INTERNATIONAL TRADE, GROWTH, AND PER CAPITA INCOME

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Abstract

I construct a dynamic, two-country model of international trade and endogenous economic growth where agents have nonhomothetic preferences. I study the role that per capita income plays in jointly determining economic growth and international trade. The model exhibits multiple steady states. I find that in a steady state where all varieties are traded inequality has no effect on the world growth rate and an ambiguous effect on the volume of trade. In a steady state where only part of all varieties are traded inequality has a positive effect on world growth and a negative effect on the volume of trade.

What role does per capita income play in jointly determining growth and trade? The model presented aims to shed light on this question by incorporating nonhomothetic preferences in a dynamic, two country model of trade and growth.

The influence of per capita income on international trade has been discussed since Linder (1961). The Linder hypothesis states that the more similar the demand structures of countries, the more intensive they will trade among each other. Linder argues that the more similar the demand patterns of countries, the larger will be their overlap of production and consumption patterns. He makes the point that this implies a more similar commodities composition of trade and a greater volume of trade. He considers per capita income to be the most important determinant of the demand structure. Thus, the Linder hypothesis essentially predicts international trade to be more intensive between countries the more equal their per capita incomes are. There is also empirical evidence that per capita income affects international trade. Hunter and Markusen (1988) reject the hypothesis of homotheticity and suggest that differences in demand play an important role in explaining trade. Hunter (1991) estimates that nonhomothetic preferences may account for more than one quarter of inter-industry trade. Bernasconi (2009) finds evidence for the Linder hypothesis over the extensive margin of trade.

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There is a vast literature that studies the channels through which international trade influences economic growth (for a survey see Grossman and Helpman (1994)). Grossman and Helpman (1991a) identify several features of the global economy which they regard as important for understanding trade and growth. For example, comparative advantage leading to specialization in the creation of knowledge, large scale of the world economy, or spillovers of knowledge in trade partners (knowledge transfer). However, Grossman and Helpman (1990a) also mention in their conclusion: 'We need to learn much more about the mechanisms by which knowledge and technology diffuse across international borders ...'. Grossman and Helpman (1990) postulate perfect knowledge spillovers. They argue that each country has access to the knowledge stock of the world, the sum of all blueprints worldwide. Grossman and Helpman (1990) also consider the cases if only a fraction of the global knowledge stock is accessible, or, if there is a time lag in the diffusion of knowledge. There are models of North-South trade (Grossman and Helpman (1991), Dinopoulos and Segerstrom (2003), and Matsuyama (2000), among others) which assume that the developed North innovates differentiated goods whereas the South imitates those differentiated goods.

The bulk of the literature on trade and growth neglects or plain ignores demand side issues by assuming homothetic preferences. This implies that per capita income has no role to play in determining the demand structure. However, the effect of per capita income on the demand structure can only be studied in a model where agents have nonhomothetic preferences. There is a narrow strand of literature that is concerned with nonhomothetic preferences in trade and/or growth models. However, these models are either static trade models (Foellmi et al. (2008)) or are not models of endogenous growth in the sense of Romer (1990) where new differentiated goods are invented (Spilimbergo (2000)). The model closest to the one developed in this paper is Hanslin (2005). She develops a North-South model of endogenous growth and nonhomothetic preferences. Technological progress happens in the North through investment in research and development that creates new blueprints. The South does not create new blueprints but imitates goods that have been invented in the North. Households have nonhomothetic preferences of the zero-one form (see Matsuyama (2000)). All households in the North are equal whereas in the South there are two groups of households, namely rich and poor. It is assumed that the households in the North are wealthier than the rich in the South. There is free trade between countries. The analysis is restricted to the steady-state. Hanslin finds that an increase in inequality has a positive effect on the growth rate and the fraction of goods that are imitated. The fundamental difference to Hanslin (2005) is the different structure of the North-South to the model developed in this paper. Furthermore, trade in her model is free across borders. Thus, she cannot analyze the interaction of nonhomothetic preferences and trade liberalization.

In section 1 I describe the framework of the model in detail. Section 2 elaborates the balanced growth path properties. The model exhibits multiple steady states which are discussed in sections 2.1 and 2.2. Section 3 concludes.

1 The Model

I construct a dynamic, two-country model of costly international trade and endogenous growth. The two countries are labeled $i = A, B$. Each country is populated by identical households. However, I allow households to be potentially different with respect to their endowment of efficiency units of labor across countries. The model follows closely Foellmi and Zweimüller (2006) and Foellmi et al. (2008).

1.1 The Demand Side

The households in this world are all identical with respect to their preferences. Furthermore, households within a country are not only equal in what concerns their preferences but also their endowment with efficiency units of labor. However, I allow for potential heterogeneity on the country level, in particular, households in country A can have a larger endowment of efficiency units of labor than households in country B.

Households in country i have preferences of the following form

$$U_i(0) = \int_0^\infty \frac{1}{1-\sigma} u_i(t)^{1-\sigma} e^{-\rho t} dt \tag{1}$$

where $u_i(t)$ denotes the instantaneous utility function and is given by

$$u_i(t) = \int_0^{N_i(t)} c_i(j,t) dj.$$

Consumption is a zero-one decision modeled by the indicator function $c_i(j,t)$ that takes the value 1 if good j is consumed by a household in country i at time t, and zero otherwise. Zero-one preferences imply that households' consumption choice is restricted to the extensive margin. In contrast, with constant elasticity of substitution preferences households can only choose consumption along the intensive margin. $N_i(t)$ is the measure of differentiated goods purchased by a household in country i. The household faces essentially a two-stage budgeting problem. In a first stage the household optimally allocates her expenditure, $E_i(t)$, across differentiated goods. The household's optimization problem in the first stage can be formulated as

$$\max \int_0^{N_i(t)} c_i(j,t) dj$$

by choosing $c(j,t)$, subject to

$$\int_0^{N_i(t)} p^i(j,t) c_i(j,t) dj = E_i(t).$$

Here, $p^i(j,t)$ denotes the price of variety j at time t charged in country i. The first-order (Kuhn-Tucker) conditions of the problem are given by

$$c_i(j,t) = \begin{cases} 1, & p^i(j,t) \leq 1/\lambda_i(t) \\ 0, & p^i(j,t) > 1/\lambda_i(t) \end{cases} \tag{2}$$

where $\lambda_i(t)$ is the Lagrange multiplier (here the marginal utility of income of a household from i) associated with the optimization problem of the first stage. Substituting the first-order condition back into the budget constraint yields the following demand equation

$$N_i(t) = \frac{E_i(t)}{p^i(t)}.$$

Note that I have used the fact that in equilibrium prices charged in country i will be symmetric. It follows that the indirect instantaneous utility function, $v_i(t)$, of a household from country i can be written as

$$v_i(t) = N_i(t) = \frac{E_i(t)}{p^i(t)}.$$

In the second-step a household needs to allocate her expenditure optimally across periods given the optimal choice of consumption within each period. The household's optimization problem in the second stage is

$$\max \int_0^\infty \frac{1}{1-\sigma} \left(\frac{E_i(t)}{p^i(t)} \right)^{1-\sigma} e^{-\rho t} dt$$

by choosing $E_i(t)$, subject to

$$\int_0^\infty E_i(t) e^{-R^i(t)} dt = \int_0^\infty w^i(t) l_i e^{-R^i(t)} dt + V_i(0)$$

where $w^i(t)$ denotes the market-clearing wage in country i at date t, and l_i the stationary efficiency units of labor endowment of a household in country i. Since the labor market is competitive in country i the wage rate $w^i(t)$ is the same for each household and taken as given. $R^i(t) = \int_0^t r^i(s) ds$ denotes the cumulative discount factor in country i. The solution to the optimization problem is characterized by

$$\left(\frac{E_i(t)}{p^i(t)} \right)^{-\sigma} \frac{1}{p^i(t)} e^{-\rho t} = \mu_i e^{-R^i(t)}$$

where $V_i(0)$ is the initial wealth endowment of a household from i, and μ_i is the Lagrange multiplier associated with the second stage optimization problem. I can rewrite the first-order condition as

$$N_i(t)^{-\sigma} \frac{1}{p^i(t)} e^{-\rho t} = \mu_i e^{-R^i(t)}$$

taking logs and differentiating with respect to time yields

$$\frac{\dot{N}_i(t)}{N_i(t)} = \frac{r^i(t) - \rho - \frac{\dot{p}^i(t)}{p^i(t)}}{\sigma}. \tag{3}$$

Note that $\frac{\partial R^i(t)}{\partial t} = \frac{\partial}{\partial t} \int_0^t r^i(s) ds = r^i(t)$. Equation (3) is the Euler equation telling us how the optimal consumption path of a household in country i evolves over time.

1.2 The Supply Side

I abstract from heterogeneity in the supply side. All firms in the world are identical with respect to their technology. The technology they employ requires labor as its only input factor. Technology is characterized as follows. A firm has to create a design or blueprint which grants the firm access to a linear production technology. The use of the designs is then protected by infinitely lived patents that are fully enforced. Hence, firms are in a monopoly position and can charge prices above their marginal costs. The innovation of a new design requires $F^i(t) = F/N(t)$ units of labor. Here, $N(t)$ denotes the measure of known designs at time t in the entire world. Let the stock of designs at time t in country i be $N^i(t)$. The stock of designs in the world is then the sum of the stocks of designs of all countries in the world, in particular $N(t) = N^A(t) + N^B(t)$. That is both countries have access to the same technology. Production of 1 unit of final output requires $b^i(t) = b/N(t)$ units of labor. Labor is not mobile across borders. The labor market is competitive and $w^i(t)$ denotes the market-clearing wage rate in country i at time t. Thus, in country i the cost of inventing a new design is $w^i(t)F^i(t)$, and the cost of producing 1 unit of output is $w^i(t)b^i(t)$. I am free to choose a numeraire. I set the marginal cost of production in country A equal to one, so that $w^A(t)b^A(t) = 1$. This implies that the wage rate in country A, $w^A(t) = N(t)/b$, grows at the same rate as the stock of designs in the world, and that the innovation cost in country A remains constant over time, $w^A(t)F^A(t) = F/b$.

2 Balanced Growth Path

2.1 Full Trade Equilibrium

I consider a situation where the inequality between country A and country B is sufficiently low, so that all households in the world consume all differentiated goods available in equilibrium. I assume that households in country A have a higher labor endowment than households in country B. In particular I assume $l_A > \tau l_B$ which also implies $l_A > l_B$. Trade across borders is costly. The transport costs, denoted by τ, are assumed to take the form of iceberg costs, i.e. to make sure that one unit of the good reaches its destination $\tau \geq 1$ units have to be shipped.

2.1.1 Prices and Interest Rate

I consider an equilibrium where all households in the world consume all differentiated goods available in the world. How can such a situation be an equilibrium? First, in equilibrium, firms will charge prices in country i that equal the willingness to pay of households in country i. This implies that prices in country i are identical for all j since within country i all households have the same willingness to pay (remember I abstract from within country inequality). I assume that households in country A are richer than households in country B, which will indeed turn out to be the case in equilibrium since households in country A have the higher labor endowment, and in equilibrium the wage rates in both countries will be equalized. Furthermore, discounted profits of monopolists owned by the households (each household in country i holds an equal share in the stocks of a monopolist) will be equal to the cost of innovation in equilibrium. I assume that households in country i hold equal shares only in monopolistic firms from country i, i.e. there is a perfect home bias in the composition of a household's portfolio. This implies that prices in country A will be higher in equilibrium than in country B since the willingness to pay of households in country A is higher than in country B.

There is the following caveat. In principle a monopolist can perfectly price discriminate between households from country A and B. However, the price setting behavior of a monopolist is restricted if I allow for parallel imports. In this case, the threat of parallel imports disciplines the price setting behavior of the monopolist in the sense that if the difference between the willingness to pay of households in country A and B is high, arbitrage possibilities emerge. The price setting restriction becomes binding if the willingness to pay of households in the rich country exceeds the willingness to pay of the households in the poor country plus transport costs.

I now assume that the inequality between country A and B is not very high such that the price setting restriction for monopolists is not binding, i.e. the willingness to pay of households in country A does not exceed the willingness to pay of households in country B plus transport costs. In this case, monopolists charge higher prices in country A than in B, and since those prices equal the willingness to pay of households their budget constraints are exhausted. In other words, monopolists can perfectly price discriminate. There is no incentive to deviate for a monopolist and sell only to households in country A. Thus, the proposed equilibrium is indeed a (Nash) equilibrium.

First, consider the profits of a monopolist j at time t in country A, which are given by

$$\Pi^A(j,t) = \left[p^A(j,t) - 1\right] L^A + \left[p^B(j,t) - \tau\right] L^B \quad \forall j,t.$$

Profits of a monopolist j at time t in country B are

$$\Pi^B(j,t) = \left[p^A(j,t) - \tau b \frac{w^B(t)}{N(t)}\right] L^A + \left[p^B(j,t) - b \frac{w^B(t)}{N(t)}\right] L^B \quad \forall j,t.$$

I assume that the number of households is equal in both countries, $L^A = L^B \equiv L$. On the balanced growth path profit flows have to be constant over time. This implies that prices on the balanced growth path have to be stationary, $\dot{p}^i(j,t)/p^i(j,t) = 0$. It also implies that the wage rate in country B has to grow at a rate equal to the growth rate of the stock of designs in the world. I define the growth rate of the world stock of designs as $g^W(t) := \dot{N}(t)/N(t)$. On the balanced growth path the stock of designs in the world grows at a constant rate equal to $g^W(t) = g^W$. Going back to the Euler equation (3) and using the conditions on the balanced growth path, I get

$$g^W = \frac{r^A(t) - \rho}{\sigma}$$

implying $r^A(t) = r^A$, and

$$g^W = \frac{r^B(t) - \rho}{\sigma}$$

implying $r^B(t) = r^B$. Combining the two expressions yields $r^A = r^B \equiv r$, i.e. the discount factor has to be equal across countries. I can rewrite the Euler equation in the following form

$$g^W = \frac{r - \rho}{\sigma}. \tag{4}$$

The Euler equation (4) applies to both countries. Hence, on the bgp considered the evolution of consumption of households in country A and B is identical.

2.1.2 Resource Constraints

The resource constraint in country i is composed of two parts. The first part tells me how much resources are allocated to the research and development (R&D) sector whereas the second part tells me how much resources are allocated to the production sector of the economy. The resources required in the R&D sector are determined by $F^i(t)\dot{N}^i(t)$. Thus, I have for country A

$$F\frac{\dot{N}^A(t)}{N(t)} = \frac{1}{1+n(t)}Fg^A(t)$$

where $g^A(t) := \dot{N}^A(t)/N^A(t)$, and $n(t) := N^B(t)/N^A(t)$. Similarly, I get for country B

$$F\frac{\dot{N}^B(t)}{N(t)} = \frac{n(t)}{1+n(t)}Fg^B(t)$$

where $g^B(t) := \dot{N}^B(t)/N^B(t)$. In the production sector the resources required in country i are determined by

$$\int_0^{N^i(t)} b^i(t) \left[c^i_{k=i}(j,t)L^i + c^i_{k\neq i}(j,t)L^{k\neq i}\right] dj$$

where $k, i \in \{A, B\}$. c^i_k denotes the consumption of differentiated goods produced in country i by households from country k, and L^i denotes the number of households in country i which is constant over time. Thus, I have for country A

$$\int_0^{N^A(t)} b^A(t) \left[c^A_A(j,t)L^A + \tau c^A_B(j,t)L^B\right] dj = \frac{b(L^A + \tau L^B)}{1+n(t)}$$

and, respectively, for country B

$$\int_0^{N^B(t)} b^B(t) \left[c^B_B(j,t)L^B + \tau c^B_A(j,t)L^A\right] dj = \frac{n(t)b(\tau L^A + L^B)}{1+n(t)}.$$

A competitive labor market ensures that demand equals supply in the economy at every point in time. It follows that the resource constraint of the economy in country A is given by

$$l_A L^A = \frac{1}{1+n(t)} \left[F g^A(t) + b(L^A + \tau L^B) \right] \tag{5}$$

whereas in country B the resource constraint is

$$l_B L^B = \frac{n(t)}{1+n(t)} \left[F g^B(t) + b(\tau L^A + L^B) \right]. \tag{6}$$

A balanced growth path along which the allocation of resources across sectors is constant requires that, $g^A(t) = g^A$, $g^B(t) = g^B$, and $n(t) = n = N^B/N^A$, which implies that $g^A = g^B \equiv g$. Combining this with the resource constraints yields the following expression for n

$$n = \frac{l_B}{l_A} < 1 \tag{7}$$

since $l_A > l_B$ by assumption. Recall that I further assume the number of households to be equal in both countries, $L^A = L^B \equiv L$.

2.1.3 Zero-Profit Conditions

There is free entry into the R&D sector that leads to zero-profits in equilibrium in the sense that the discounted value of future profits is equal to the cost of innovation. Thus, in country i the zero profit condition can be written as $w^i(t)F^i(t) = \int_0^\infty \Pi^i(j,t)e^{-R^i(t)}dt$. On the balanced growth path the profit flows are constant and equal for every monopolist j, and the discount factor is constant over time. I use these facts to rewrite the corresponding zero-profit condition for country A as follows

$$\frac{F}{b} = \frac{\left[p^A - 1\right] L + \left[p^B - \tau\right] L}{r} \tag{8}$$

and for country B, respectively,

$$F\frac{w^B(t)}{N(t)} = \frac{\left[p^A - \tau b \frac{w^B(t)}{N(t)}\right] L + \left[p^B - b\frac{w^B(t)}{N(t)}\right] L}{r}. \tag{9}$$

2.1.4 Budget Constraints

I can now rewrite the intertemporal budget constraint of a representative household in country A as

$$\begin{aligned}\int_0^\infty \int_0^{N(t)} p^A(j,t)c_A(j,t)dje^{-rt}dt &= \int_0^\infty w^A(t)l_Ae^{-rt}dt + V_A(0)\\ p^A\int_0^\infty N(t)e^{-rt}dt &= \frac{l_A}{b}\int_0^\infty N(t)e^{-rt}dt + V_A(0)\\ \frac{p^AN(0)}{(r-g^W)} &= \frac{l_AN(0)}{b(r-g^W)} + V_A(0)\\ p^A &= \frac{l_A}{b} + \frac{V_A(0)(r-g^W)}{N(0)}\end{aligned}$$

where $V_A(0)$ is the initial wealth endowment of a household in A. The initial wealth endowment is equal to the share of the household in the market value of monopolistic firms at time zero. All households hold equal shares in monopolistic firms. The market value of monopolistic firms in A is equal to the discounted value at time zero of their future profits. From the zero-profit condition (8) the market value equals the cost of creating a new design, F/b. Hence, the price p^A can be written as

$$p^A = \frac{l_A}{b} + \frac{F}{bL}\frac{(r-g^W)}{1+n(0)} \tag{10}$$

where $n(0) := N^B(0)/N^A(0)$. Substituting equation (10) into equation (8) yields the following expression for p^B

$$p^B = (1+\tau) + \frac{Fr - Ll_A}{bL} - \frac{F(r-g^W)}{bL(1+n(0))} \tag{11}$$

Now, I combine equations (11) and (10) with the zero-profit condition of a monopolist in country B (9) to solve for $w^B(t)$.

$$w^B(t) = \frac{N(t)}{b} \tag{12}$$

Hence, the wage rates are equal in both countries and grow at the same rate as the stock of designs in the world. In a similar way as I rewrote the budget constraint of a representative household in country A, I can rewrite the budget constraint of a representative household in country B as

$$
\begin{aligned}
\int_0^\infty \int_0^{N(t)} p^B(j,t) c_B(j,t) dj e^{-rt} dt &= \int_0^\infty w^B(t) l_B e^{-rt} dt + V_B(0) \\
p^B \int_0^\infty N(t) e^{-rt} dt &= \frac{l_B}{b} \int_0^\infty N(t) e^{-rt} dt + V_B(0) \\
\frac{p^B N(0)}{(r - g^W)} &= \frac{l_B N(0)}{(r - g^W)} + V_B(0) \\
p^B &= \frac{l_B}{b} + \frac{V_B(0)(r - g^W)}{N(0)}
\end{aligned}
$$

where $V_B(0)$ is the initial wealth endowment of a household in B. The initial wealth endowment is equal to the share of the household in the market value of monopolistic firms at time zero. All households hold equal shares in monopolistic firms. The market value of monopolistic firms in B is equal to the discounted value at time zero of their future profits. From the zero-profit condition (9) and the wage rate in B (12) the market value equals the cost of creating a new design, F/b. Hence, the price p^B can be written as

$$
p^B = \frac{l_B}{b} + \frac{F}{bL} \frac{n(0)(r - g^W)}{1 + n(0)} \tag{13}
$$

2.1.5 Balance of Payments

At every point in time trade has to be balanced on the balanced growth path. From the perspective of country A, the value of imports, $p^A N^B(t) L^A$, has to be equal to the value of exports, $p^B N^A(t) L^B$, which yields

$$
\frac{l_B}{l_A} = \frac{L l_B (1 + n(0)) + n(0) F (r - g^W)}{L l_A (1 + n(0)) + F (r - g^W)}. \tag{14}
$$

From (14) follows that $n(0) = l_B/l_A$. This is true since $n(t) = n = l_B/l_A$ on the balanced growth path, and there is no population growth.

2.1.6 Growth Rate

I am now able to solve for the growth rate on the balanced growth path by combining equations (10), (13), and (8)

$$
g^W = \frac{L}{F} \left[(l_A + l_B) - b(1 + \tau) \right]. \tag{15}
$$

The growth rate is independent of preference parameters like the subjective discount factor of households ρ, and the intertemporal elasticity of substitution $1/\sigma$. To understand why the growth rate is independent of preference parameters consider a decrease in the subjective discount factor ρ which translates into households being more patient. As in standard endogenous growth models a decrease in ρ leads to a decrease in the interest rate r. This increases the present discounted value of future profits of monopolistic firms (the value of the firms) and thus induces more firms to enter the market. This effect increases the growth rate. However, in this model it is crucial to notice that markups of monopolistic firms are endogenous. If households become more patient the willingness to pay for differentiated goods today relative to tomorrow falls. Thus prices of varieties, markups and hence the present discounted value of profits fall reducing the incentive to innovate for firms. This effect reduces the number of monopolistic firms entering the market lowering the growth rate. On this balanced growth path where firms can perfectly price discriminate these two effects exactly offset each other.

An increase in transport costs τ lowers the present discounted value of profits and thereby the growth rate of the economy.

The growth rate is increasing in the endowment of efficiency units of labor in both countries, l_A and l_B. A higher endowment of efficiency units of labor means a higher income and thus a higher willingness to pay. Hence firms can charge higher prices, markup and therefore profits are higher increasing the incentive to innovate. Note that the degree of inequality on this growth path has no bearing on the growth rate. Intuitively, if both countries consume all varieties that are produced in the world inequality does not matter. However, inequality can not rise without bound for this equilibrium to be sustainable. If inequality reaches a certain level the economy will transition to a balanced growth path where only part of all varieties are traded.

An increase in the amount of labor needed to create a new blueprint, F, or to produce one unit of final output, b, decreases the present discounted value of profits and thus the incentive to innovate. This results in a lower growth rate.

The population size L has a positive effect on the growth rate. Due to increasing returns a larger market means that monopolistic firms can produced at lower average costs. This increases profits and thus the incentive to innovate.

2.1.7 Discussion

In sum, on a balanced growth path where all differentiated goods produced in the world are traded income inequality (i.e. a mean preserving spread) across countries has no effect on the growth rate of the world economy (and thereby on the growth rate of the individual countries). The effect of income inequality on the volume of trade is ambiguous. Reducing the inequality by increasing the efficiency units of labor of every household in B increases the volume of trade because it increases the number of varieties produced in B. On the other hand, reducing inequality by decreasing the efficiency units of labor of every household in A decreases the volume of trade because it decreases the number of varieties produced in A.

2.2 Partial Trade Equilibrium

I now turn to the same situation as before but where the inequality between country A and B is sufficiently high, so that the price setting restriction of monopolists becomes binding. Monopolists can no longer set prices in country A equal to willingness to pay of households in A but instead are forced to set prices equal to the willingness to pay of households in B plus transport costs. In such a situation only part of all differentiated goods produced in A will be shipped to B. Some producers in A will sell to households from A exclusively, and thus can set a price equal to the willingness of households in A. They might miss out on a larger market but instead they can charge a higher price. Of course, in equilibrium producers have to be indifferent as to serve the world market or the market in A exclusively.

2.2.1 Balance of Payments

For further use it is convenient to consider the balance of payments. The balance of payments requires that the value of imports equal the value of exports of a country. From the perspective of A the balance of payments is given by

$$\underbrace{\tau p^B N^B(t) L}_{\text{Value of Imports}} = \underbrace{p^B N_T^A(t) L}_{\text{Value of Exports}}$$

On the bgp the balance of payments has to hold in every period t. This implies that $\tau N^B(t) = N_T^A(t)$. Thus the number of nontraded varieties produced in A can be expressed as $N_{NT}^A(t) = N^A(t) - \tau N^B(t)$.

2.2.2 Prices and Interest Rate

I assume that the partial trade equilibrium is characterized as follows. Households from country A consume all differentiated goods produced in A and B whereas households from B can only afford a subset of all goods produced in A and all goods produced in B. The subset of goods produced in A that is not traded will be priced according to the willingness to pay of households in A. Goods that are produced in A and traded will have a price in A equal to the willingness to pay of households in B plus transport costs. All goods produced in B will be imported by A at a price equal to the willingness to pay of households in B plus transport costs. All goods sold in B have the same price equal to the willingness to pay of households in B.

First, I look at the profits of a monopolist j at time t in country A, that sells only to households in A. Her profits are given by

$$\Pi_A^A(j,t) = \left[p^A(j,t) - 1\right] L \quad \forall j, t.$$

The profits of a monopolist j at time t in country A, selling to households in A and B, has profits equal to

$$\Pi_{tot}^A(j,t) = \left[\tau p^B(j,t) - 1\right] L + \left[p^B(j,t) - \tau\right] L \quad \forall j, t.$$

A monopolist j in country B that sells both to households in A and B makes profits at time t

$$\Pi^B_{tot}(j,t) = \left[\tau p^B(j,t) - \tau b\frac{w^B(t)}{N(t)}\right] L + \left[p^B(j,t) - b\frac{w^B(t)}{N(t)}\right] L \qquad \forall j,t.$$

On the balanced growth path profit flows have to be constant over time. This implies that prices have to be constant as well, $\dot{p}^A_{NT}(j,t)/p^A_{NT}(j,t) = 0$, and $\dot{p}^B(j,t)/p^B(j,t) = 0$. It further implies that, $w^B(t)/N(t)$, has to be constant. It means that wages in country B grow at the same rate as the stock of designs in the world.

The Euler equation in country A is now given by

$$\frac{\dot{N}_A(t)}{N_A(t)} = \frac{r^A(t) - \rho - \frac{\dot{p}^B(t)}{p^B(t)}}{\sigma}$$

where $N_A(t)$ denotes the number of differentiated goods a household in A consumes at time t. Using the fact that $N_A(t) = N(t)$ and imposing the bgp results in

$$g^W = \frac{r^A - \rho}{\sigma}. \tag{16}$$

The Euler equation on the bgp in country B is now given by

$$\frac{\dot{N}_B(t)}{N_B(t)} = \frac{r^B(t) - \rho}{\sigma}$$

where where $N_B(t)$ denotes the number of differentiated goods a household in B consumes at time t. $N_B(t)$ consists of all goods produced in B, $N^B(t)$, and the subset of goods produced in A that are traded, $N^A_T(t)$. The balance of payments implies that $N^A_T(t) = \tau N^B(t)$. Thus, I can write

$$N_B(t) = (1+\tau)N^B(t).$$

Taking logs and differentiating with respect to time t yields

$$\frac{\dot{N}_B(t)}{N_B(t)} = \frac{\dot{N}^B(t)}{N^B(t)} = \frac{r^B(t) - \rho}{\sigma}.$$

2.2.3 Resource Constraints

The resource constraints are derived in an analogue way to the previous section. First, the resources required in the R&D sector in A are determined by

$$F\frac{\dot{N}^A(t)}{N^A(t)} = \frac{1}{1+n(t)} F g^A(t)$$

whereas in country B required resources for R&D are given by

$$F\frac{\dot{N}^B(t)}{N^B(t)} = \frac{n(t)}{1+n(t)}Fg^B(t).$$

The production sector in country A requires resources of

$$\int_0^{N^A(t)} b^A(t)c_A^A(j,t)Ldj + \int_0^{N_T^A(t)} b^A(t)\tau c_B^A(j,t)Ldj = bL\left(\frac{1}{1+n(t)}\right) + bL\tau^2\left(\frac{n(t)}{1+n(t)}\right)$$

where I have used $N_T^A(t) = \tau N^B(t)$ from the balance of payments. For country B

$$\int_0^{N^B(t)} b^B(t)\left[c_B^B(j,t)L + \tau c_A^B(j,t)L\right]dj = bL\,(1+\tau)\left(\frac{n(t)}{1+n(t)}\right).$$

A competitive labor market ensures that demand equals supply in the economy at every point in time. It follows that the resource constraint in A is given by

$$l_A L = g^A(t)F\left(\frac{1}{1+n(t)}\right) + bL\left(\frac{1}{1+n(t)}\right) + bL\tau^2\left(\frac{n(t)}{1+n(t)}\right) \tag{17}$$

whereas in B the resource constraint of the economy is

$$l_B L = \left(\frac{n(t)}{1+n(t)}\right)\left[g^B(t)F + bL(1+\tau)\right]. \tag{18}$$

On a bgp along which the allocation of resources across sectors is constant requires that, $g^A(t) = g^A$, $g^B(t) = g^B$, $n(t) = n$ which implies $g^A = g^B$.

The resource constraints yield the ratio of differentiated goods produced in B to A, $n(t)$. Combining the two constraints gives the quadratic equation

$$n(t)^2\left(l_A - b\tau^2\right) + n(t)\left(l_A - l_B + b\tau\right) - l_B = 0. \tag{19}$$

The relevant solution to equation (19) is

$$n(t) = \frac{-\left(l_A - l_B + b\tau\right) + \sqrt{\left(l_A - l_B + b\tau\right)^2 + 4\left(l_A - b\tau^2\right)l_B}}{2\left(l_A - b\tau^2\right)} \tag{20}$$

for all t. The derivation and discussion of equation (20) has been moved to the appendix.

2.2.4 Interest Rate

I can now go back to the previous section and take another look at the Euler equations. First, I consider the Euler equation (3) in country B. Imposing the bgp, I can rewrite the equation as

$$\frac{\dot{N}_B}{N_B} = \frac{\dot{N}^B}{N^B} = g^W = \frac{r^B - \rho}{\sigma}.$$

This implies that the interest rates are equalized, $r^A = r^B = r$. It follows that the consumption of a household in B grows at the same rate as the consumption of a household in A, namely at the rate the stock of designs in the world grows. Thus, the interest rate on the bgp is given by

$$r = \rho + \sigma g^W. \tag{21}$$

2.2.5 Zero-Profit Conditions

Free entry into the R&D sector implies that monopolistic firms will make zero profits in equilibrium. The present value of future profits has to be equal to the entry costs. The zero-profit condition for a monopolistic firm in country A that sells only on its domestic market is given by

$$\frac{F}{b} = \frac{\left[p_{NT}^A - 1\right] L}{r} \Leftrightarrow p_{NT}^A = \frac{bL + Fr}{bL}. \tag{22}$$

For a firm located in A and serving the world market the zero-profit condition is

$$\frac{F}{b} = \frac{\left[\tau p^B - 1\right] L + \left[p^B - \tau\right] L}{r}. \tag{23}$$

For all firms located in B the zero-profit condition is determined by

$$F\frac{w^B(t)}{N(t)} = \frac{\left[\tau p^B - \tau b\frac{w^B(t)}{N(t)}\right] L + \left[p^B - b\frac{w^B(t)}{N(t)}\right] L}{r}. \tag{24}$$

Combining equations (22) and (24) yields the equilibrium wage rate in country B

$$w^B(t) = \frac{N(t)}{b} \tag{25}$$

2.2.6 Budget Constraints

The budget constraint of the representative household in A is

$$\int_0^\infty \int_0^{N_T^A(t)} \tau p^B(j,t) c_A^{A,T}(j,t) dj e^{-rt} dt + \int_0^\infty \int_0^{N_{NT}^A(t)} p_{NT}^A(j,t) c_A^{A,NT}(j,t) dj e^{-rt}$$
$$+ \int_0^{N^B(t)} \tau p^B(j,t) c_A^B(j,t) dj e^{-rt} dt = \int_0^\infty w^A(t) l_A e^{-rt} dt + V_A(0)$$

where $c_A^{A,T}(j,t)$ denotes the consumption of a good j at time t, that is produced in A and is traded, and $c_A^{A,NT}(j,t)$ is the consumption of a good j at t, that is produced in A but is not traded. Imposing the bgp, I can rewrite the budget constraint as follows

$$\tau p^B \left[N_T^A(0) + N^B(0)\right] + p_{NT}^A N_{NT}^A(0) = \frac{l_A}{b} N(0) + V_A(0)(r - g^W). \tag{26}$$

The budget constraint of the representative household in B is given by

$$\int_0^\infty \int_0^{N^B(t)} p^B(j,t) c_B^B(j,t) dj e^{-rt} dt + \int_0^\infty \int_0^{N_T^A(t)} p^B(j,t) c_B^{A,T}(j,t) dj e^{-rt} dt$$
$$= \int_0^\infty w^B(t) l_B e^{-rt} dt + V_B(0)$$

where $c_B^B(j,t)$ denotes the consumption of good j at time t, that is produced in B, and $c_B^{A,T}(j,t)$ is the consumption of a good j at time t, that is produced in A and is traded. Again, imposing the bgp implies the following budget constraint for the representative household in B

$$p^B \left[N_T^A(0) + N^B(0) \right] = \frac{l_B}{b} N(0) + V_B(0)(r - g^W). \tag{27}$$

By combining equations (26) and (27) I get an expression for the price of a nontraded good in country A

$$\begin{aligned} p_{NT}^A &= \frac{N(0)}{N_{NT}^A(0)} \frac{(l_A - \tau l_B)}{b} + \frac{F\left(r - g^W\right)}{bL} \left[\frac{N^A(0)}{N_{NT}^A(0)} - \tau \frac{N^B(0)}{N_{NT}^A(0)} \right] \\ p_{NT}^A &= \left(\frac{1 + n(0)}{1 - \tau n(0)} \right) \frac{l_A - \tau l_B}{b} + \frac{F\left(r - g^W\right)}{bL} \end{aligned} \tag{28}$$

where $N_{NT}^A(t) = N^A(t) - \tau N^B(t)$ is used.

2.2.7 Growth Rate

If I combine equations (22) and (28) I get the following expression for the growth rate on the bgp

$$g^W = \frac{L}{F} \left[\left(\frac{1 + n(0)}{1 - \tau n(0)} \right) (l_A - \tau l_B) - b \right]. \tag{29}$$

where $n(0)$ is given by (20). One can show that $n(0)$ is increasing in transport costs τ, decreasing in l_A, and increasing in l_B.

One can further show that an increase in transport costs τ decreases the growth rate. On one hand there is a negative direct effect of τ on the growth rate by reducing profits of monopolistic firms. On the other hand there is a positive direct effect on the growth rate by increasing the ratio of varieties produced in B to A. However, the negative direct effect outweighs the positive indirect effect.

Increasing inequality by increasing the endowment with efficiency units of labor of households in A has a negative indirect effect on the growth rate and a positive direct effect. The indirect effect works through a lower ratio of varieties produced in B to A whereas the direct effect works through a higher income of households in A. One can show that the positive direct effect outweighs the negative indirect effect. Hence increasing inequality increases the world growth rate. Similarly, if the inequality is reduced by increasing the efficiency units of labor of households in B. There is a positive indirect effect by increasing the ratio of varieties produced in B to A and a negative direct effect by reducing markups charged on differentiated goods exclusively sold to households in A. Again, the direct effect outweighs the indirect effect. In sum, an increase in inequality is unambiguously increasing the world growth rate.

As in the previous section 2.1 an increase in the amount of labor needed to create a new blueprint, F, or to produce one unit of final output, b, decreases the growth rate. The population size L has a positive effect on the growth rate as before due to the same argument.

2.2.8 Discussion

Summarizing the results I note that an increase in inequality unambiguously increases the world growth rate. The positive price effects of higher inequality outweigh the negative market size effects. The effect of inequality on the volume of trade is negative. Increasing the inequality reduces the number of varieties produced in A that are traded thereby lowering the volume of trade.

3 Conclusion

I studied a dynamic, two-country model of international trade and endogenous growth where agents have nonhomothetic preferences. I find that the model exhibits multiple steady states. In a steady state where all differentiated goods worldwide are traded inequality has no effect on the growth rate of the world economy and an ambiguous effect on the volume of trade. In a steady state where only part of all varieties are traded I find that inequality has a positive effect on the world growth rate and a negative effect on the volume of trade.

Future research will be directed in investigating the dynamic properties of the model discussed above.

4 Appendix

The appendix discusses the derivation of equation (20) in section 2.2. Households in A are endowed with more efficiency units of labor than households in B, in particular I assume that $l_A > \tau l_B$. Again, economic reasoning requires $n(t) > 0$. Now assume that the relevant real solution to equation (19) is

$$n(t) = \frac{-\left(l_A - l_B + b\tau\right) - \sqrt{\left(l_A - l_B + b\tau\right)^2 + 4\left(l_A - b\tau^2\right) l_B}}{2\left(l_A - b\tau^2\right)}.$$

Note that $(l_A - l_B + b\tau) > 0$, and $n(t) > 0$ requires that $\left(l_A - b\tau^2\right) < 0$. Second, inspection of the growth rate (29) uncovers that if $g^W > 0$, $\tau n(0) < 1$ must hold. Thus, for all t

$$n(t) = \tau\left(\frac{-\left(l_A - l_B + b\tau\right) - \sqrt{\left(l_A - l_B + b\tau\right)^2 + 4\left(l_A - b\tau^2\right) l_B}}{2\left(l_A - b\tau^2\right)}\right) < 1$$

$$\vdots$$

$$0 < \left(l_A - b\tau^2\right)\left(l_A - \tau l_B\right) + \tau\left(l_A - b\tau^2\right)\left(l_A - \tau l_B\right)$$

$$0 < \underbrace{\left(l_A - b\tau^2\right)}_{<0}\underbrace{\left(l_A - \tau l_B\right)}_{>0}\underbrace{(1+\tau)}_{>0}$$

which is a contradiction to $\tau n(0) < 1$. Thus the relevant solution to equation (19) has to be the one given in the text. The relevant solution implies that $\left(l_A - b\tau^2\right) > 0$ or $l_A/b > \tau^2$. The labor productivity in the production sector in A has to exceed the squared transport cost. If this holds then $\tau n(t) < 1$ is smaller than one which implies that $(1 + n(0))/(1 - \tau n(0)) > 1$.

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