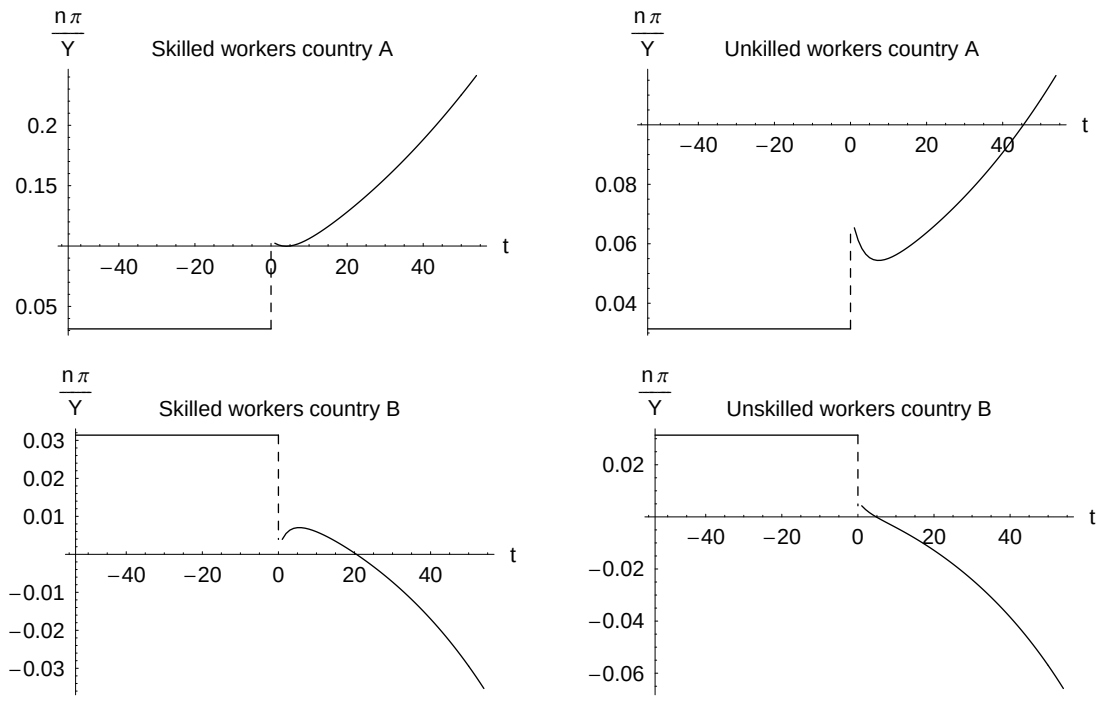

Figure 7: Net asset income

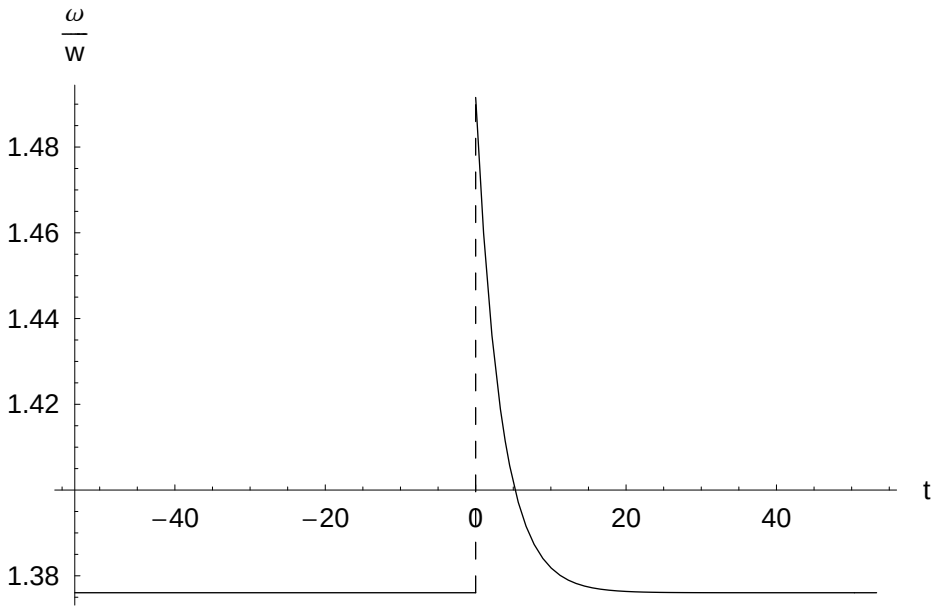

Figure 8: Wage inequality – both countries

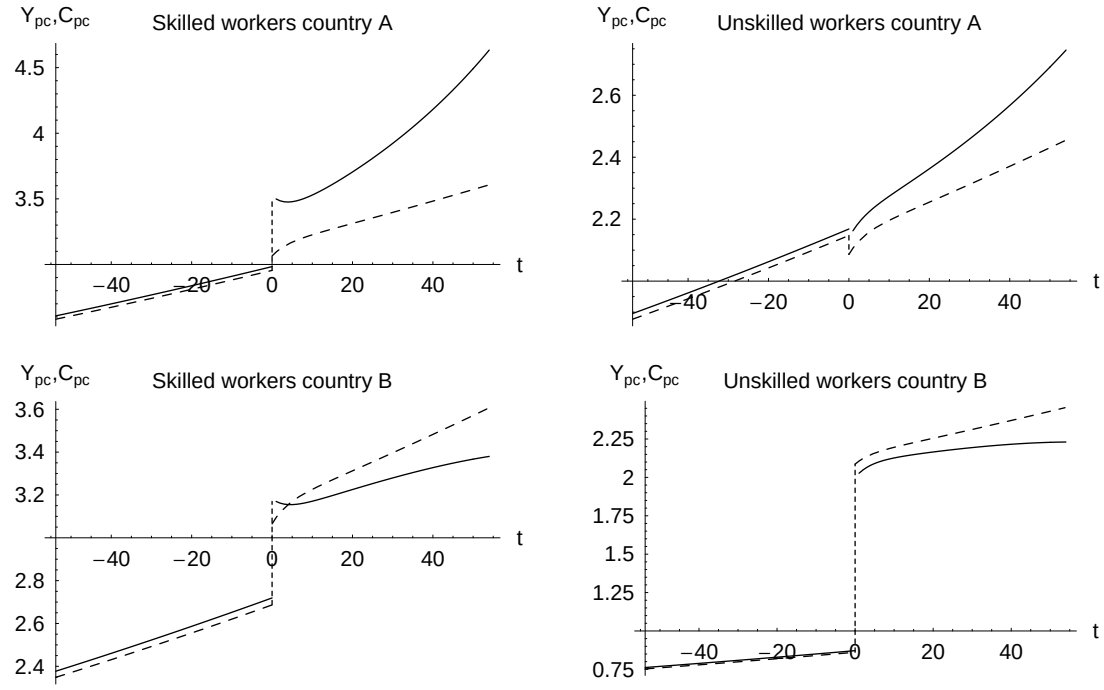

Figure 9: Y_{pc} (solid) and C_{pc} (dashed) by income group; shock in H/L

unification for shareholders in the large country.

Next, we will turn to the second scenario in which the small country's ratio of skilled to unskilled workers is much lower than that of the large country. In particular, for the small country $H_B/L_B = 0.2$ while for the large country this ratio is kept at 0.4. The other parameters are the same as with the first scenario, such that the ratio H/L for the entire post-unification economy equals 0.38.

Figure 9 shows income and consumption per capita for the four groups. In comparison with the previous scenario, unskilled workers in B gain more from integration than before as do the skilled workers in A, whereas there do not seem to be any gains anymore for unskilled workers in A. The gains for skilled workers are less than with the first scenario.

All these deviations from the first scenario are the result of the change in the ratio of wages. Contrary to what was the case previously, unification has permanent effects on the ratio ω/w in the second scenario. This is not surprising as the relative ratio of skilled to unskilled workers after unification is 0.38 in stead of 0.4. In the small country ω/w falls sharply after unification (figure 10), while ω/w rises somewhat in the large country (figure 11).

Besides the direct effect of the change in the wages, there is also an indirect effect that severely reduces the gains from integration for the shareholders in country B, mostly skilled workers. As can be seen from figures 3 and 12, the rise in H/L has affected the scale of production. The scarcity of skilled labor had worked as a 'barrier to invention' – or rather, a 'barrier to imitation' – thereby leading to fewer product types per capita and higher profits than is the case in scenario

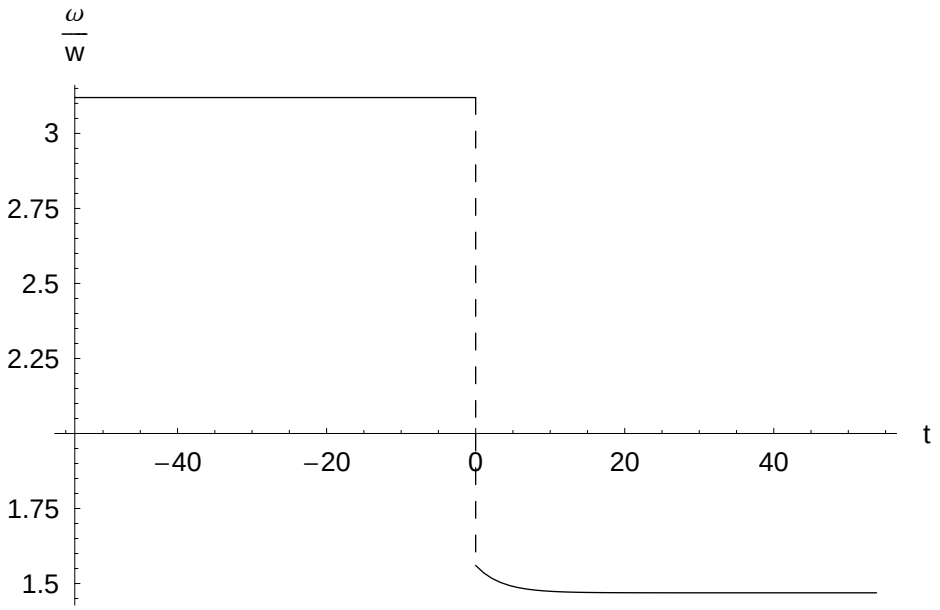

Figure 10: Wage inequality – small country; shock in H/L

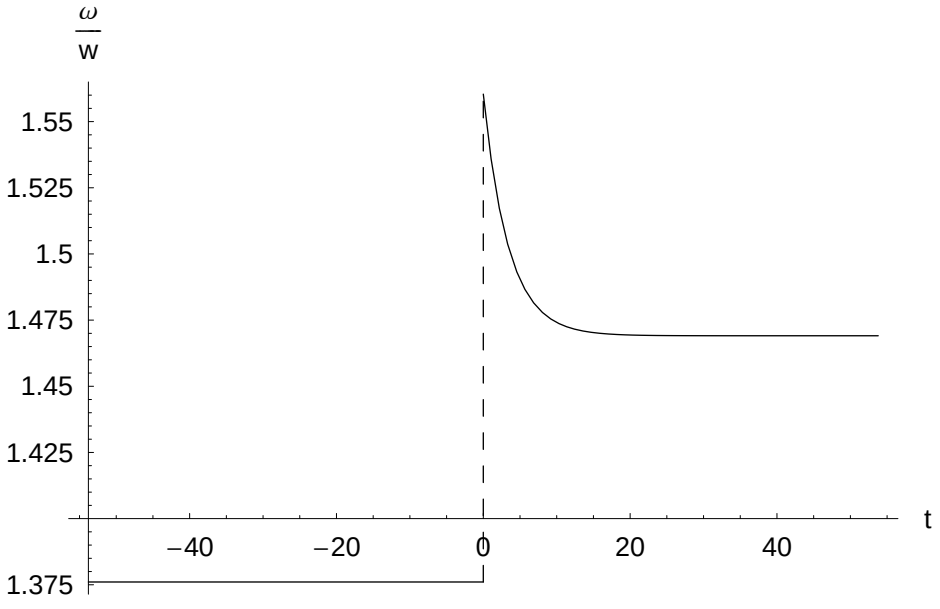

Figure 11: Wage inequality – large country; shock in H/L

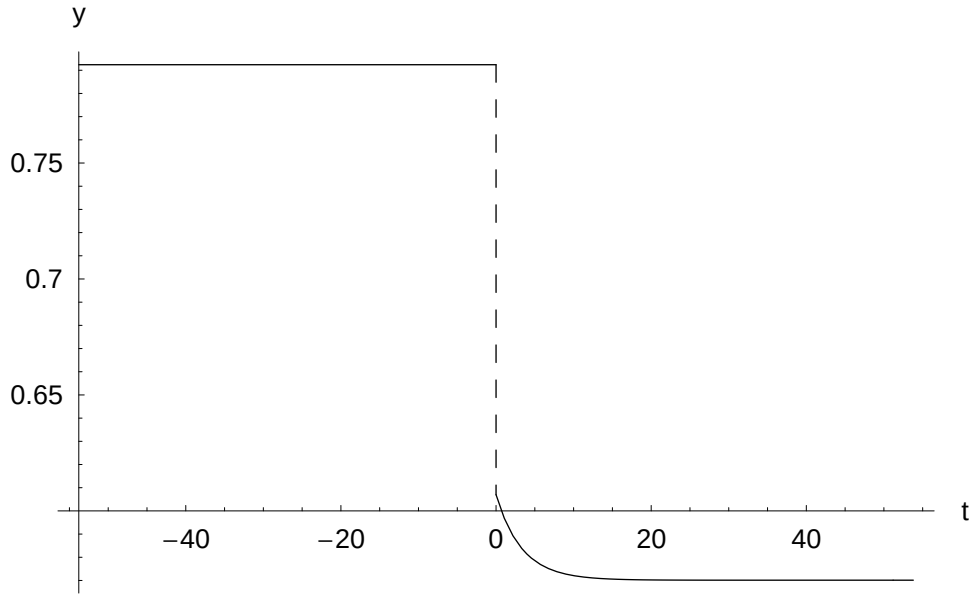

Figure 12: Scale of production (final products) – small country

one. Due to the disappearance of this 'barrier to invention', the shareholders in country B have less to gain from unification than in the first scenario.

5 Concluding remarks

Economic integration enables consumers in small countries to buy a larger variety of products. Additionally, the welfare of all consumers rises due to economies of scale at the firm level. The corresponding rise in profits makes research more attractive, which leads to the invention of new products. In this way, the benefits due to economies of scale are gradually replaced by benefits stemming from newly invented products.

Although economic integration stimulates aggregate welfare, the gains from integration are not likely to be distributed evenly. In the typical situation where a small country with many unskilled workers joins a large economy, changes in the distribution of income is only partly caused by the change in relative wages.

The enforcement of IPRs has two effects on the distribution of income. First, not all shareholders benefit equally from integration due to the asymmetric validity of patents. Contrary to shareholders in the large economy, all of the wealth of small country shareholders is invested in patents with limited geographical validity. By this mechanism, the international protection of IPRs will contribute to the proliferation of income inequality. Second, the 'barrier to invention' due to the scarcity of skilled workers in the small country is reduced after unification, which negatively affects the value of firms in the small country.

In reality the consequences of rapid economic integration will might be understated by the model. First, patents on imitated products might be ruled illegal,

thereby strengthening the negative effects of integration on the relative income of small country shareholders. Second, firms in the larger economy will tend to produce goods with a higher quality, such that consumers in the small country will not only see the range of available products expand but these products will also be of a higher quality.

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A Stability of the model

A first step in the search after the path leading from an initial state of the economy to balanced growth involves the rescaling of variables such that the rescaled variables are constant along the balanced growth path. Technically, rescaling transforms a moving equilibrium into a fixed equilibrium.

$$c \equiv \frac{C}{P^{\frac{1}{\gamma}}} \quad l \equiv \frac{L}{n} - \frac{\tilde{b}}{\tilde{a}} \quad \nu \equiv \frac{n}{P}$$
$$h \equiv \frac{H}{n} - \frac{b}{a} \quad h_R \equiv \frac{H_R}{n}$$

The rescaled variables l and h refer to the variable part of the employment by a single firm and should not be confused with l_y and h_y which refer to total employment by a firm.

After rescaling equations 9, 19, and 18 become

$$\hat{\nu} = h_R - g_P \tag{23}$$

$$c = \tilde{a}^{1-\beta} a^{\beta} \nu^{\frac{1}{\gamma}} l^{1-\beta} \left(h - h_R\right)^{\beta} \tag{24}$$

$$\hat{c} = \frac{(1-\gamma)}{\beta\gamma}\left(h - h_R\right) - \frac{(1-\beta)\,\tilde{b}}{\beta\tilde{a}}\frac{(h - h_R)}{l} - \frac{b}{a} - \rho + \frac{\gamma - 1}{\gamma} g_P. \tag{25}$$

Moreover, l and h can be expressed as functions of ν

$$l = \frac{1}{(1+\varphi)\,\nu} - \frac{\tilde{b}}{\tilde{a}} \tag{26}$$

$$h = \frac{\varphi}{(1+\varphi)\,\nu} - \frac{b}{a} \tag{27}$$

where $\varphi \equiv H/L$. Except for temporary shocks, the growth rates both of skilled and of unskilled labor are taken to be equal and constant. This implies that φ is constant as a rule and thus that it is possible to reach the steady state.

The last five equations yield a system of differential equations in ν and h_R. The system has a fixed point which has coordinates

$$h_R^* = g_P$$

$$\nu^* = \frac{\frac{1-\gamma}{\beta\gamma}\frac{\varphi}{(1+\varphi)}}{\frac{1}{\beta\gamma}\frac{b}{a} + \rho + \left(\frac{(1-\gamma)(1+\beta)}{\beta\gamma} - \frac{(1-\beta)\tilde{b}}{\beta\tilde{a}}\right) g_P + \frac{(1-\beta)\tilde{b}}{\beta\tilde{a}}}.$$

The stability of the fixed point can be checked by a linear approximation to the system around the steady state. Table 1 reports the eigenvalues and eigenvectors stemming from the linearized system for a range of plausible parameter values. As every eigenvalue is accompanied by an eigenvalue of the opposite sign, the fixed point exhibits saddle point stability. The eigenvectors indicate that the stable and unstable manifolds do not 'switch places' when parameter values change.

The non-linearized transition path has been found using backward integration (Brunner and Strulik 2002). This technique exploits the fact that the stable manifold becomes the unstable manifold when time is running backward. A numerical solution to an unstable manifold belonging to a saddle point can be found easily. With a starting point close to the unstable manifold, the numerical solution will quickly converge to the actual manifold. The parameter values used in the first simulation are $\beta = 0.3$, $\gamma = 0.8$, $\rho = 0.03$, $g_P = 0.01$, $\phi = 0.4$, and $a = \tilde{a} = b = \tilde{b} = 1$ for both countries; $P(0) = 1000$ and $n(0) = 50$ for country A prior to integration; $P(0) = 100$ and $n(0) = 5$ for country B prior to integration. For the second simulation, the following alterations were made: $\phi = 0.4$ for country A and $\phi = 0.2$ in country B.

Table 1: Eigenvalues and eigenvectors for linearized system

β	γ	g_P	ϕ	*Eigenvalue*	*Eigenvector*
0.1	0.5	0	0.1	11.5	$(0.00712 \quad , \ 1)$
				-1.02	$(-0.0798 \quad , \ 1)$
0.1	0.5	0	10	0.267×10^3	$(0.179\times10^{-3} \quad , \ 1)$
				-0.256×10^3	$(-0.186\times10^{-3} \quad , \ 1)$
0.1	0.5	0.04	0.1	11.9	$(0.0066 \quad , \ 1)$
				-1.06	$(-0.0739 \quad , \ 1)$
0.1	0.5	0.04	10	0.266×10^3	$(0.179\times10^{-3} \quad , \ 1)$
				-0.256×10^3	$(-0.187\times10^{-3} \quad , \ 1)$
0.1	0.99	0	0.1	25.1	$(0.183\times10^{-3} \quad , \ 1)$
				-14.7	$(-0.313\times10^{-3} \quad , \ 1)$
0.1	0.99	0	10	0.925×10^3	$(0.00108\times10^{-3} \quad , \ 1)$
				-0.915×10^3	$(-0.00109\times10^{-3} \quad , \ 1)$
0.1	0.99	0.04	0.1	25.1	$(0.183\times10^{-3} \quad , \ 1)$
				-14.7	$(-0.312\times10^{-3} \quad , \ 1)$
0.1	0.99	0.04	10	0.925×10^3	$(0.00108\times10^{-3} \quad , \ 1)$
				-0.915×10^3	$(-0.00109\times10^{-3} \quad , \ 1)$
0.9	0.5	0	0.1	-1.02	$(-0.0461 \quad , \ 1)$
				2.21	$(0.0212 \quad , \ 1)$
0.9	0.5	0	10	34.7	$(0.00236 \quad , \ 1)$
				-33.5	$(-0.00244 \quad , \ 1)$
0.9	0.5	0.04	0.1	-1.06	$(-0.0427 \quad , \ 1)$
				2.3	$(0.0196 \quad , \ 1)$
0.9	0.5	0.04	10	34.5	$(0.00237 \quad , \ 1)$
				-33.3	$(-0.00246 \quad , \ 1)$
0.9	0.99	0	0.1	11.1	$(0.0863\times10^{-3} \quad , \ 1)$
				-9.93	$(-0.0967\times10^{-3} \quad , \ 1)$
0.9	0.99	0	10	22.9	$(0.201\times10^{-3} \quad , \ 1)$
				-21.7	$(-0.212\times10^{-3} \quad , \ 1)$
0.9	0.99	0.04	0.1	11.1	$(0.0864\times10^{-3} \quad , \ 1)$
				-9.96	$(-0.0964\times10^{-3} \quad , \ 1)$
0.9	0.99	0.04	10	22.9	$(0.201\times10^{-3} \quad , \ 1)$
				-21.7	$(-0.212\times10^{-3} \quad , \ 1)$

The other parameter values are: $\rho = 0.04,\ a = \tilde{a} = b = \tilde{b} = 1$