Globalization, Rent Protection Institutions, and Going Alone In Freeing Trade

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Abstract: We construct a two-country North-South product cycle model of trade and non-scale growth to explore the growth and relative-wage effects of two forms of globalization – an expansion of the relative size of the South and unilateral trade liberalization by either country. Both Northern innovation and Southern imitation are endogenously determined. We find that the location of rent protection institutions and the sectoral trade structure determine whether or not globalization raises steady-state economic growth. We demonstrate that for accelerating worldwide economic growth, contrary to conventional wisdom, unilateral Northern trade liberalization is preferable to bilateral trade liberalization.

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1 Introduction

The past two decades have been marked by the entry of large developing countries, such as Argentina, Brazil, China, Egypt, India, Turkey, Poland and Romania into the world trading system. As shown in Figure 1, between 1990 and 2002 the world trade share of middle-income countries has increased from 15 percent to 22 percent. During the 1983-2003 period, China as the world's most populous country has increased its share in global trade from 1.01 percent to 5.04 percent.

Insert here: Figure 1

Moreover, during the eight GATT negotiation rounds from Geneva 1947-48 to Uruguay 1986-93, the average tariff rates among participants declined from 52.7 % to 13.1% of the 1931 level, as shown in Table 1. From earlier to later rounds, the number of participants increased significantly, mainly due to developing countries joining the GATT negotiations.

Insert here: Table 1

With more developing countries establishing international trade linkages and pursuing freer trade policies, these globalization trends are likely to continue in the following years.

Is 'globalization' good for economic growth? We analyze this question theoretically in a general-equilibrium North-South Schumpeterian growth model with a continuum of high-tech industries.[1] Northern entrepreneurs participate in R&D races to innovate higher quality consumption goods. Southern entrepreneurs compete to imitate the current Northern production technologies. In each industry, the winner of the R&D race establishes temporary monopoly power until driven out of the market by further innovation or imitation. Global economic growth is driven by the continuous arrival of higher quality goods through Northern R&D races. During their tenure, Northern monopolists engage in Rent-Protection Activities (RPAs) to safeguard their monopoly profits.[2] Northern innovation and Southern imitation rates are determined endogenously. With lower production costs in the South, successful imitation in a certain industry implies the shifting of production from the North to the South. This gives rise to North-South "product-cycle trade": the North exports newly invented goods which are not yet imitated, and the South exports imitated products. The governments in both the North and the South impose ad-valorem tariffs on high-tech imports.

We focus on two alternative aspects of globalization: increased trade integration of the South in the form of an expansion of the relative size of the South that is open to trade (modeled as an

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[1] The empirical evidence on the trade-growth nexus is mixed: while the majority 'optimistic' view is that trade raises growth (see e.g. Lewer and van den Berg, 2003, Wacziarg and Welch, 2003, Winters, 2004, or Noguer and Siscart, 2005), other researchers have important reservations on how the 'optimists' have derived and interpreted their results, and hence remain overall skeptic (see e.g. Rodríguez and Rodrik, 2001, Hallak and Levinsohn, 2004, or Wälde and Wood, 2004).

[2] RPA in an endogenous growth model are originally proposed by Dinopoulos and Syropoulos (2007). See that paper as well as Şener (2006) for empirical evidence on the significance of RPA.

increase in the Southern population size relative to the North)[3], and incremental trade liberalization that takes the form of a reduction of ad-valorem import tariffs.

In our model, we make two distinctions which turn out to be crucial for our main findings on whether or not globalization raises growth. **First**, we differentiate between two institutional frameworks through which rent protection in the South may materialize:

1. Local-resource using rent protection: Southern resources are used for imitation-deterring activities and Northern resources are used for innovation-deterring activities;

2. Northern-resource using rent protection: Both activities are combined as general rent protection and use only Northern resources.

We find that in the Northern-resource-using case, increased Southern trade integration exerts a positive effect on imitation, innovation, and hence on economic growth. In the local-resource using case, imitation still increases, but the rates of innovation and economic growth can be lower (**main result 1**).

Second, we consider as our baseline setting a model in which only "high-tech" sector goods are produced in both countries. We then allow for a Southern "low-tech" sector that does not feature quality improvements and operates under free trade conditions. We find that without a low-tech sector, tariff changes have no impact on the rates of Northern innovation, Southern imitation, and economic growth (we refer to this as the "*tariff-neutrality*" result). If a low-tech sector exists (which we consider the more realistic case[4]), unilateral Northern trade liberalization for high-tech goods unambiguously increases Northern innovation, Southern imitation, and economic growth, whereas unilateral Southern trade liberalization has the exact opposite results. From a growth perspective, this provides the North with an argument for 'going alone' in freeing trade (**main result 2**).

Our model differs from the existing literature on endogenous growth and trade on five accounts. **First**, we consider incremental trade liberalization in a North-South setting. The relevant

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[3] This exercise follows Dinopoulos and Segerstrom (2007). The standard North-South product cycle model essentially represents a world economy that consists of three regions: an Open North, an Open South, and a Closed South that has no contact with the open regions. Thus, an increase in the relative size of the *Open* South can appropriately capture the South's increased presence in the world trading system. This integration encapsulates two potential effects on Northern innovation incentives: on the one hand, more Southern labor resources allow the South to invest more in imitation, thereby increasing the imitation threat faced by Northern monopolists. On the other hand, more Southern consumers mean a larger market for sales of Northern incumbent firms, which raises monopoly profits.

[4] The existence of a low-tech sector only in the South implies that the unit cost of low-tech production in the North is prohibitively high for any Northern firm to successfully compete under free trade. Low-tech industries appear to be vanishing in high-wage countries, as already noted by Wood (1995, p. 65) when he criticizes factor-content studies for Northern developed countries: "[…] manufactured imports from developing countries […] consist mostly of items of low skill intensity that are no longer produced on any significant scale in developed countries".

product cycle literature mostly focuses on North-North settings with a few exceptions (e.g., Dinopoulos and Segerstrom, 2007, and Grieben, 2005). Moreover, we introduce into our main North-South setting a Southern low-tech sector and show its crucial role in determining the impact of tariff reductions.

Second, we investigate the effects of unilateral trade liberalization by both the North and the South. Most of the existing literature studies bilateral trade liberalization.[5] Our results show that Northern and Southern unilateral trade liberalization have opposite effects on innovation and imitation.

Third, we incorporate rent-protection activities by incumbents into our North-South model. We find that the effects of economic integration crucially depend on the location of these activities. The only other North-South model with rent-protection activities is the companion paper by Şener (2006) which investigates the global effects of strengthening intellectual property rights under free trade.

Fourth, we offer a scale-free endogenous growth model, which distinguishes our paper from the early literature (like Grossman and Helpman, 1991, or Rivera-Batiz and Romer, 1991) where the steady-state growth rate increases in the amount of resources allocated to R&D. As a consequence of this scale effect, these models propose a positive relationship between economic integration and growth: in an integrated world economy, more workers can create more technical knowledge without duplicating each other's R&D efforts, and R&D returns are higher when technical knowledge can be applied to a larger market. Hence, economic growth should be higher than under autarky. However, despite clear evidence for increased global integration as stated above, and dramatically rising R&D investments during the last decades (as documented e.g. in Jones, 1995a, and Segerstrom, 1998), there has been no clear tendency for growth rates to increase in the advanced countries, which suggests that the scale effect is counterfactual.[6]

Fifth, our model features fully endogenous growth, that is, the steady-state growth rate is affected by all of the model's parameters. Tariff rates and the degree of international integration can have an impact on the long-run growth rate by changing the fraction of resources allocated to inno-

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5 Exceptions are Dinopoulos and Syropoulos (1997), Baldwin and Forslid (1999), and Ben-David and Loewy (2000). None of these papers studies a specific North-South setting, and hence none proposes opposite growth effects of unilateral trade liberalization.

6 Among the many non-scale growth models that have emerged since the "Jones critique", we note Jones (1995b), Young (1998), Peretto (1998), Segerstrom (1998), Peretto and Smulders (2002), Dinopoulos and Segerstrom (1999a), and Şener (2001), where only the latter two consider international trade (in a symmetric North-North setting) at the same time. For further insightful discussion on growth with and without scale effects, see e.g. Dinopoulos and Thompson (1999), Jones (1999, 2005), Christiaans (2004), and Laincz and Peretto (2006).

vation. Within the non-scale growth literature, this differentiates our paper from the semi-endogenous growth models such as Dinopoulos and Segerstrom (2007), where the steady-state growth rate is pinned down by exogenous parameters and unaffected by tariffs and increased integration. [7]

The remainder of this paper is organized as follows. Section 2 presents the elements of the baseline model in which RPAs exclusively use Northern resources and there is no low-tech sector in the South. Section 3 analyses the steady-state effects of increased Southern trade integration and unilateral trade liberalization. Section 4 provides the two crucial extensions of the baseline model (Southern imitation-deterring activities, Southern low-tech sector) which are shown to change the main results. Section 5 concludes.

2 The Model

2.1 Household Behavior

The world economy consists of two countries, the North and the South, indexed by $i \in \{N, S\}$, respectively (variables and parameters without country index are common to both countries). Each country has a fixed number of identical households, normalized to one. Let N_{0i} denote the size of the population and also the labor force of country i at time zero, where we allow for $N_{0N} \neq N_{0S}$. The number of household members in both countries is growing at the common rate $n > 0$, thus the population size in country i at time t, $N_i(t)$, equals $N_{0i}e^{nt}$.

The representative household maximizes the utility function

$$U_i(t) = \int_0^\infty N_{0i} e^{-(\rho-n)t} \log u_i(t)\, dt \qquad \text{for } i = N, S, \tag{1}$$

where $\rho > n$ is the subjective discount (or time preference) rate, and where the instantaneous logarithmic utility function of each household member is

$$\log u_i(t) \equiv \int_0^1 \log\left[\sum_j \lambda^{j(\omega,t)} x_i(j,\omega,t)\right] d\omega \qquad \text{for } i = N, S. \tag{2}$$

$\lambda > 1$ is the size of each quality improvement, $j(\omega,t)$ is the number of successful innovations in industry $\omega \in [0,1]$ up to time t, $x_i(j,\omega,t)$ denotes per-capita demand for a product with j quality im-

[7] Ha and Howitt (2007) argue that the predictions of the fully-endogenous growth models are more consistent with time series data from advanced countries than those of semi-endogenous growth models. Important fully-endogenous growth models include Howitt (1999), Segerstrom (2000), Dalgaard and Kreiner (2001), and Strulik (2005), but they all are confined to a closed economy and stress the role of public policies to affect the long-run growth rate. However, based on more general considerations, Temple (2003, p. 501-502) points out that emphasizing the different long-run policy implications of semi- and fully-endogenous growth models may be of little practical relevance.

provements in industry ω at time t, and $p(j,\omega,t)$ is the corresponding goods price. Hence, as is standard in quality-ladder models, product quality starts at $\lambda^0 = 1$ in any industry ω and improves at discrete steps with each successful innovation following a stochastic process. The household optimization process involves two steps: to allocate labor income across consumer goods that enter (2) at each point in time subject to $\int_0^1 p(j,\omega,t)x(j,\omega,t)d\omega = c_i(t)$, where goods prices are treated as given, and to determine the consumption expenditure path over time. Since the goods produced in each industry ω differ only in their quality, and λ units of quality j are a perfect substitute for one unit of quality j+1, only goods with the lowest quality-adjusted price $p(\omega,t)$ are consumed. In addition, since products enter (2) symmetrically, each household spreads consumption expenditure evenly across product lines. This results in a unit-elastic demand function $x_i(\omega,t) = c_i(t)/p(\omega,t)$ in each industry ω, where $c_i(t)$ is the consumption expenditure per capita in country i at time t, and $p(\omega,t)$ is the market price for the purchased product.[8]

Given the static demand functions, the second step of the representative household's optimization problem is to maximize

$$\int_0^\infty N_{0i} e^{-(\rho-n)t} \log c_i(t)\, dt \qquad \text{for } i = N, S, \tag{3}$$

subject to the intertemporal budget constraint

$$\dot{B}_i(t) = W_i(t) + r(t)B_i(t) - c_i(t)N_i(t),$$

where $B_i(t)$ denotes the stock of financial assets owned by the household (that arises from the ownership of firms earning monopoly profits to be discussed later), $W_i(t)$ is the household's per-period wage income and $r(t)$ is the instantaneous rate of return in the global market. The solution to this dynamic optimization problem is the familiar Euler equation ("Keynes-Ramsey rule")

$$\dot{c}_i(t)/c_i(t) = r(t) - \rho \qquad \text{for } i = N, S. \tag{4}$$

At the steady-state equilibrium, c_i will be constant since the wage rate and labor supply per worker will be constant, thus $r(t) = \rho$. Since we focus on steady-state results, we henceforth drop the time index for variables that remain constant in equilibrium.

2.2 Labor and Activities

Labor is the only factor of production and is immobile across countries. In the North, the labor force

[8] In an extension of the basic model, we will later introduce a "low-tech sector" where goods of constant quality are produced. Then, we will term the goods we have been discussing so far as "high-tech goods".

consists of general-purpose and specialized workers, with the proportion of the former given as $1-s_N$ and that of the latter given as $s_N \in (0, 1)$. In the North, there are three types of activities: innovation, manufacturing of final goods and rent-protection. General-purpose workers can be employed in manufacturing or innovation, whereas specialized workers (like lawyers or lobbyists) are only employed in rent-protection activities.[9] In the South, there is only general-purpose labor which can be employed in manufacturing of final goods or imitation, which are the only types of activities. In an extension of the basic model, we will later introduce Southern specialized labor which will be employed in rent-protection activities.

2.3 Industry Structure and Product Markets

The world economy consists of a continuum of structurally-identical industries indexed by $\omega \in [0, 1]$, i.e. the mass of industries is normalized to unity. In the North, entrepreneurs participate in innovation races to discover the technology of producing *next* generation consumer goods, where each innovation improves the existing generation by a quality step of size $\lambda > 1$. In the South, entrepreneurs participate in imitation races to acquire the technology of producing *current* generation products, which refer to the existing state-of-the-art products manufactured by the current Northern quality leader in industry ω. Producer firms compete to offer the lowest quality-adjusted price given their state of technology and regional factor prices. Northern entrepreneurs target their innovation efforts at *all* industries, while Southern entrepreneurs target their imitation efforts only at industries with a Northern quality leader since price competition among two Southern firms with identical technologies for the same industry ω would imply zero profits. As is usual in neo-Schumpeterian growth theory, whenever a higher quality product is discovered in the North, the technology of producing the previous generation product becomes common knowledge in the world economy.

In both countries, production of one unit of final goods requires one unit of general-purpose labor, regardless of the quality level of the manufactured goods. Let w_{LN} represent the wage rate of general-purpose labor in the North, while the Southern wage rate is normalized to 1. For each industry, there are two possible structures at any point in time. Whenever a Northern entrepreneur discovers a next-generation product, the resulting structure is a *Northern industry*, in which the Northern quality leader competes with Southern followers that have access to the one-step down technology. Whenever a Southern entrepreneur acquires the technology of producing a current generation product, the resulting structure is a *Southern industry*, in which a successful Southern imitator competes with a Northern incumbent, where both firms have access to the same state-of-the-art technology. Northern (Southern) firms face an ad-valorem import tariff rate of τ_S (τ_N) in the Southern

[9] This labor assignment follows Dinopoulos and Syropoulos (2007).

(Northern) market. According to the terminology of Dinopoulos and Segerstrom (1999b, p. 194), these are "rent-extracting", but not "protective" tariffs: they transfer rents from foreign quality leaders to domestic governments in both countries, but are not large enough to enable domestic follower firms to survive competition from foreign quality leaders.

Consider first the profits of the **Northern quality leader** who competes with Southern followers in both Northern and Southern markets.[10] **In the Northern market,** the Northern quality leader competes against Southern followers who can produce the one-step-down quality product at the marginal cost of 1. Under marginal cost pricing and with tariffs in place, the Southern followers can offer their goods to the Northern consumers at a price $1+\tau_N$. In this case, the Northern quality leader charges the limit price $p_N^N = \lambda(1+\tau_N)$ and drives the Southern followers out of the market. The profits of the Northern quality leader from sales in the Northern market are:

$$\pi_N^N = \frac{c_N N_N}{\lambda(1+\tau_N)}[\lambda(1+\tau_N) - w_{LN}] = c_N N_N \left[1 - \frac{w_{LN}}{\lambda(1+\tau_N)}\right].$$

Intuitively, the existence of tariffs enables the *local* producer to raise its price and thus enjoy higher profits from local sales.

In the Southern market, the Northern quality leader faces tariffs and again competes with Southern followers. This time though competition takes place in the local market of Southern followers; thus, under marginal cost pricing, they can offer a price of 1. The Northern quality leader faces an ad-valorem tariff rate of τ_S. To capture the Southern market, the Northern firm must set its price such that the price faced by the Southern consumers does not exceed λ. This implies that the Northern firm's limit price is $p_N^S = \lambda$, of which the firm receives $\lambda/(1+\tau_S)$ per unit sold. The profits of the Northern quality leader from sales in the Southern market are:

$$\pi_N^S = \frac{c_S N_S}{\lambda}\left(\frac{\lambda}{1+\tau_S} - w_{LN}\right).$$

For $\pi_N^S > 0$, we need $\tau_S < (\lambda/w_{LN}) - 1$. Total profits from sales of Northern monopolists are:

$$\pi_N^P = \pi_N^N + \pi_N^S = c_N N_N \left[1 - \frac{w_{LN}}{\lambda\left(1+\tau_N\right)}\right] + c_S N_S \left(\frac{1}{1+\tau_S} - \frac{w_{LN}}{\lambda}\right). \tag{5}$$

[10] Northern followers' unit cost is w_{LN} whereas the Southern followers' unit cost is 1. Northern followers cannot compete with Southern followers in the Southern market if $w_{LN}(1+\tau_N) > 1$. This condition holds automatically given that $w_{LN} > 1$ at the steady-state. Moreover, Northern followers cannot compete with Southern followers in the Northern market provided $w_{LN} > 1+\tau_N$. We assume that this restriction holds which implies that Southern imitators realize positive profits from sales in the North as is shown further below.

Consider next the profits of the successful **Southern imitator** who competes with the Northern quality leader in both Northern and Southern markets.[11] **In the Southern market,** the Southern imitator competes against a Northern quality leader. Under marginal cost pricing and with tariffs in place, the Northern firm can offer its product to Southern consumers at a price of $w_{LN}(1+\tau_S)$. In this case, the Southern imitator charges the limit price $p_S^S = w_{LN}(1+\tau_S)$ and drives the Northern firm out of the market. The profits of the Southern imitator from sales in the Southern market are:

$$\pi_S^S = \frac{c_S N_S}{w_{LN}(1+\tau_S)}[(1+\tau_S)w_{LN} - 1] = c_S N_S \left[1 - \frac{1}{w_{LN}(1+\tau_S)}\right].$$

In the Northern market, the Southern imitator again competes with a Northern quality leader. This time though, competition takes place in the local market of the Northern quality leader; thus, under marginal cost pricing the Northern firm can offer a price of w_{LN}. The Southern imitator faces an ad-valorem tariff rate of τ_N. To capture the Northern market, the Southern imitator must set its price such that the price faced by the Northern consumers does not exceed w_{LN}. This implies that its limit price is $p_S^N = w_{LN}$, of which the firm receives $w_{LN}/(1+\tau_N)$ per unit sold. The profits of the Southern imitator from sales in the North are:

$$\pi_S^N = \frac{c_N N_N}{w_{LN}}\left(\frac{w_{LN}}{1+\tau_N} - 1\right).$$

For $\pi_S^N > 0$, we need $\tau_N < w_{LN} - 1$. Total profits from sales of Southern monopolists are:

$$\pi_S = \pi_S^S + \pi_S^N = c_S N_S \left[1 - \frac{1}{w_{LN}(1+\tau_S)}\right] + c_N N_N \left(\frac{1}{1+\tau_N} - \frac{1}{w_{LN}}\right) \tag{6}$$

Finally note that in equilibrium, positive rates of innovation and imitation require positive profits of both successful Northern innovators and Southern imitators, thus $1+\tau_N < w_{LN} < \lambda/(1+\tau_S)$ must be fulfilled: the lower bound for the Northern general-purpose wage rate ensures both $\pi_S^S > 0$ and $\pi_S^N > 0$, while the upper bound for w_{LN} ensures both $\pi_N^N > 0$ and $\pi_N^S > 0$.

While Northern quality leaders earn monopoly profits, they face the threat of innovation from the North and imitation from the South. To safeguard their monopoly positions, the incumbents undertake RPAs. These can take the form of patent enforcement, practicing trade secrecy, lobbying the government to promote stronger intellectual property rights protection, corruption to influence the legal and political system, and such. RPAs work to deter the innovation and imitation efforts

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[11] The followers in both regions are undercut by the top-quality producers and exit the market.

targeted at the incumbent. To conduct RPAs, each Northern incumbent hires Northern specialized labor at a wage rate of w_{HN}. The cost of performing $X(t)$ units of rent-protection activities (RPAs) is $w_{HN}\gamma X(t)$, where γ is the unit labor requirement of such activities. Hence, a Northern incumbent's profit flow net of RPA costs equals:

$$\pi_N = \pi_N^P - w_{HN}\gamma X \ . \tag{7}$$

2.4 Technology of Innovation and Imitation

In the North, there are sequential and stochastic R&D races in each industry $\omega \in [0,1]$ to discover the next generation product on the industry-specific quality ladder. The R&D technology is identical across Northern firms: by using general-purpose labor, the instantaneous probability of success (Poisson arrival rate) ι_j by firm j is given as

$$\iota_j(\omega,t) = R_j(\omega,t)/D(\omega,t) \qquad \text{with} \qquad \dot{D}(\omega,t) = n_N \delta X(\omega,t), \tag{8}$$

where $R_j(\omega,t)$ represents the intensity of innovation activities undertaken by a typical Northern entrepreneur j targeting industry ω, and $D(\omega,t)$ measures the difficulty of targeting innovation at industry ω at time t. According to (8), D is modeled as a stock variable[12], where n_N is the proportion of industries located in the North, $X(\omega,t)$ is the flow of RPAs undertaken by the Northern incumbent in industry ω at time t, and δ measures the effectiveness of these RPAs. Hence, whenever an industry is registered as a Northern industry – the probability of which is equal to n_N in equilibrium – the Northern incumbents undertake RPAs which increases the stock of R&D difficulty in that industry by $\delta X(\omega,t)$. A constant steady-state innovation rate requires that R&D difficulty must grow at the same rate as R&D labor input; hence, $\dot{D}(\omega,t) = nD(\omega,t)$ is required. From this and (8), we get the following expression of the stock of R&D difficulty along any steady-state growth path: [13]

$$D(\omega,t) = n_N \delta X / n \ . \tag{9}$$

Since the ι_j are independently distributed across firms and industries, the Poisson arrival rate for innovation at the industry level (which is 'the' Northern innovation rate) equals

[12] Modeling R&D difficulty D as a stock variable better captures the persistence of the institutional and legal framework surrounding intellectual property rights protection than the alternative modeling as a flow variable in Dinopoulos and Syropoulos (2007). All results are robust to assuming a constant depreciation rate for R&D difficulty.

[13] The introduction of R&D difficulty via RPAs removes the scale effects from the model. An alternative would be the "permanent effects on growth" (PEG) specification, as suggested by Dinopoulos and Segerstrom (1999a), which we analyze in Appendix A instead of our RPA approach. This demonstrates that the specific way scale effects are removed from our model does not matter for the main results.

$$\iota(\omega,t)=\sum_j \iota_j(\omega,t)=R(\omega,t)/D(\omega,t) \quad \text{with} \quad R(\omega,t)=\sum_j R_j(\omega,t). \tag{10}$$

Analogously, the instantaneous probability of imitation success (Poisson arrival rate) μ_j by any Southern firm j is given as

$$\mu_j(\omega,t)=M_j(\omega,t)/D(\omega,t) \tag{11}$$

with $\dot{D}$ as in (8), and D now measures the difficulty of targeting imitation at industry ω as in (9). Note that RPAs are modeled as a general activity that deters both innovation and imitation simultaneously; hence, D stands for both innovation and imitation difficulty (in section 4.1 we differentiate between innovation- and imitation-deterring activities and their resource requirements). Therefore, the Poisson arrival rate for imitation at the industry level equals

$$\mu(\omega,t)=\sum_j \mu_j(\omega,t)=M(\omega,t)/D(\omega,t) \quad \text{with} \quad M(\omega,t)=\sum_j M_j(\omega,t). \tag{12}$$

Since Southern entrepreneurs target only Northern industries, the economy-wide Southern imitation rate is given as $m \equiv \mu n_N$. Northern incumbent firms are driven from the market at the *replacement rate* $\iota+\mu$.

2.5 Optimal Innovation and Imitation Decisions

In the North, general-purpose labor is hired for performing innovative R&D. The cost of conducting R_j units of innovative activity is $w_{LN}a_\iota R_j$, where a_ι is the unit labor requirement of innovation. Imposing the usual free-entry assumption for R&D races, expected profits from R&D are competed away, and the maximization problem yields

$$\max_{R_j} \frac{v_N R_j}{D}dt - w_{LN}a_\iota R_j dt \quad \Rightarrow \quad v_N = w_{LN}a_\iota D, \tag{13}$$

where v_N is the valuation of a successful Northern innovator. In the South, general purpose labor is hired for performing imitative R&D. The cost of conducting M_j units of imitative activity in the South is $a_\mu M_j$ (given that the Southern wage rate is normalized to 1), where a_μ is the unit labor requirement of imitation. Under free entry into imitation, expected profits from R&D are competed away again, and the maximization problem yields

$$\max_{M_j} \frac{v_S M_j}{D}dt - a_\mu M_j dt \quad \Rightarrow \quad v_S = a_\mu D, \tag{14}$$

where v_S is the valuation of a successful Southern imitator.

2.6 Stock Markets

As usual in Schumpeterian growth models, household savings are channeled to firms investing in R&D by means of a global stock market. Over any time period dt, the stockholders of a successful Northern innovating firm receive dividend payments $\pi_N dt$. With probability $(\iota + \mu)dt$, the firm is driven out of the market and the stockholders face a capital loss of size v_N. With probability $1 - (\iota + \mu)dt)$, the firm maintains its monopoly position and the stockholders experience a capital gain or loss given by $\dot{v}_N\, dt$. Households can engage in complete diversification of their asset portfolio to eliminate the industry-specific risk of unsuccessful R&D expenditure, hence in an arbitrage-free asset market equilibrium, the expected return from a stock issued by any firm investing in innovative R&D $\pi_N dt - v_N(\iota + \mu)dt + \dot{v}_N\, dt(1 - (\iota + \mu)dt)$ must equal the return of a risk-free asset that pays the market interest rate on an investment of equal size during the same time period, $rv_N dt$. Imposing this condition for $dt \to 0$ yields

$$v_N = \frac{\pi_N}{r + \iota + \mu - \left(\dot{v}_N / v_N\right)} \ . \tag{15}$$

Similarly, the no-arbitrage condition for investments in Southern R&D firms (which do not face the risk of imitation) yields

$$v_S = \frac{\pi_S}{r + \iota - \left(\dot{v}_S / v_S\right)} \ . \tag{16}$$

2.7 Optimal Rent Protection Activities By Northern Incumbents

Each Northern incumbent chooses its optimal level of RPAs by maximizing the expected return on its stocks. By using (9) in (10) and (12), and differentiating, we derive that a marginal increase in X changes the innovation rate by $d\iota = -\iota(dX/X) < 0$ and the imitation rate by $d\mu = -\mu(dX/X) < 0$, so the replacement rate changes by $d\iota + d\mu = -(\iota + \mu)(dX/X)$. Totally differentiating the stock market value $\pi_N dt - v_N(\iota + \mu)dt + \dot{v}_N\, dt(1-(\iota + \mu)dt)$ with respect to ι and μ yields

$$-v_N dt\left(d\iota + d\mu\right) - \dot{v}_N dtdt\left(d\iota + d\mu\right) = v_N dt\left(\iota + \mu\right)\left(dX/X\right) + \dot{v}_N dtdt\left(\iota + \mu\right)\left(dX/X\right).$$

Setting this equal to the incremental cost of RPAs during dt, $w_{HN}\gamma dXdt$, dividing both sides by dt and letting $dt \to 0$, we derive the first order condition for the optimal flow of RPAs X:

$$v_N\left(\iota + \mu\right) = w_{HN}\gamma X \ . \tag{17}$$

Intuitively, X increases with the firm value v_N (since there is more at stake) and the replacement rate $\iota + \mu$ (the instantaneous probability of full capital loss at each point in time), and X decreases with the cost of RPAs (wage rate of specialized labor and unit labor requirement γ).

2.8 Labor Markets

The Northern demand for manufacturing labor is $n_N c_N N_N/[\lambda(1+\tau_N)] + n_N c_S N_S/\lambda$. The Northern demand for R&D labor is $a_\iota R = a_\iota \iota D$, where (10) is used. Thus the *Northern general-purpose labor market clearing* (*LABN*) *condition* is

$$n_N Q_N\left(c_N, c_S\right) N_N + a_\iota \iota D = \left(1 - s_N\right) N_N \quad \text{with} \quad Q_N\left(c_N, c_S\right) \equiv \frac{1}{\lambda}\left(\frac{c_N}{1+\tau_N} + c_S \eta_S\right), \tag{18}$$

where $Q_N N_N$ denotes the level of worldwide sales of a Northern incumbent firm, and $\eta_S \equiv N_S/N_N$. The *Northern specialized labor market clearing condition* is

$$n_N \gamma X = s_N N_N . \tag{19}$$

The Southern demand for manufacturing labor is $n_S c_S N_S/[w_{LN}(1+\tau_S)] + n_S c_N N_N/w_{LN}$. The Southern demand for R&D labor is $n_N a_\mu M = n_N a_\mu \mu D$, where (12) is used. Thus the *Southern labor market clearing* (*LABS*) *condition* is

$$n_S Q_S\left(c_N, c_S, w_{LN}\right) N_N + a_\mu \mu D n_N = N_S \quad \text{with} \quad Q_S\left(c_N, c_S, w_{LN}\right) \equiv \frac{1}{w_{LN}}\left(\frac{c_S \eta_S}{1+\tau_S} + c_N\right), \tag{20}$$

where $Q_S N_N$ denotes the level of worldwide sales of a Southern incumbent firm, and n_S is the fraction of Southern industries.

2.9 Steady-State Equilibrium

Northern (Southern) entrepreneurs capture industry leadership from Southern (Northern) firms at a rate of ιn_S (μn_N), and constancy of industry shares requires $\iota n_S = \mu n_N$. Given $n_N + n_S = 1$, this implies

$$n_S = \mu/\left(\iota + \mu\right) \qquad \text{and} \qquad n_N = \iota/\left(\iota + \mu\right). \tag{21}$$

Let $A_\iota \equiv (a_\iota \delta)/(n\gamma)$ and $A_\mu \equiv (a_\mu \delta)/(n\gamma)$. We solve the model for a steady-state equilibrium where the endogenous variables c_N, c_S, ι, μ, w_{LN} and w_{HN} remain constant, and $R(t)$, $M(t)$, $\pi_N(t)$, $\pi_S(t)$, $X(t)$, $v_N(t)$ and $v_S(t)$ all grow at a common rate of n. We impose a *balance-of-trade* (*BOT*) *condition*, which requires that the value of exports net of tariffs be equal between the North and the South[14]:

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[14] As an alternative approach, Appendix B considers the steady-state solution with an asset market equilibrium condition instead of a BOT condition. It turns out that this leads to exactly the same conclusions re-

$$n_N \frac{c_S N_S}{\lambda} \frac{\lambda}{(1+\tau_S)} = n_S \frac{c_N N_N}{w_{LN}} \frac{w_{LN}}{(1+\tau_N)} \ ,$$

where the LHS (RHS) denotes the value of Northern (Southern) exports net of tariffs. This can be rewritten, by using (21), as

$$c_S = c_N \frac{\mu}{\iota \eta_S} \frac{(1+\tau_S)}{(1+\tau_N)} \qquad \textbf{BOT} \ . \tag{22}$$

which determines the relative consumer expenditure levels for both countries.

Substituting in (17) for v_N from (13), then for D from (9) and finally for n_N from (21), we obtain the Northern specialized wage rate as

$$w_{HN} = A_\iota \iota w_{LN} \ , \tag{23}$$

implying that w_{HN}/w_{LN} is increasing in ι. This is because a higher innovation rate increases the profitability of RPAs relative to innovation and thus w_{HN}/w_{LN}. Both Northern wage rates are positively related to each other since an increase in the Northern stock-market value v_N (discounted firm profits) raises demand for both types of labor: demand for general-purpose labor rises because of higher expected R&D returns, and demand for specialized labor rises with higher v_N since there is more at stake for current quality leaders.

Plugging (17) into (7), using (5), and inserting all this into (15), using the steady-state results $r_t = \rho$ and $\dot{v}_N / v_N = n$, we solve for the stock-market value of Northern firms as

$$v_N = \frac{c_N N_N \left[1 - \frac{w_{LN}}{\lambda(1+\tau_N)}\right] + c_S N_S \left(\frac{1}{1+\tau_S} - \frac{w_{LN}}{\lambda}\right)}{\rho + 2\iota + 2\mu - n} \ . \tag{24}$$

Setting (24) equal to (13), substituting for D from (9), then for Xn_N from (19), using the definitions of A_ι and η_S, and imposing the BOT condition (22), we obtain the *free-entry in innovation* (*FEIN*) *condition*

$$\frac{c_N \left[1 + \frac{\mu}{\iota(1+\tau_N)}\right] - \tilde{Q}_N\left(c_N\right) w_{LN}}{\rho - n + 2\left(\iota + \mu\right)} = A_\iota w_{LN} s_N \qquad \textbf{FEIN}\left(c_N, w_{LN}, \iota, \mu\right), \tag{25}$$

with $Q_N\left[c_N, c_S\left(c_N\right)\right] \equiv \tilde{Q}_N\left(c_N\right)$ by using (22). Analogously, we obtain the *free-entry in imitation* (*FEIM*) condition by setting (14) equal to (16), and using (6), (9), (19), and (22):

garding the globalization effects on the main variables of interest.

$$\frac{\overbrace{\frac{c_N}{1+\tau_N}\left[1+\frac{\mu(1+\tau_S)}{\iota}\right]}^{\lambda\tilde{Q}_N(c_N)}-\tilde{Q}_S\left(c_N,w_{LN}\right)}{\rho-n+\iota}=A_\mu s_N \qquad \mathbf{FEIM}\left(c_N,w_{LN},\iota,\mu\right), \tag{26}$$

with $Q_S\left[c_N,c_S\left(c_N\right),w_{LN}\right]\equiv\tilde{Q}_S\left(c_N,w_{LN}\right)$ by using (22). For given ι and μ, a unique steady-state solution for c_N and w_{LN} exists as shown in Figure 2 below.

Insert here: Figure 2

The LHS of (25) is increasing in c_N and decreasing in w_{LN}, while the RHS is increasing in w_{LN}, hence the curve for (25) is upward sloping in (c_N, w_{LN})-space. The LHS of (26) is increasing both in c_N and in w_{LN}, hence the curve for (26) is downward sloping in (c_N, w_{LN})-space. The FEIN curve is upward sloping because a higher w_{LN} reduces R&D profitability by increasing both production and R&D costs in the North. Restoring the zero-profit condition for innovation requires an increase in c_N. The FEIM curve is downward sloping because a higher w_{LN} raises imitation profitability by raising the limit price successful Southern followers can charge both in the Northern and in the Southern market. Restoring the zero-profit condition for imitation requires a decrease in c_N. Solving (25) and (26) simultaneously for c_N and w_{LN} yields

$$c_N\left(\iota,\mu\right)=\frac{\iota s_N\lambda\left(1+\tau_N\right)\left\{A_\iota\left[\rho-n+2\left(\iota+\mu\right)\right]+A_\mu\left(\rho-n+\iota\right)\right\}}{\left(\lambda-1\right)\left[\iota+\mu\left(1+\tau_S\right)\right]}\ , \tag{27}$$

$$w_{LN}\left(\iota,\mu\right)=\frac{\lambda\left\{A_\iota\left[\rho-n+2\left(\iota+\mu\right)\right]+A_\mu\left(\rho-n+\iota\right)\right\}\left[\iota\left(1+\tau_N\right)+\mu\right]}{\left\{\lambda A_\iota\left[\rho-n+2\left(\iota+\mu\right)\right]+A_\mu\left(\rho-n+\iota\right)\right\}\left[\iota+\mu\left(1+\tau_S\right)\right]}\ . \tag{28}$$

We note for future reference that $c_N/(1+\tau_N)$ in (27) is pinned down by μ and ι independently of τ_N.

Using (9), (19), (21) and the expression for $\tilde{Q}_N$, the *LABN* condition (18) can be rewritten as

$$\frac{\tilde{Q}_N\left(c_N\right)\iota}{\iota+\mu}+A_\iota\iota s_N=1-s_N \qquad \mathbf{LABN}\left(c_N,\iota,\mu\right). \tag{29}$$

Similarly, by using (9), (19), (21) and the expression for $\tilde{Q}_S$, the *LABS* condition (20) can be rewritten as

$$\frac{\tilde{Q}_S\left(c_N,w_{LN}\right)\mu}{\eta_S\left(\iota+\mu\right)}+\frac{A_\mu\mu s_N}{\eta_S}\frac{\iota}{\iota+\mu}=1 \qquad \mathbf{LABS}\left(c_N,w_{LN},\iota,\mu\right). \tag{30}$$

Using (27) in (29) gives the Northern labor market equilibrium condition as a function solely in ι and μ:

$$\frac{\iota s_N \left\{ A_\iota \left[\rho - n + (\iota + \mu)(1 + \lambda) \right] + A_\mu (\rho - n + \iota) \right\}}{(\lambda - 1)(\iota + \mu)} = 1 - s_N \qquad \mathbf{LABN}(\iota, \mu), \tag{31}$$

which does not depend on the tariff rates. The LHS of (31) is strictly increasing in ι and strictly decreasing in μ (since $\rho - n > 0$), hence the curve for LABN is strictly upward sloping in (ι, μ)-space. Intuitively, an increase in ι raises Northern general-purpose labor demand for R&D and for manufacturing by raising both n_N and c_N, where the latter follows from $\partial c_N/\partial \iota > 0$ in (27).[15] Restoring the Northern labor market equilibrium requires an increase in μ since this reduces Northern labor demand by decreasing both n_N and c_N, where the latter follows from differentiating (27) with respect to μ.

Using (27) and (28) in (30) gives the Southern labor market equilibrium condition as a function solely in ι and μ:

$$\frac{\mu s_N \left\{ A_\iota \lambda \left[\rho - n + 2(\iota + \mu) \right] + A_\mu (\rho - n + \iota\lambda) \right\}}{\eta_S (\lambda - 1)(\iota + \mu)} = 1 \qquad \mathbf{LABS}(\iota, \mu), \tag{32}$$

which also does not depend on the tariff rates. The LHS of (32) is strictly increasing in μ, while it is strictly increasing in ι provided that the following condition is satisfied which will be maintained for the rest of this paper:

$$\mu > (\rho - n)\left(\frac{1}{\lambda} + \frac{A_\iota}{A_\mu} \right) . \tag{33}$$

This amounts to the assumption that the households' net discount rate $\rho - n$ is sufficiently small. Given that condition (33) is satisfied, the curve for LABS is strictly downward sloping in (ι, μ)-space such that a unique steady-state equilibrium exists as is illustrated in Figure 3 below.[16] Intuitively, an increase in μ raises the labor demand for Southern manufacturing by increasing both n_S and c_S (the latter can be seen by plugging (27) into (22) and differentiating this with respect to μ). This is reinforced by the lower w_{LN} which is triggered by an increase in μ. To see this, differentiate (28) with respect to μ.

[15] Intuitively, an increase in ι accelerates creative destruction, putting downward pressure on the profitability of innovation and imitation, which requires an increase in c_N to restore zero profits under free entry. It should be noted that the secondary effects coming from the BOT relation do not overturn this result.

[16] Uniqueness of the steady-state equilibrium is ensured by noting that, first, the LABS curve (32) cannot hit the vertical axis since (33) guarantees $\mu > 0 \ \forall \ \iota$, and second, the LABN curve (31) for $\mu \to 0$ clearly starts at a $\iota > 0$.

Intuitively, an increase in Southern imitation reduces the Northern general-purpose wage rate since it reduces discounted monopoly profits by shortening the quality leaders' incumbency period, which implies lower R&D-labor demand. A decrease in w_{LN} increases Southern production employment because it reduces the limit prices successful Southern imitators can charge in the Southern and the Northern market, respectively, which in turn raises consumption demand and hence production. In addition, an increase in μ directly increases Southern R&D labor demand by raising the Southern economy-wide imitation rate $m \equiv \mu n_N$. Restoring the Southern labor market equilibrium requires a decrease in ι, which has four effects on Southern labor demand: first, it reduces Southern R&D labor demand by reducing the Southern economy-wide imitation rate $m \equiv \mu n_N$. Second, it increases w_{LN} provided that both tariff rates are sufficiently low. To see this, differentiate (28) with respect to ι. An increase in w_{LN} raises the limit prices (in both countries) charged by successful Southern imitators and hence reduces Southern production employment. Third, a decrease in ι raises n_S which tends to increase Southern production employment. Fourth, a decrease in ι has an ambiguous effect on c_S. The net effect is a decrease in total Southern labor demand provided that (33) is fulfilled.

Insert here: Figure 3

Finally, from (2) we can derive as usual the common steady-state utility growth rate of both countries, which is $\dot{u}_N/u_N = \dot{u}_S/u_S = \iota \log \lambda$.

3 Globalization Effects

3.1 Increased Trade Integration Of The South

We first consider the effects of increased trade integration of the South, modeled as an increase in the relative size of the South as measured by $\eta_S \equiv N_S/N_N$.[17] This exercise is motivated by the recent entry of large developing countries into the world trading system. Using the Sachs and Warner openness criteria, Wacziarg and Welch (2003) calculate that between 1980 and 2000, the percentage of open economies had increased from about 25 % to 73 %. During the same time period, the percentage of the world population living in open economies has increased from about 25 % to 47 %. The discrepancy between the two measures stems from the fact that China and India, the world's

[17] When one investigates the consequences on North-South integration, the issue of scale effects becomes especially important. In scale-dependent product cycle models like Grossman and Helpman (1991), changes in one region's population size affect the steady-state levels of the rates of innovation or imitation even if that region's *share* in the world economy remains the same. Scale-free product cycle models like this one do not have this questionable feature. Instead, steady-state outcomes depend on *relative* population sizes; that is, an expansion in the absolute size of the South generates the same qualitative steady-state effects as does a contraction in the absolute size of the North, and vice versa.

two most populous countries, were still classified as closed economies as of year 2000 in Wacziarg and Welch (2003). However, it is well known that these two countries have made substantial progress towards trade liberalization and appear to be on their way to meeting the Sachs and Warner openness criteria.

In Figure 3, an increase in η_S does not affect the LABN curve (31). The reasoning for this is as follows: first note that the BOT condition implies that total expenditure by Southern consumers is proportional to that by Northern consumers: $c_S N_S = c_N N_N(1+\tau_S)(\mu/\iota)(1+\tau_S)$. Thus, Northern exports $n_N c_S N_S/\lambda$ are proportional to N_N. Given that the levels of Northern domestic consumption and innovation difficulty D are also proportional to N_N, the N_N terms in LABN cancel out and the effects of changes in N_S/N_N on Northern labor markets are completely nullified.

In the South, using again the BOT condition, we observe that Southern domestic consumption $n_S c_S N_S/[(1+\tau_S)w_{LN}]$ is proportional to N_N. The levels of Southern exports and imitation difficulty D are also proportional to N_N. Hence, in the South, aggregate labor demand is proportional to N_N, whereas aggregate labor supply is obviously proportional to N_S. Therefore a higher η_S creates room for an expansion in both imitative and manufacturing activities, resulting in a larger μ for a given ι. Consequently, the LABS curve shifts to the right, and the equilibrium rates of both μ and ι increase. The intuition can be understood by appealing to the upward sloping LABN curve. When μ increases, Northern manufacturing labor demand falls due to the decrease in n_N and c_N. Restoring equilibrium calls for an increase in ι, which boosts both R&D and manufacturing labor demand in the North. The result is shown in Figure 4 below.

Insert here: Figure 4

What are the effects on w_{LN}? To analyze this, note that the LHS of (25) is the expected discounted profit from innovation, and the RHS of (25) is the marginal cost of innovation. Equation (26) captures the same type of information for imitation. Hence the ratio of (25) to (26) gives the profitability of innovation relative to imitation. An increase in this ratio requires an increase in the relative Northern general-purpose wage rate w_{LN} to restore the FEIN and the FEIM condition. This is because an increase in w_{LN} reduces the profit margin of Northern innovators and increases their costs. Furthermore, it increases the profit margin of Southern imitators since their supply prices are proportional to w_{LN}.

The rise in ι and μ driven by increased Southern trade integration reduces the *absolute* profitability of both innovation and imitation by increasing the rate of firm turnover. However, the profitability of innovation *relative* to imitation – and thus the relative returns to Northern general-purpose labor w_{LN} – decreases for sufficiently low tariffs[18]. Furthermore, we can also establish[19] $dn_N/d\eta_S < 0$ and $dm/d\eta_S > 0$. The effects of increased Southern trade integration are summarized in

Proposition 1: *Given that* (33) *is fulfilled, a unique steady-state equilibrium exists, and increased Southern trade integration (i.e. an increase in* η_S*) results in*

i. an increase in the Northern innovation rate ι *and hence in the steady-state utility growth rate of both countries,*

ii. an increase in the frequency of imitations per industry μ*,*

iii. an increase in the economy-wide Southern imitation rate $m \equiv \mu n_N$*, and*

iv. a decrease in the fraction of the Northern industries n_N*.*

For sufficiently low τ_N *and* τ_S*, it also results in*

v. a decrease in the relative Northern general-purpose wage rate w_{LN}*.*

3.2 Unilateral Trade Liberalization

Since tariffs do not enter equations (31) and (32), a decrease in τ_N or τ_S does not affect the curves in Figure 3, and ι and μ remain unchanged. For each type of tariff change, the technical mechanisms can be understood in four steps. We begin with τ_N. First, recall that $c_N/(1+\tau_N)$ is pinned down by ι and μ in (27) independently of τ_N. Second, given this and the definition of Q_N in (18), it follows that the $\tilde{Q}_N$-expression in (25) is also pinned down by ι and μ independently of τ_N. Third, it then follows from (26) that the $\tilde{Q}_S$-expression is also pinned down by ι and μ independently of τ_N. Fourth, it now immediately follows in (29) and (30) that ι and μ are determined independently of τ_N.

The technical analysis for τ_S is very similar. First, note that from (27) and (28), the ratio c_N/w_{LN} is independent of τ_S. Second, given this, using (22) in the definition of Q_S in (20) shows that $\tilde{Q}_S$ in (26) is independent of τ_S. Third, the FEIM condition (26) then determines $\tilde{Q}_N$ independently of τ_S. Fourth, it now immediately follows in (29) and (30) that ι and μ are determined independently of τ_S.

[18] This restriction means that we are able to formally establish this result for $\tau_N = \tau_S = 0$, bur obviously it holds for a full range of tariff rates, although the exact upper boundaries cannot be determined. These boundaries are consistent with our assumptions $\tau_N < w_{LN} - 1$ (which is necessary to ensure $\pi_S^N > 0$) and $\tau_S < (\lambda/w_{LN}) - 1$ (which is necessary to ensure $\pi_N^S > 0$).

[19] For proofs, see Appendix C.

Intuitively, in a two-country monopolistic competition setting with a symmetric production and trade structure, with prices being proportional to marginal costs (by limit pricing) and consumption expenditure being proportional to tariffs (by balanced trade), we conclude that the levels of world-wide sales $Q_N N_N$ and $Q_S N_N$ are independent of tariffs. Hence, changes in tariffs are neutral on manufacturing employment and do not call for any reallocation between manufacturing and innovation or imitation. It should be noted that this neutrality result also holds with CES consumer preferences and monopolistic pricing, as is shown by Dinopoulos and Segerstrom (2007) in a setting with symmetric trade costs instead of tariffs.

As for the wage effects, it immediately follows from (28) that a decline in τ_N reduces the profitability of innovation relative to imitation and hence decreases the relative wage w_{LN} of Northern general-purpose labor. The opposite is true for the case of a decline in τ_S.[20] We summarize our findings in

Proposition 2: *Given that* (33) *is fulfilled, a unique steady-state equilibrium exists, and a reduction in the Southern [Northern] import tariff* τ_S *[*τ_N*] results in*

i. *no change in the Northern innovation rate* ι *or the Southern imitation rate* μ*, and therefore also no change in the fraction of the Northern industries* n_N *and the economy-wide Southern imitation rate* $m \equiv \mu n_N$ *(‘**tariff-neutrality result**’),*
ii. *an unambiguous increase [decrease] in the Northern general purpose wage rate* w_{LN}*.*

4 Variations Of The Basic Model

4.1 Increased Southern Trade Integration With Southern Specialized Labor

How robust are the findings to incorporating Southern institutions that require employment of Southern resources for imitation-deterring activity? To check for this, we now assume that Northern firms hire Northern specialized labor for innovation-deterring activity, and Southern specialized labor for imitation-deterring activity (the latter being paid the Southern specialized wage rate w_{HS}). We denote the level of imitation (innovation)-deterring activities X_μ (X_ι) with corresponding unit-labor requirement γ_μ (γ_ι), and the share of specialized labor in the South is given by s_S. Innovation and imitation difficulty evolves according to $\dot{D}_\iota(\omega, t) = n_N \delta_\iota X_\iota(\omega, t)$ and $\dot{D}_\mu(\omega, t) = n_N \delta_\mu X_\mu(\omega, t)$,

[20] This takes place in the presence of multiple competing effects. The interested reader can uncover these from (22), (25), and (26).

respectively. On the steady-state growth path, $\dot{D}_\iota / D_\iota = \dot{D}_\mu / D_\mu = n$. This, together with the new Southern specialized-labor market-clearing condition $n_N \gamma_\mu X_\mu = s_S N_S$, implies $D_\mu = (s_S N_S \delta_\mu)/(\gamma_\mu n)$.

The FEIN condition (25) remains the same (with only $\hat{A}_\iota \equiv (a_\iota \delta_\iota)/(n\gamma_\iota)$ replacing A_ι), whereas the RHS of the FEIM condition (26) becomes $\hat{A}_\mu s_S \eta_S$, with $\hat{A}_\mu \equiv (a_\mu \delta_\mu)/(n\gamma_\mu)$. Using this notation and D_μ from above, we present the new reduced-form equations for LABN(ι, μ) and LABS(ι, μ) in Appendix D.1. As before, the LABN curve is upward sloping and the LABS curve is downward sloping. To simplify the exposition, we set $\tau_N = \tau_S = 0$ since tariffs do not matter for Southern trade integration effects.

To investigate the impact of increased Southern trade integration, we first note that an increase in η_S does not affect the FEIN curve but shifts the FEIM curve upwards in Figure 2, hence both c_N and w_{LN} increase for given levels of ι and μ. Intuitively, an increase in η_S now renders more resources available for imitation-deterring activities and reduces the profitability of imitation. Restoring the free-entry condition requires an increase in c_N and hence an upward shift of the FEIM curve.

Next, to uncover the labor-market implications, we write the new labor market equilibrium conditions as

$$\frac{c_N(\iota,\mu,\eta_S)}{\lambda} + \hat{A}_\iota \iota s_N = 1 - s_N \qquad \mathbf{LABN}(\iota,\mu), \tag{34}$$

$$\frac{c_N(\iota,\mu,\eta_S)\mu}{w_{LN}(\iota,\mu,\eta_S)\iota} + \frac{\hat{A}_\mu \mu s_S \iota \eta_S}{\iota+\mu} = (1-s_S)\eta_S \qquad \mathbf{LABS}(\iota,\mu). \tag{35}$$

In the South, an increase in η_S raises the (relative) Southern labor supply and also labor demand via two channels. First, an increase in η_S raises the intensity of imitation-deterring activity per Northern worker D_μ/N_N, and thereby increases the resource requirement for imitation. Second, a higher η_S leads to an expansion in Southern manufacturing activity (because $\partial(c_N/w_{LN})/\partial\eta_S > 0$, see Appendix D.1) and puts more pressure on Southern resources. The direct increase in labor supply outweighs the increase in labor demand, creating room to expand imitation for any given ι, which explains the rightward shift of the LABS curve as in Figure 4 before.

In the North, an increase in η_S leads to an expansion in Northern manufacturing by raising c_N. To restore equilibrium in (34), there must be a decline in ι for a given μ, and hence the LABN curve shifts down (recall that aggregate labor demand in the North is increasing in ι). This is a new effect relative to the analysis illustrated in Figure 4 for the case of general RPAs performed only by Northern specialized workers. Hence, contrary to the basic setting in section 3.1, the net effect of increased Southern trade integration on Northern innovation becomes ambiguous[21], whereas Southern imitation again increases.

To investigate the change in w_{LN}, we again take the ratio of FEIN to FEIM. The increase in μ works towards a decrease in the profitability of innovation relative to imitation, whereas the decrease in ι generates an ambiguous effect. However, the crucial effect that determines the net change in relative innovation profitability comes from an expansion in the relative size of the South. This raises the amount of resources channeled to imitation-deterring activities (due to the η_S-term on the RHS of FEIM), and thereby increases the relative cost of imitation. With the net effect on the relative innovation profitability being positive, w_{LN} increases (see Appendix D.2 for formal proof). This is the exact opposite of our finding from the basic setup. It follows our

Main result 1: *When the institutional set-up requires Southern resources to be employed for imitation deterring, increased Southern trade integration will bring forth an expansion in imitation-deterring activities as well. Relative to the baseline model, this*

i. ***will*** *reverse the (negative) effect of increased Southern trade integration on the Northern general-purpose wage rate* w_{LN} *and*

ii. ***can*** *reverse the (positive) effect of increased Southern trade integration on the Northern innovation rate and thus global growth.*

4.2 Trade Liberalization With A Low-Tech Sector In The South

We now introduce inter-industry trade to our basic setup and reevaluate the tariff-neutrality result of proposition 2. We assume that in the South, there is an additional, perfectly competitive sector which produces a low-tech good Z according to the production function $Z_S = bL_Z$, where $b > 0$ is a productivity factor and L_Z is Southern labor input in Z production. The two distinctive features relative to the other ("high-tech") sector are that, first, no innovation targets the low-tech sector, and, second, the South is the sole producer of the low-tech good and thus becomes the net exporter of this product to the North.[22] The real wage received by Southern low-tech workers equals their marginal product b, hence $w_Z = bp_Z$, with p_Z being the supply price for Z. Since Southern workers are perfectly mobile between the high-tech and the low-tech sector, and the wage rate in the former is normalized to 1, the low-tech goods price is fixed to the unit labor requirement, $p_Z = 1/b$. This is also the price faced by Northern consumers, given that we assume free trade for low-tech goods (which is reasonable since there is no low-tech Northern industry to protect).

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[21] Indeed, for a sufficiently low consumer discount rate $\rho - n$, one can show that the net impact on ι becomes unambiguously negative, see Appendix D.1.

[22] The modeling of the low-tech sector follows Grieben (2004, 2005).

Appendix E derives the following additional condition for optimal consumer behavior in both countries:

$$\frac{c_i(t)}{z_i(t)} = \frac{\alpha}{1-\alpha}\ , \qquad \text{for } i = N, S, \tag{36}$$

hence in each country, consumers spend a portion α on high-tech goods and the rest $(1-\alpha)$ of their expenditure on low-tech goods.

The free-entry conditions (25) and (26) remain unchanged because the functions for Northern and Southern monopoly profits, (5) and (6), do not change, respectively. The Northern general-purpose labor market clearing condition (29) also does not change since (18) is not affected, but the Southern labor market clearing condition (30) changes because we have to account for Southern labor demand in the low-tech sector L_Z, which is derived by imposing that the value of Northern low-tech consumption must equal the value of Southern low-tech exports:

$$z_N N_N = \frac{1-\alpha}{\alpha} c_N N_N \overset{!}{=} p_Z Z_S - z_S N_S = L_Z - \frac{1-\alpha}{\alpha} c_S N_S$$

$$\Leftrightarrow L_Z = \frac{1-\alpha}{\alpha}\left(c_N N_N + c_S N_S\right), \tag{37}$$

where we have used (36), $Z_S = bL_Z$, and $p_Z = 1/b$. The BOT condition now implies that the value of Northern exports of high-tech goods net of tariffs must equal the value of Southern high-tech exports net of tariffs plus the value of Southern low-tech exports, formally:

$$n_N \frac{c_S N_S}{\lambda} \frac{\lambda}{(1+\tau_S)} = n_S \frac{c_N N_N}{w_{LN}} \frac{w_{LN}}{(1+\tau_N)} + \frac{(1-\alpha) c_N N_N}{\alpha}$$

$$\Leftrightarrow \qquad \frac{c_S}{c_N} = \frac{1+\tau_S}{n_N \eta_S}\left(\frac{n_S}{1+\tau_N} + \frac{1-\alpha}{\alpha}\right) = \frac{1+\tau_S}{\iota \eta_S}\left[\frac{\mu}{1+\tau_N} + \frac{(\iota+\mu)(1-\alpha)}{\alpha}\right] \qquad \mathbf{BOT}(c_N, c_S, \iota, \mu), \tag{38}$$

where (21) has been used for the second equality. With (37) included and using (21), (20) is replaced by

$$\frac{Q_S(c_N, c_S)\mu}{\eta_S(\iota+\mu)} + \frac{A_\mu \mu s_N}{\eta_S} \frac{\iota}{\iota+\mu} + \frac{1-\alpha}{\alpha}\left(\frac{c_N}{\eta_S} + c_S\right) = 1 \qquad \mathbf{LABS}(c_N, c_S, \iota, \mu). \tag{39}$$

Setting (24) equal to (13), substituting for D from (9), then for Xn_N from (19), and imposing the new BOT condition (38), we obtain the new **FEIN**(c_N, w_{LN}, ι, μ) condition as

$$\frac{c_N \left\{ \iota \left[\frac{\lambda(1+\tau_N)}{\alpha} - w_{LN} \left[1 + \left(1+\tau_N\right)\left(1+\tau_S\right) \frac{1-\alpha}{\alpha} \right] \right] + \mu \frac{1+\tau_N(1-\alpha)}{\alpha} \left[\lambda - \left(1+\tau_S\right) w_{LN} \right] \right\}}{\iota \lambda \left(1+\tau_N\right) \left[\rho - n + 2\left(\iota + \mu\right) \right]} = A_\iota w_{LN} s_N . \tag{40}$$

Analogously, by setting (14) equal to (16), and using (6), (9), (19), and (38), we obtain the new **FEIM**(c_N, w_{LN}, ι, μ) condition as

$$\frac{c_N \left\{ \iota \left[-\frac{1+\tau_N}{\alpha} + w_{LN} \left[1 + \left(1+\tau_N\right)\left(1+\tau_S\right) \frac{1-\alpha}{\alpha} \right] \right] + \mu \frac{1+\tau_N(1-\alpha)}{\alpha} \left[w_{LN} \left(1+\tau_S\right) - 1 \right] \right\}}{\iota w_{LN} \left(1+\tau_N\right) \left(\rho - n + \iota\right)} = A_\mu s_N . \tag{41}$$

The curve for (40) is unambiguously upward sloping and the curve for (41) is unambiguously downward sloping in (c_N, w_{LN})-space as in Figure 2. Solving (40) and (41) simultaneously for c_N and w_{LN} yields $c_N(\iota, \mu)$ and $w_{LN}(\iota, \mu)$, given in Appendix F. Using (38) and $c_N(\iota, \mu)$ in (29) gives again (31) as the upward-sloping **LABN**(ι, μ) condition since without low-tech production in the North, all terms containing α and the tariff rates just cancel out. Substituting $c_N(\iota, \mu)$ in (39) and using (38) reveals that the aggregate Southern high-tech production level $Q_S N_S$ again does not depend on tariffs, as in the case without a Southern low-tech sector. The difference is that low-tech sector production, as captured by the third term in (39), now depends on tariffs through c_N and c_S. In the following, we uncover the mechanism through which tariff changes affect Southern low-tech production and imitation, and Northern innovation, by using (38) and the logic of Figure 2. Formal derivations used for this reasoning can be found in Appendix F.

A decline in τ_N exerts two competing effects on Northern firms' profits. First, a lower τ_N reduces π_N^P by reducing the protection granted to Northern incumbents in their domestic markets, which forces them to cut their limit price p_N^N. Second, a lower τ_N increases π_N^P by increasing c_S through the BOT condition (38). This is because the per-unit net-of-tariff revenue from Southern exports, $w_{LN}/(1+\tau_N)$, increases – an outcome which amounts to a Southern terms-of-trade improvement that allows an increase in c_S. To sum up, the FEIN curve for (40) may shift up or down in Figure 2.

Next, a lower τ_N unambiguously raises Southern firms' profits π_S by increasing $w_{LN}/(1+\tau_N)$ and c_S. To restore the FEIM condition (41), c_N must decline and hence the FEIM curve shifts down. The net effect of both curves' shifts in Figure 2 turns out to be that a lower τ_N decreases c_N. From the BOT condition (38), c_S decreases with c_N, and at the same time the lower τ_N indirectly increases c_S as explained above. The net effect turns out to be a decrease in c_S.

With both c_N and c_S declining, the Southern low-tech sector unambiguously contracts (see the third term on the RHS of (39), and also (37)), and this creates room for an expansion in imitation activity and high-tech goods production, calling for an increase in μ to clear the Southern labor market. Consequently, for a given ι, the LABS curve shifts to the right as in Figure 4. Since the LABN curve does not shift, the equilibrium levels of ι and μ both increase. Intuitively, the increase in ι follows from the upward sloping LABN curve: the decline in Northern labor demand triggered by a higher μ must be offset by a higher ι, which raises n_N and c_N.

We now investigate the impact of a decline in τ_S. It exerts two competing effects on π_N^P. First, a lower τ_S increases π_N^P by increasing the per-unit net-of-tariff revenue from Northern exports, $\lambda/(1+\tau_S)$. Second, a lower τ_S decreases π_N^P by decreasing c_S through the BOT condition (38), which is implied by the increase in $\lambda/(1+\tau_S)$, a terms-of-trade deterioration for the South. To sum up, again the FEIN curve for (40) may shift up or down in Figure 2.

Next, a lower τ_S unambiguously decreases Southern firms' profits π_S by reducing the protection for Southern incumbents in the domestic market, which forces them to cut their limit price p_S^S. This effect is magnified by the fall in c_S as explained above. To restore the FEIM condition (41), c_N must increase, and the FEIM curve shifts up. The net effect of both curves' shifts in Figure 2 turns out to be that a lower τ_S increases c_N. From the BOT condition (38), c_S increases with c_N, and at the same time the lower τ_S indirectly decreases c_S as explained above. The net effect again turns out to be a decrease in c_S.

With c_N increasing and c_S decreasing, the net impact on the Southern low-tech sector appears ambiguous, but the c_N effect turns out to dominate and thus L_Z increases. The expansion of the Southern low-tech sector leaves less labor resources for imitation and high-tech production, calling for a decrease in μ to clear the Southern labor market. Consequently, for a given ι, the LABS curve shifts to the left, opposite to the situation shown in Figure 4. The equilibrium levels of both ι and μ decline. We summarize our findings in

Proposition 3: *Given that the initial tariff levels are sufficiently low but starting at $\tau_N > 0$, a unilateral reduction of the Southern (Northern) import tariff τ_S (τ_N) results in a decrease (increase) in both Northern innovation and Southern imitation.*

The formal proof of Proposition 3, including the existence and uniqueness of equilibrium, is provided in Appendix G.[23] These findings imply:

[23] We have also analyzed the effects of bilateral trade liberalization $\Delta\tau_N = \Delta\tau_S < 0$ (which allows for different starting levels of tariff rates). The result is equivalent to unilateral Northern trade liberalization, but the positive growth effect is obviously smaller since Southern trade liberalization works towards reducing innovation and growth. Appendix H provides the details of this analysis.

Main result 2:

i. *If a Southern low-tech sector exists, the tariff-neutrality result of Proposition 2 no longer holds except for the case $\tau_N = 0$.*

ii. *Northern (Southern) unilateral product-cycle trade liberalization unambiguously raises (reduces) growth in both countries.*

iii. *Bilateral trade liberalization has qualitatively the same but quantitatively a weaker implication for growth compared to unilateral Northern trade liberalization. This provides the North with an argument for 'going alone' in freeing trade.*

iv. *Maximization of Northern innovation and Southern imitation requires $\tau_N = 0$.*

5 Conclusions

Our findings suggest that the institutional set-up in rent protection and the sectoral trade structure of the model play a crucial role in determining whether or not globalization promotes long-run economic growth. We obtain our results in a fully-endogenous growth model that features rent-protection activities and is free of scale effects. We consider as globalization both increased presence of the South in the world economy and incremental unilateral trade liberalization.

With respect to trade liberalization, our results provide two strong policy recommendations: **first**, Northern – but not Southern – trade liberalization in high-tech goods is necessary to stimulate worldwide growth. Hence, the South's refusal to reduce its trade barriers should not be an excuse for the North to refrain from trade liberalization as well (contrary to what is regularly observed at WTO negotiations). **Second**, by imposing import tariffs on Southern imitated goods, the North can reduce the threat of Southern imitation, but in general equilibrium, this hurts the North by leading to lower rates of innovation and growth.

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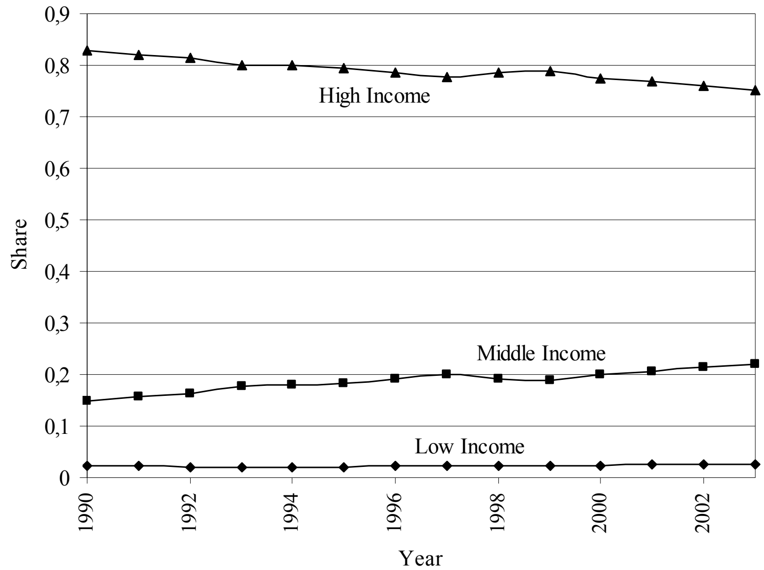
Figure 1: World Trade Share of Country Groups



Data Source: World Bank (2005). For each country group, world trade share is imports plus exports of goods and services measured in current US dollars divided by the corresponding value for the world. Income divisions, which follow the World Bank classifications, are based on 2003 gross national income per capita levels: low income countries, $765 or less; middle income countries (including China), $766–9,385; and high income countries, $9,386 or more.

Table 1: Tariff reductions during GATT and WTO rounds

Round	Number of partici-pants	Average % cut in all tariffs	Average tariff level as % of 1931 level
Geneva, 1947-48	23	21.9	52.7
Annecy, 1949	13	1.9	51.7
Torquay, 1950-51	38	3.0	50.1
Geneva II, 1956	26	3.5	48.9
Dillon, 1960-62	26	2.4	47.7
Kennedy, 1964-67	62	36.0	30.5
Tokyo, 1973-79	102	29.6	21.2
Uruguay, 1986-93	123	38.0	13.1
Doha, 2001-?	141*	?	?

* 141 at the start, 149 at Hong Kong Conference, December 2005

Sources: Van den Berg (2004), Table 8.1, p. 278; Neary (2004), Table 1, p. 321; www.wto.org

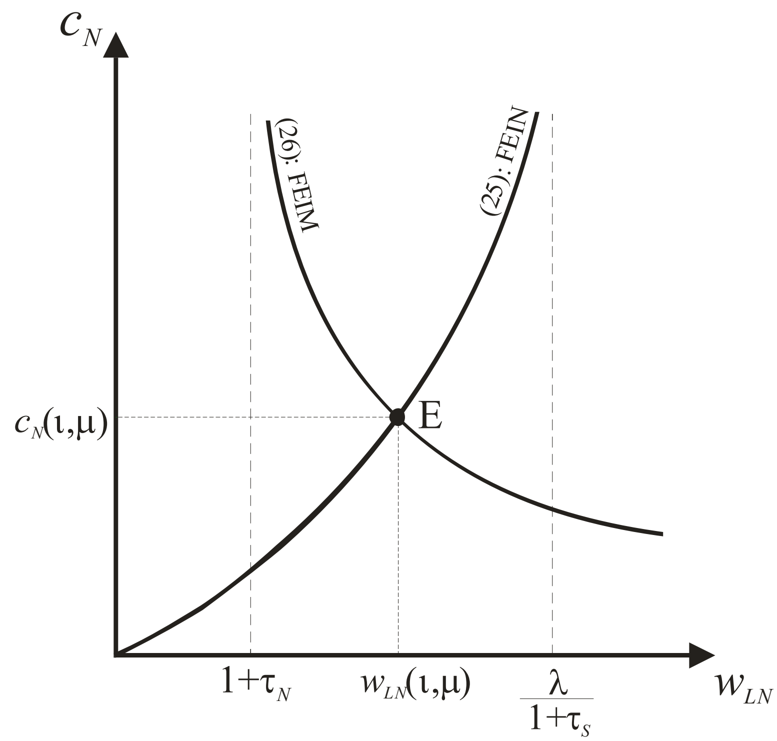


Figure 2: The determination of $c_N(\iota,\mu)$ and $w_{LN}(\iota,\mu)$

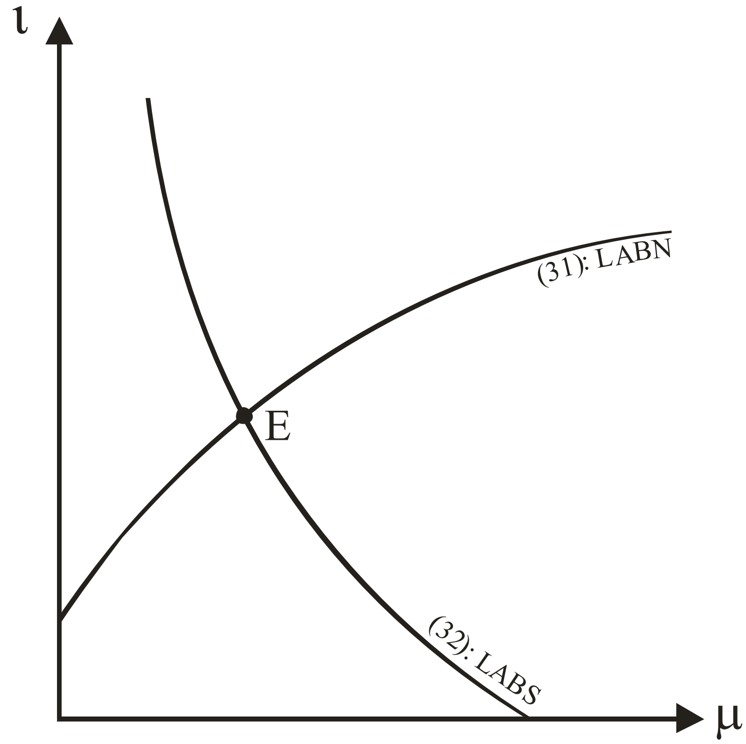


Figure 3: The steady-state equilibrium

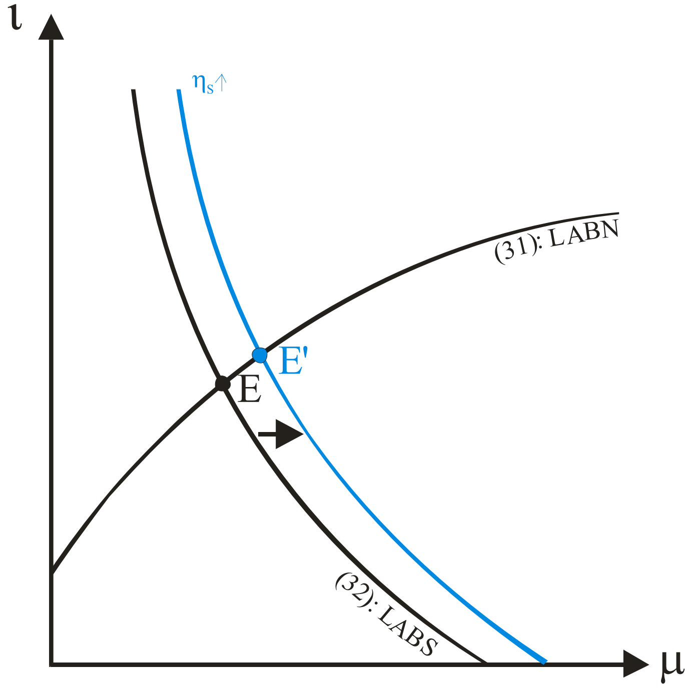


Figure 4: Steady-state effects of increased Southern trade integration in (ι, μ)-space

6 Appendices *(not to be published, only for referees)*

Appendix A: The PEG Model

In order to verify whether the assumption of RPAs is crucial for the tariff-neutrality result of proposition 2, we replace this route of removing scale effects by the more conventional "permanent-effects-on-growth" (PEG) specification of rising R&D difficulty, which can be found, e.g., in Dinopoulos and Segerstrom (1999a), Dinopoulos and Thompson (1996, 2000), or Şener (2001). In this formulation, R&D difficulty is tied to the exogenous (Northern) population size and is therefore independent of the Northern firm value. Formally, relative to our RPA formulation, the following changes: instead of (7), we have $\pi_N \equiv \pi_N^P$, instead of (9), we have

$$D = kN_N, \tag{A.1}$$

(17) is skipped, in (18) s_N = 0 (there is no specialized labor since there are no RPAs), (19) is skipped, and (23) is skipped. The rest of the model does not change.

In the PEG model, (25) becomes

$$\frac{c_N\left[1-\frac{w_{LN}}{\lambda(1+\tau_N)}\right]+c_S\eta_S\left(\frac{1}{1+\tau_S}-\frac{w_{LN}}{\lambda}\right)}{\rho+\iota+\mu-n}=w_{LN}a_\iota k \qquad \textbf{FEIN}\left(c_N,c_S,\iota,\mu,w_{LN}\right), \tag{A.2}$$

(26) becomes

$$\frac{c_N\left(\frac{1}{1+\tau_N}-\frac{1}{w_{LN}}\right)+c_S\eta_S\left[1-\frac{1}{w_{LN}(1+\tau_S)}\right]}{\rho+\iota-n}=a_\mu k \qquad \textbf{FEIM}\left(c_N,c_S,\iota,w_{LN}\right), \tag{A.3}$$

(29) becomes

$$\left(\frac{c_N}{1+\tau_N}+c_S\eta_S\right)\frac{\iota}{\lambda(\iota+\mu)}+a_\iota\iota k=1 \qquad \textbf{LABN}\left(c_N,c_S,\iota,\mu\right), \tag{A.4}$$

(30) becomes

$$\left(\frac{c_S}{1+\tau_S}+\frac{c_N}{\eta_S}\right)\frac{\mu}{w_{LN}(\iota+\mu)}+\frac{a_\mu\mu k}{\eta_S}\frac{\iota}{\iota+\mu}=1 \qquad \textbf{LABS}\left(c_N,c_S,w_{LN},\iota,\mu\right), \tag{A.5}$$

and (22) is unchanged. Using (22) and the definition for Q_N in (A.2) gives

$$\frac{c_N\left[1+\frac{\mu}{\iota(1+\tau_N)}\right]-Q_N w_{LN}}{\rho-n+\iota+\mu}=w_{LN}a_\iota k \qquad \textbf{FEIN}\left(c_N,w_{LN},\iota,\mu\right), \tag{A.6}$$

using (22) and the definition for Q_S in (A.3) gives

$$\frac{\frac{c_N}{1+\tau_N}\left[1+\frac{\mu(1+\tau_S)}{\iota}\right]-Q_S}{\rho-n+\iota}=a_\mu k \qquad \mathbf{FEIM}\left(c_N, w_{LN}, \iota, \mu\right). \qquad \text{(A.7)}$$

Solving (A.6) and (A.7) yields

$$w_{LN}=\frac{\lambda\left[A_{\iota,\mu}\left(\rho-n+\iota+\mu\right)+\rho-n+\iota\right]\left[\iota\left(1+\tau_N\right)+\mu\right]}{\left[\lambda A_{\iota,\mu}\left(\rho-n+\iota+\mu\right)+\rho-n+\iota\right]\left[\iota+\mu\left(1+\tau_S\right)\right]} \qquad \boldsymbol{w_{LN}}\left(\iota,\mu\right) \qquad \text{(A.8)}$$

and

$$c_N=\frac{\iota a_\mu\left(1-\sigma_\mu\right)k\left(1+\tau_N\right)\lambda\left[A_{\iota,\mu}\left(\rho-n+\iota+\mu\right)+\rho-n+\iota\right]}{\left(\lambda-1\right)\left[\iota+\mu\left(1+\tau_S\right)\right]} \qquad \boldsymbol{c_N}\left(\iota,\mu\right), \qquad \text{(A.9)}$$

where $A_{\iota,\mu}\equiv a_\iota\left(1-\sigma_\iota\right)\big/\left[a_\mu\left(1-\sigma_\mu\right)\right]$. Using (22) and (A.9) in (A.4) gives

$$\frac{\iota k\left\{a_\mu\left(1-\sigma_\mu\right)\left[\left(\rho-n+\iota\right)\left(A_{\iota,\mu}+1\right)+A_{\iota,\mu}\mu\right]+a_\iota\left(\lambda-1\right)\left(\iota+\mu\right)\right\}}{\left(\lambda-1\right)\left(\iota+\mu\right)}=1 \qquad \mathbf{LABN}\left(\iota,\mu\right). \qquad \text{(A.10)}$$

Using (22), (A.8) and (A.9) in (A.5) gives

$$\frac{\mu a_\mu k\left\{\eta_S\left(1-\sigma_\mu\right)\left[\left(\rho-n+\iota\right)\left(\lambda A_{\iota,\mu}+1\right)+\lambda A_{\iota,\mu}\mu\right]+\left(\lambda-1\right)\iota\right\}}{\eta_S\left(\lambda-1\right)\left(\iota+\mu\right)}=1 \qquad \mathbf{LABS}\left(\iota,\mu\right). \qquad \text{(A.11)}$$

Again, tariff rates do not show up in these two steady-state equilibrium equations. Therefore, the fact that in the model with RPAs, changes in firm profits trigger proportional changes in RPAs is not responsible for the neutrality of tariff changes with respect to the steady-state rates of innovation and imitation.

Comparing (A.6) and (A.7) with (25) and (26), respectively, reveals that the predictions on the effects of unilateral tariff rate changes in the PEG model on w_{LN} and c_N are the same as in the baseline RPA model. Furthermore, it is straightforward to see that increased Southern trade integration has also the same effects in the PEG model as in the baseline RPA model.

Appendix B: Asset Ownership Conditions Instead Of The BOT Condition

As an alternative to imposing the BOT condition (22), we can impose an asset market equilibrium condition to solve the system (25) – (30) in order to derive an additional equation for c_N or c_S, respectively. By this we can verify that it is not the chosen particular way to derive this additionally required equation which is driving our results from propositions 1 and 2.

Since π_N / N_N is constant during the incumbency period of any Northern monopolist in the steady state (X / N_N is constant due to (19) in a steady-state equilibrium), the stock-market value per Northern capita is constant over time and equals

$$\frac{v_N}{N_N} = \frac{w_{LN} a_\iota D}{N_N} = \frac{\pi_N / N_N}{\rho + \iota + \mu - n} = \frac{c_N \left(1 - \frac{w_{LN}}{\lambda}\right) + c_S \eta_S \left(\frac{1}{1+\tau_S} - \frac{w_{LN}}{\lambda}\right) - w_{HN} \gamma \frac{X}{N_N}}{\rho + \iota + \mu - n} ,$$

thus the total market value of all Northern firms at time *t*, $V_N = v_N n_N$, is

$$V_N = n_N w_{LN} a_\iota D , \tag{B.1}$$

where *D* is a linearly increasing function of $N_N(t)$ according to (9) and (19). Similarly, the total market value of all Southern firms at time *t*, $V_S = v_S n_S$, is found as

$$V_S = n_S a_\mu D . \tag{B.2}$$

The intertemporal budget constraint of a Northern *consumer* supplying specialized labor is $\dot{B}_{HN} = w_{HN} + \rho B_{HN} - c_{HN} - n B_{HN}$. Since $\dot{B}_{HN} / B_{HN}$ must be constant in a steady-state equilibrium, it follows

$$\frac{\dot{B}_{HN}}{B_{HN}} = \frac{w_{HN} - c_{HN}}{B_{HN}} + \rho - n = 0 \qquad \Leftrightarrow \qquad c_{HN} = w_{HN} + (\rho - n) B_{HN} ,$$

which applies to a fraction s_N of the Northern population. Similarly, we get

$$c_{LN} = w_{LN} + (\rho - n) B_{LN} ,$$

which applies to a fraction $1-s_N$ of the Northern population. Therefore, defining average financial assets of a Northern consumer as $B_N \equiv s_N B_{HN} + (1-s_N) B_{LN}$, it follows:

$$c_N = s_N w_{HN} + (1 - s_N) w_{LN} + (\rho - n) B_N , \tag{B.3}$$

and, analogously,

$$c_S = 1 + (\rho - n) B_S . \tag{B.4}$$

Similar to Dinopoulos and Segerstrom (2007, p. 21), we can assume "balanced asset ownership", i.e. we impose the assumption that Northern (Southern) consumers only own Northern (Southern) firms, hence

$$B_N = V_N / N_N \qquad \text{and} \qquad B_S = V_S / N_S . \tag{B.5}$$

Plugging (B.1) and (B.5) into (B.3) gives the Northern per-capita consumption expenditures (including payments for the Southern import tariff)

$$c_N = s_N w_{HN} + (1-s_N) w_{LN} + \left[(\rho - n) n_N w_{LN} a_\iota D / N_N \right]$$

which, after using (23), (9), (19) and (21), can be rewritten as

$$c_N = \left[s_N A_\iota \iota \left(1 + \tfrac{\rho - n}{\iota + \mu}\right) + 1 - s_N \right] w_{LN} \,. \tag{B.6}$$

Similarly, we derive the Southern per-capita consumption expenditures (including payments for the Northern import tariff)

$$c_S = 1 + \left[(\rho - n) n_S a_\mu D / N_S \right]$$

which, after using (9), (19) and (21), can be rewritten as

$$c_S = 1 + \frac{(\rho - n) A_\mu \mu s_N}{(\iota + \mu) \eta_S} \,. \tag{B.7}$$

We now have six equations [(25) – (30), and (B.6) – (B.7)] in five unknowns c_N, c_S, ι, μ and w_{LN}. By Walras Law, we can use either (B.6) or (B.7) to derive the steady-state equilibrium of our model. Solving the model yields again (31) and (32) as steady-state solution of our model. Accordingly, performing the same comparative static exercises as in the version of the model with the BOT condition (22) yields exactly the same results in terms of ι, μ and n_N as those stated for the BOT version in Propositions 1 and 2 before.[1]

Alternatively, we can follow Lundberg and Segerstrom (2002, p. 185) by assuming an "unbalanced asset ownership". This would mean to set $B_S = \phi B_W / N_S$ and $B_N = (1-\phi) B_W / N_N$, where $B_W = n_N V_N + n_S V_S$ measures the valuation of worldwide assets, and ϕ is the share of assets owned by Southern consumers (i.e., opposite to the "balanced asset ownership" case, we allow for international cross ownership of firms). Again, solving the model under these assumptions and performing the same comparative static exercises as before yields exactly the same results in terms of ι, μ and n_N as those stated in Proposition 1 and 2 before.[2]

Hence, the bottom line is that allowing for unbalanced asset ownership does not change the steady-state results relative to balanced asset ownership, and more generally, whether we use a BOT

---

1 Contrary to the balanced-trade specification, the sign of $dw_{LN}/d\eta_S$ and $dw_{LN}/d\tau_N$ becomes ambiguous. However, for sufficiently low tariff rates and sufficiently low consumer discount rate $\rho - n$, $dw_{LN}/d\eta_S < 0$ as before. $dw_{LN}/d\tau_S$ remains qualitatively the same as with balanced trade.

2 As for the effects on w_{LN}, the same reservations as with balanced asset ownership apply.

condition or an asset market equilibrium condition to solve our set of steady-state equilibrium equations does not matter for results in terms of ι, μ and n_N at all.

```
In[301]:=
"APPENDIX C: PROOF OF PROPOSITION 1 (MATHEMATICA PROGRAM)  ";

In[302]:=
"- This program requires Mathematica Version 5.0. Before
   evaluating the cells, 'Math Econ' package written by Cliff Huang
   and Philip Crooke needs to be run. This package accompanies
   the book 'Mathematics and Mathematica for Economists', 1997,
   Blackwell Publishers: Oxford, written by the above authors.
 - Notes: In this program, for convenience we enter the
   subscripts and superscripts of the main model in regular
   format. We define dr = ρ-n. The elimination of minus
   terms helps Mathematica to obtain more tidy expressions.";

In[303]:=
"1. THE MAIN EQUATIONS OF THE MODEL";

In[304]:=
Clear[τN, τS]

In[305]:=
"We enter the expressions for nN and m";
nN = i / (i + μ); m = μ * nN;

In[307]:=
"The equation for wLN is from (28)";

In[308]:=
```

$$wLN = \frac{\lambda\,(Ai\,(dr + 2\,(i + \mu)) + A\mu\,(dr + i))\,(i\,(1 + \tau N) + \mu)}{(Ai\,\lambda\,(dr + 2\,(i + \mu)) + A\mu\,(dr + i))\,(i + \mu\,(1 + \tau S))};$$

```
In[309]:=
"We express the labor market equilibrium conditions for the North and South,
   equations (31) and (32), as functions to conduct comparative statics";

In[310]:=
FLABN[i_, μ_, dr_, ηS_, λ_, Ai_, Aμ_, sN_] :=
```

$$\frac{i\,sN\,(A\mu\,(dr + i) + Ai\,(dr + (1 + \lambda)\,(i + \mu)))}{(-1 + \lambda)\,(i + \mu)} - (1 - sN)$$

```
In[311]:=
FLABS[i_, μ_, dr_, ηS_, λ_, Ai_, Aμ_, sN_] :=
```

$$\frac{sN\,\mu\,(A\mu\,(dr + i\,\lambda) + Ai\,\lambda\,(dr + 2\,(i + \mu)))}{\eta S\,(-1 + \lambda)\,(i + \mu)} - 1$$

```
In[312]:=
"Let J define the gradient matrix with respect to i and μ";
```

In[313]:=

```
J = {gradf[FLABN[i, μ, dr, ηS, λ, Ai, Aμ, sN] , {i, μ}],
   gradf[FLABS[i, μ, dr, ηS, λ, Ai, Aμ, sN] , {i, μ}]};
```

In[314]:=

2. COMPARATIVE STATICS FOR ηS;

In[315]:=

```
"Let B define the gradient matrix with respect to ηS";
```

In[316]:=

```
B = {gradf[FLABN[i, μ, dr, ηS, λ, Ai, Aμ, sN] , {ηS}],
  gradf[FLABS[i, μ, dr, ηS, λ, Ai, Aμ, sN] , {ηS}]}
```

Out[316]=

$$\left\{\{0\},\ \left\{-\frac{\mathrm{sN}\,\mu\,(\mathrm{A}\mu\,(\mathrm{dr}+\mathrm{i}\,\lambda)+\mathrm{Ai}\,\lambda\,(\mathrm{dr}+2\,(\mathrm{i}+\mu)))}{\eta\mathrm{S}^2\,(-1+\lambda)\,(\mathrm{i}+\mu)}\right\}\right\}$$

In[317]:=

```
"Using Cramer's rule, it follows that the impact of ηS
   on i and μ can be found by the following matrix equation.";
```

In[318]:=

```
impactηS = -Inverse[J].B.{ΔηS};
```

In[319]:=

```
MatrixForm[impactηS] // FullSimplify
```

Out[319]//MatrixForm=

$$\begin{pmatrix} \dfrac{\mathrm{i}\,(\mathrm{Ai}\,\mathrm{dr}+\mathrm{A}\mu\,(\mathrm{dr}+\mathrm{i}))\,\Delta\eta\mathrm{S}\,\mu\,(\mathrm{A}\mu\,(\mathrm{dr}+\mathrm{i}\,\lambda)+\mathrm{Ai}\,\lambda\,(\mathrm{dr}+2\,(\mathrm{i}+\mu)))}{\eta\mathrm{S}\,(\mathrm{Ai}\,\mathrm{A}\mu\,(\mathrm{i}+\mu)\,(\mathrm{i}\,(\mathrm{dr}+2\,\mathrm{dr}\,\lambda+\mathrm{i}\,\lambda\,(3+\lambda))+2\,(\mathrm{dr}+2\,\mathrm{i})\,\lambda\,\mu)+\mathrm{Ai}^2\,\lambda\,(\mathrm{i}+\mu)\,(2\,(1+\lambda)\,(\mathrm{i}+\mu)^2+\mathrm{dr}\,(\mathrm{i}+\mathrm{i}\,\lambda+2\,\mu))+\mathrm{A}\mu^2\,\mathrm{i}\,(\mathrm{i}\,\lambda\,(\mathrm{i}+\mu)+\mathrm{dr}\,(\mathrm{i}+\lambda\,\mu)))} \\ \dfrac{\Delta\eta\mathrm{S}\,\mu\,(\mathrm{A}\mu\,(\mathrm{dr}+\mathrm{i}\,\lambda)+\mathrm{Ai}\,\lambda\,(\mathrm{dr}+2\,(\mathrm{i}+\mu)))\,(\mathrm{A}\mu\,(\mathrm{i}^2+\mathrm{dr}\,\mu+2\,\mathrm{i}\,\mu)+\mathrm{Ai}\,(\mathrm{dr}\,\mu+(1+\lambda)\,(\mathrm{i}+\mu)^2))}{\eta\mathrm{S}\,(\mathrm{Ai}\,\mathrm{A}\mu\,(\mathrm{i}+\mu)\,(\mathrm{i}\,(\mathrm{dr}+2\,\mathrm{dr}\,\lambda+\mathrm{i}\,\lambda\,(3+\lambda))+2\,(\mathrm{dr}+2\,\mathrm{i})\,\lambda\,\mu)+\mathrm{Ai}^2\,\lambda\,(\mathrm{i}+\mu)\,(2\,(1+\lambda)\,(\mathrm{i}+\mu)^2+\mathrm{dr}\,(\mathrm{i}+\mathrm{i}\,\lambda+2\,\mu))+\mathrm{A}\mu^2\,\mathrm{i}\,(\mathrm{i}\,\lambda\,(\mathrm{i}+\mu)+\mathrm{dr}\,(\mathrm{i}+\lambda\,\mu)))} \end{pmatrix}$$

In[320]:=

```
{di, dμ} = %;
```

In[321]:=

"It follows that $\frac{\mathrm{di}}{\mathrm{d}\eta\mathrm{S}}>0$ and also $\frac{\mathrm{d}\mu}{\mathrm{d}\eta\mathrm{S}}>0$.";

In[322]:=

```
"Below, we totally differentiate m,nN and
   wLN and plug in the results for di and dμ. This gives:";
```

In[323]:=

```
dm = D[m, i] di + D[m, μ] dμ + D[m, ηS] ΔηS // FullSimplify
```

Out[323]=

$$(\mathrm{i}\,\Delta\eta\mathrm{S}\,\mu\,(\mathrm{i}^2\,(\mathrm{Ai}+\mathrm{A}\mu+\mathrm{Ai}\,\lambda)+((\mathrm{Ai}+\mathrm{A}\mu)\,(\mathrm{dr}+\mathrm{i})+\mathrm{Ai}\,\mathrm{i}\,\lambda)\,\mu)\,(\mathrm{A}\mu\,(\mathrm{dr}+\mathrm{i}\,\lambda)+\mathrm{Ai}\,\lambda\,(\mathrm{dr}+2\,(\mathrm{i}+\mu))))\,/\,(\eta\mathrm{S}\,(\mathrm{i}+\mu)\,(\mathrm{Ai}\,\mathrm{A}\mu\,(\mathrm{i}+\mu)\,(\mathrm{i}\,(\mathrm{dr}+2\,\mathrm{dr}\,\lambda+\mathrm{i}\,\lambda\,(3+\lambda))+2\,(\mathrm{dr}+2\,\mathrm{i})\,\lambda\,\mu)+\mathrm{Ai}^2\,\lambda\,(\mathrm{i}+\mu)\,(2\,(1+\lambda)\,(\mathrm{i}+\mu)^2+\mathrm{dr}\,(\mathrm{i}+\mathrm{i}\,\lambda+2\,\mu))+\mathrm{A}\mu^2\,\mathrm{i}\,(\mathrm{i}\,\lambda\,(\mathrm{i}+\mu)+\mathrm{dr}\,(\mathrm{i}+\lambda\,\mu))))$$

In[324]:=

```
dnN = D[nN, i] di + D[nN, μ] dμ + D[nN, ηS] ΔηS // FullSimplify
```

Out[324]=

```
-(i ΔηS μ (Aμ i + Ai (1 + λ) (i + μ)) (Aμ (dr + i λ) + Ai λ (dr + 2 (i + μ)))) /
  (ηS (i + μ) (Ai Aμ (i + μ) (i (dr + 2 dr λ + i λ (3 + λ)) + 2 (dr + 2 i) λ μ) +
      Ai^2 λ (i + μ) (2 (1 + λ) (i + μ)^2 + dr (i + i λ + 2 μ)) + Aμ^2 i (i λ (i + μ) + dr (i + λ μ))))
```

In[325]:=

```
dwLN = D[wLN, i] di + D[wLN, μ] dμ + D[wLN, ηS] ΔηS // FullSimplify
```

Out[325]=

```
(ΔηS λ μ (Aμ (dr + i λ) + Ai λ (dr + 2 (i + μ)))
    (i (Ai dr + Aμ (dr + i)) (-(Aμ (dr + i) + Ai (dr + 2 (i + μ))) (Aμ (dr + i) + Ai λ (dr + 2 (i + μ)))
          (i + μ + i τN) + (Aμ (dr + i) + Ai (dr + 2 (i + μ))) (Aμ (dr + i) + Ai λ (dr + 2 (i + μ)))
          (1 + τN) (i + μ + μ τS) - (Aμ + 2 Ai λ) (Aμ (dr + i) + Ai (dr + 2 (i + μ))) (i + μ + i τN)
          (i + μ + μ τS) + (2 Ai + Aμ) (Aμ (dr + i) + Ai λ (dr + 2 (i + μ))) (i + μ + i τN) (i + μ + μ τS)) +
      (Aμ (i^2 + dr μ + 2 i μ) + Ai (dr μ + (1 + λ) (i + μ)^2))
       (-Aμ^2 i (dr + i)^2 (τN + τS + τN τS) - Ai^2 i λ (dr + 2 (i + μ))^2 (τN + τS + τN τS) -
         Ai Aμ (dr + i) (2 (-1 + λ) μ^2 (1 + τS) + 2 i^2 (-1 + λ + 2 λ τN + (1 + λ) (1 + τN) τS) +
            i (dr (1 + λ) (τN + τS + τN τS) + 4 μ (-1 + λ (1 + τN) (1 + τS))))))) / (ηS
    (Aμ (dr + i) + Ai λ (dr + 2 (i + μ)))^2 (Ai Aμ (i + μ) (i (dr + 2 dr λ + i λ (3 + λ)) + 2 (dr + 2 i) λ μ) +
      Ai^2 λ (i + μ) (2 (1 + λ) (i + μ)^2 + dr (i + i λ + 2 μ)) +
      Aμ^2 i (i λ (i + μ) + dr (i + λ μ))) (i + μ + μ τS)^2)
```

In[326]:=

```
"It follows that (dm/dηS)>0, (dnN/dηS)<0 and (dwLN/dηS)><0 .";
```

In[327]:=

```
" To sign dwLN, we evaluate it around the free-
  trade equilibrium by imposing"; τN = τS = 0; FullSimplify[dwLN]
```

Out[327]=

```
(Ai Aμ ΔηS (-1 + λ) λ μ (Aμ (dr + i λ) + Ai λ (dr + 2 (i + μ))) (-i (Ai dr + Aμ (dr + i)) (dr - 2 μ) -
      2 (dr + i) (Aμ (i^2 + dr μ + 2 i μ) + Ai (dr μ + (1 + λ) (i + μ)^2)))) / (ηS
    (Aμ (dr + i) + Ai λ (dr + 2 (i + μ)))^2 (Ai Aμ (i + μ) (i (dr + 2 dr λ + i λ (3 + λ)) + 2 (dr + 2 i) λ μ) +
      Ai^2 λ (i + μ) (2 (1 + λ) (i + μ)^2 + dr (i + i λ + 2 μ)) + Aμ^2 i (i λ (i + μ) + dr (i + λ μ))))
```

```
"It thus follows that (dwLN/dηS)<0
  for sufficiently small levels of τN and τS  .";
```

Appendix D.1: Technical Details For Section 4.1

The FEIN equation is

$$\frac{c_N(\iota+\mu)(\lambda-w_{LN})}{\iota\lambda\left[\rho-n+2(\iota+\mu)\right]}=\hat{A}_\iota w_{LN}s_N \qquad \mathbf{FEIN}(c_N,w_{LN},\iota,\mu), \tag{D.1}$$

and the FEIM equation is

$$\frac{c_N(\iota+\mu)(w_{LN}-1)}{\iota w_{LN}(\rho-n+\iota)}=\hat{A}_\mu s_S\eta_S \qquad \mathbf{FEIM}(c_N,w_{LN},\iota,\mu). \tag{D.2}$$

Solving these two equations simultaneously for w_{LN} and c_N gives

$$w_{LN}=\frac{\lambda\left\{\hat{A}_\iota s_N\left[\rho-n+2(\iota+\mu)\right]+\hat{A}_\mu s_S\eta_S(\rho-n+\iota)\right\}}{\lambda\hat{A}_\iota s_N\left[\rho-n+2(\iota+\mu)\right]+\hat{A}_\mu s_S\eta_S(\rho-n+\iota)} \tag{D.3}$$

and

$$c_N=\frac{\iota\lambda\left\{\hat{A}_\iota s_N\left[\rho-n+2(\iota+\mu)\right]+\hat{A}_\mu s_S\eta_S(\rho-n+\iota)\right\}}{(\lambda-1)(\iota+\mu)}\;. \tag{D.4}$$

The ratio c_N/w_{LN} is then found as

$$\frac{c_N}{w_{LN}}=\frac{\iota\left\{\lambda\hat{A}_\iota s_N\left[\rho-n+2(\iota+\mu)\right]+\hat{A}_\mu s_S\eta_S(\rho-n+\iota)\right\}}{(\lambda-1)(\iota+\mu)}\;, \tag{D.5}$$

which is unambiguously increasing in η_S.

Substituting (D.4) in (34), LABN becomes

$$\frac{\iota\left\{\hat{A}_\iota s_N\left[\rho-n+(\iota+\mu)(1+\lambda)\right]+\hat{A}_\mu s_S\eta_S(\rho-n+\iota)\right\}}{(\lambda-1)(\iota+\mu)}=1-s_N \qquad \mathbf{LABN}(\iota,\mu), \tag{D.6}$$

which is unambiguously upward sloping in (ι, μ)-space as before. Substituting (D.5) in (35), LABS becomes

$$\frac{\mu\left\{\lambda\hat{A}_\iota s_N\left[\rho-n+2(\iota+\mu)\right]+\hat{A}_\mu s_S\eta_S(\rho-n+\iota\lambda)\right\}}{\eta_S(\lambda-1)(\iota+\mu)}=1-s_S \qquad \mathbf{LABS}(\iota,\mu), \tag{D.7}$$

The LHS of (D.7) is unambiguously increasing in μ, and it is increasing in ι if, and only if,

$$\mu > (\rho - n)\left(\frac{1}{\lambda} + \frac{\hat{A}_\iota s_N}{\hat{A}_\mu s_S \eta_S}\right) \tag{D.8}$$

is fulfilled, which corresponds to (33). Given this, the curve for the LABS equation (D.7) is downward sloping in (ι, μ)-space as before.

Since an increase in η_S shifts both the curves for LABN and LABS to the right in a graph similar to Figure 4, μ increases unambiguously, while ι decreases if and only if the horizontal shift of the curve for (D.6) is larger than the horizontal shift of the curve for (D.7). The condition for this is derived from totally differentiating (D.6) and (D.7) with respect to μ and η_S while holding ι constant, which gives

$$\left.\frac{d\mu}{d\eta_S}\right|_{(D.6)} = \frac{\hat{A}_\mu s_S(\rho - n + \iota)(\iota + \mu)}{\hat{A}_\mu s_S \eta_S(\rho - n + \iota)(\iota + \mu) + \hat{A}_\iota s_N(\rho - n)} > \left.\frac{d\mu}{d\eta_S}\right|_{(D.7)} = \frac{\lambda \hat{A}_\iota s_N\left[\rho - n + 2(\iota + \mu)\right]}{\eta_S\left[2\lambda A_\iota s_N + \frac{(1-s_S)\iota}{\mu^2}\eta_S(\lambda - 1)\right]}$$

$$\Leftrightarrow \quad \frac{(\iota + \mu)(1 - s_S)\iota \eta_S(\lambda - 1)}{\lambda \hat{A}_\iota s_N \mu^2} > (\rho - n)\left\{1 + \frac{\hat{A}_\iota s_N\left[\rho - n + 2(\iota + \mu)\right]}{\hat{A}_\mu s_S \eta_S(\rho - n + \iota)}\right\}, \tag{D.9}$$

which is obviously fulfilled for a sufficiently small consumption discount rate $\rho - n$.

In[350]:=

"APPENDIX D.2.:SIGNING dwLN/dηS IN THE MODEL WITH SOUTHERN SPECIALIZED LABOR (MATHEMATICA PROGRAM)";

In[351]:=

```
"- This program requires Mathematica Version 5.0. Before
   evaluating the cells, 'Math Econ' package written by Cliff Huang
   and Philip Crooke needs to be run. This package accompanies
   the book 'Mathematics and Mathematica for Economists', 1997,
   Blackwell Publishers: Oxford, written by the above authors.
 - Notes: In this program, for convenience we enter the
   subscripts and superscripts of the main model in regular
   format. We define dr = ρ-n. The elimination of minus
   terms help Mathematica to obtain more tidy expressions.";
```

In[352]:=

"1. THE MAIN EQUATIONS OF THE MODEL";

In[353]:=

```
"First, we clear the variables"; Clear[dr, cN, i, μ, wLN];
```

In[354]:=

```
"The equation for wLN, equation (D4), is already derived in Appendix D as";
```

In[355]:=

$$wLN = \frac{\lambda\,(A\mu\,(dr + i)\,sS\,\eta S + Ai\,sN\,(dr + 2\,(i + \mu)))}{A\mu\,(dr + i)\,sS\,\eta S + Ai\,sN\,\lambda\,(dr + 2\,(i + \mu))};$$

In[356]:=

```
"We express the general purpose labor market
   equilibrium conditions for the North and South, equations (
   D6) and (D7), as functions to conduct comparative statics";
```

In[357]:=

$$FLABN[i\_, \mu\_, dr\_, \eta S\_, \lambda\_, Ai\_, A\mu\_, sN\_, sS\_] := \frac{i\,(A\mu\,(dr + i)\,sS\,\eta S + Ai\,sN\,(dr + (1 + \lambda)\,(i + \mu)))}{(-1 + \lambda)\,(i + \mu)} - (1 - sN);$$

In[358]:=

$$FLABS[i\_, \mu\_, dr\_, \eta S\_, \lambda\_, Ai\_, A\mu\_, sN\_, sS\_] := \frac{\mu\,(A\mu\,sS\,\eta S\,(dr + i\,\lambda) + Ai\,sN\,\lambda\,(dr + 2\,(i + \mu)))}{\eta S\,(i + \mu)\,(\lambda - 1)} - (1 - sS);$$

In[359]:=

```
"Let J define the gradient matrix with respect to i and μ";
```

In[360]:=

```
J = {gradf[FLABN[i, μ, dr, ηS, λ, Ai, Aμ, sN, sS] , {i, μ}],
   gradf[FLABS[i, μ, dr, ηS, λ, Ai, Aμ, sN, sS] , {i, μ}]};
```

In[361]:=

```
"2. COMPARATIVE STATICS FOR dwLN/ηS with dr>0";
```

In[362]:=

```
"Let B define the gradient matrix with respect to ηS";
```

In[363]:=

```
B = {gradf[FLABN[i, μ, dr, ηS, λ, Ai, Aμ, sN, sS] , {ηS}],
   gradf[FLABS[i, μ, dr, ηS, λ, Ai, Aμ, sN, sS] , {ηS}]};
```

In[364]:=

```
"Using Cramer's rule, it follows that the impact of ηS
   on i and μ can be found by the following matrix equation.";
```

In[365]:=

```
impactηS = -Inverse[J].B.{ΔηS} // FullSimplify
```

Out[365]=

```
{- (i ΔηS (Aμ^2 i (dr + i) sS^2 ηS^2 (dr + i λ) - Ai^2 dr sN^2 λ μ (dr + 2 (i + μ)) +
        Ai Aμ (dr + i) sN sS ηS λ (dr (i - μ) + 2 i (i + μ))))) /
    (ηS (Ai Aμ sN sS ηS (i + μ) (i (dr + 2 dr λ + i λ (3 + λ)) + 2 (dr + 2 i) λ μ) +
        Ai^2 sN^2 λ (i + μ) (2 (1 + λ) (i + μ)^2 + dr (i + i λ + 2 μ)) +
        Aμ^2 i sS^2 ηS^2 (i λ (i + μ) + dr (i + λ μ)))), (ΔηS μ
     (-Aμ^2 i (dr + i) sS^2 ηS^2 (dr - λ μ) + Ai^2 sN^2 λ (dr + 2 (i + μ)) (dr μ + (1 + λ) (i + μ)^2) +
       Ai Aμ sN sS ηS λ (dr^2 (-i + μ) + 2 dr μ (2 i + μ) + 2 i (i + μ) (i + 2 μ)))) /
   (ηS (Ai Aμ sN sS ηS (i + μ) (i (dr + 2 dr λ + i λ (3 + λ)) + 2 (dr + 2 i) λ μ) +
       Ai^2 sN^2 λ (i + μ) (2 (1 + λ) (i + μ)^2 + dr (i + i λ + 2 μ)) +
       Aμ^2 i sS^2 ηS^2 (i λ (i + μ) + dr (i + λ μ))))}
```

In[366]:=

```
{di, dμ} = % ; "The above vector gives the changes in i and μ due to dηS > 0";
```

In[367]:=

```
"Below, we totally differentiate wLN
   and plug in the results for di and dμ. This gives:";
```

In[368]:=

```
dwLN = D[wLN, i] di + D[wLN, μ] dμ + D[wLN, ηS] ΔηS // FullSimplify
```

Out[368]=

$$\left(Ai\, A\mu\, i\, sN\, sS\, \Delta\eta S\, (-1+\lambda)\, \lambda \left(Ai^2\, sN^2\, \lambda\, (i\, (dr+i)\, (1+\lambda) + (2\, dr + i + (dr+i)\, \lambda)\, \mu)\, (dr + 2\, (i+\mu))^2 + A\mu^2\, (dr+i)^2\, sS^2\, \eta S^2\, (2\, dr\, i + dr\, (2+\lambda)\, \mu + 2\, i\, \lambda\, (i+\mu)) + Ai\, A\mu\, (dr+i)\, sN\, sS\, \eta S\, (dr + 2\, (i+\mu))\, (i\, \lambda\, (3+\lambda)\, (i+\mu) + dr\, (i + 3\, i\, \lambda + \mu + 5\, \lambda\, \mu))\right)\right) / \left((A\mu\, (dr+i)\, sS\, \eta S + Ai\, sN\, \lambda\, (dr + 2\, (i+\mu)))^2 \left(Ai\, A\mu\, sN\, sS\, \eta S\, (i+\mu)\, (i\, (dr + 2\, dr\, \lambda + i\, \lambda\, (3+\lambda)) + 2\, (dr + 2\, i)\, \lambda\, \mu) + Ai^2\, sN^2\, \lambda\, (i+\mu)\, (2\, (1+\lambda)\, (i+\mu)^2 + dr\, (i + i\, \lambda + 2\, \mu)) + A\mu^2\, i\, sS^2\, \eta S^2\, (i\, \lambda\, (i+\mu) + dr\, (i + \lambda\, \mu))\right)\right)$$

In[369]:=

"It thus follows that $\frac{dwLN}{d\eta S}$>0. Note that this holds without imposing dr=0";

Appendix E: Consumer Optimization With A Southern Low-Tech Sector

The reduced form of the instantaneous utility function (2) changes to

$$\log u_i(t) \equiv \alpha \int_0^1 \log\left[\frac{\lambda^{j(\omega,t)} c_i(t)}{p(\omega,t)}\right] d\omega + (1-\alpha)\log\left[\frac{z_i(t)}{p_Z}\right], \tag{E.1}$$

where $\alpha \in \,]0,1[$ is a taste parameter and $z_i(t)$ denotes the per-capita consumption expenditure for the low-tech goods at time t in country i. The household's optimization problem is to maximize discounted utility (1) with the subutility function (E.1) subject to the intertemporal budget constraint

$$WI_i(t) + FA_i(t) = \int_t^\infty N_{0i} e^{ns} e^{-[R(s)-R(t)]} \left[c_i(s) + z(s)\right] ds, \tag{E.2}$$

where WI_i denotes the discounted wage income of the representative household in country i from time t on, $FA_i(t)$ is the value of the financial assets of the representative household in country i at time t, and $R(t) \equiv \int_0^t r(s)\, ds$ is the market discount factor with $\dot{R}(t) = r(t)$ denoting the instantaneous interest rate at time t.

In order to transform the household's optimization problem into a standard optimal control problem that allows to apply Pontryagin's maximum principle, we define a new state variable Θ with

$$\dot{\Theta}(s) = N_0 e^{ns} e^{-[R(s)-R(t)]} \left[c_i(s) + z_i(s)\right], \quad \Theta(0) = 0, \quad \text{and} \quad \lim_{s\to\infty} \Theta(s) = WI_i(t) + FA_i(t).$$

Since the households take the evolution of the innovation index $j(\omega,t)$ and the high-tech goods price $p(\omega,t)$ as given, the term $\int_0^\infty N_{0i} e^{-(\rho-n)t} \alpha \{\int_0^1 \log[\lambda^{j(\omega,t)} / p(\omega,t)\, d\omega\} dt$ from (1) and (E.1) can be neglected, and with $p_Z = 1/b$ the present-value Hamilton function is simply

$$\begin{aligned} H(\Theta, c_i, z_i, \chi, t) = \; & N_{0i} e^{-(\rho-n)s} \left\{\alpha \log\left[c_i(s)\right] + (1-\alpha)\log\left[b z_i(s)\right]\right\} \\ & + \chi(s) N_{0i} e^{ns} e^{-[R(s)-R(t)]} \left[c_i(s) + z_i(s)\right] \end{aligned} \tag{E.3}$$

with $\chi(s)$ as the new costate variable corresponding to $\Theta(s)$. From the costate equation

$$\partial H / \partial \Theta \; = \; 0 \; \overset{!}{=} \; -\dot{\chi} \tag{E.4}$$

it follows immediately that $\chi(s) = \chi \;\forall s$, i.e. the costate variable is constant over time. Applying Pontryagin's maximum principle yields the other foc:

$$\partial H / \partial c_i(s) = e^{-\rho s} \left[\alpha / c_i(s)\right] + \chi e^{-[R(s)-R(t)]} \overset{!}{=} 0, \tag{E.5}$$

$$\partial H/\partial z_i(s) = e^{-\rho s}\left[(1-\alpha)/z_i(s)\right] + \chi e^{-[R(s)-R(t)]} \overset{!}{=} 0 . \tag{E.6}$$

Differentiating (E.5) with respect to time s gives

$$-\rho e^{-\rho s}\left[\alpha/c_i(s)\right] - e^{-\rho s}\left[\alpha/c_i(s)^2\right]\dot{c}_i(s) - \dot{R}(s)\chi e^{-[R(s)-R(t)]} = 0 ,$$

and using the definition $\dot{R}(s) \equiv r(s)$ and (E.5) in the third term of the LHS of this equation yields the Keynes-Ramsey rule (4) again. Similarly, differentiating (E.6) with respect to time s, and applying $\dot{R}(s) \equiv r(s)$ and (E.6), leads to the optimal low-tech consumption path

$$\frac{\dot{z}_i(t)}{z_i(t)} = r(t) - \rho \qquad \text{for } i = N, S, \tag{E.7}$$

Finally, dividing (E.5) by (E.6) yields

$$\frac{c_i(t)}{z_i(t)} = \frac{\alpha}{1-\alpha} , \qquad \text{for } i = N, S, \tag{E.8}$$

which is (36) in the main text. Finally, the new common steady-state utility growth rate for both countries is $\dot{u}_N/u_N = \dot{u}_S/u_S = \alpha\iota\log\lambda$.

Appendix F: Technical Details Of Section 4.2

Solving the new FEIN equation (40) and the new FEIM equation (41) simultaneously for c_N and w_{LN} yields:

$$c_N(\iota,\mu) = \frac{\iota s_N \lambda(1+\tau_N)\left\{A_\iota\left[\rho-n+2(\iota+\mu)\right]+A_\mu(\rho-n+\iota)\right\}}{(\lambda-1)\left\{\iota\left[1+\frac{1-\alpha}{\alpha}(1+\tau_N)(1+\tau_S)\right]+\frac{\mu}{\alpha}\left[1+\tau_N(1-\alpha)\right](1+\tau_S)\right\}} , \tag{F.1}$$

$$w_{LN}(\iota,\mu) = \frac{\lambda\left\{A_\iota\left[\rho-n+2(\iota+\mu)\right]+A_\mu(\rho-n+\iota)\right\}}{\left\{A_\iota\lambda\left[\rho-n+2(\iota+\mu)\right]+A_\mu(\rho-n+\iota)\right\}} \times \frac{\left\{\frac{\iota}{\alpha}(1+\tau_N)+\frac{\mu}{\alpha}\left[1+\tau_N(1-\alpha)\right]\right\}}{\left\{\iota\left[1+\frac{1-\alpha}{\alpha}(1+\tau_N)(1+\tau_S)\right]+\frac{\mu}{\alpha}\left[1+\tau_N(1-\alpha)\right](1+\tau_S)\right\}} , \tag{F.2}$$

where setting $\alpha = 1$ in (F.1) and (F.2) yields the special-case solutions (27) and (28), respectively. $c_N(\iota, \mu)$ is unambiguously increasing in τ_N:

$$\frac{\partial c_N}{\partial \tau_N} = \frac{\iota s_N \lambda\left\{A_\mu\left[\rho-n+\iota\right]+A_\iota\left[\rho-n+2(\iota+\mu)\right]\right\}\left[\iota+\mu(1+\tau_S)\right]}{(\lambda-1)\left\{(\iota+\mu)\frac{1}{\alpha}\left[1+(1-\alpha)\tau_N\right]+\tau_S\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]\right\}^2} > 0 . \tag{F.3}$$

Using (F.1) and (38) shows that $c_S(\iota, \mu)$ is also unambiguously increasing in τ_N:

$$\frac{\partial c_S}{\partial \tau_N} = \frac{\frac{1-\alpha}{\alpha}\iota s_N \lambda(\iota+\mu)(\iota+\tau_S)\left\{A_\mu[\rho-n+\iota]+A_\iota[\rho-n+2(\iota+\mu)]\right\}}{\eta_S(\lambda-1)\left\{(\iota+\mu)\frac{1}{\alpha}[1+(1-\alpha)\tau_N]+\tau_S\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]\right\}^2} > 0. \tag{F.4}$$

$c_N(\iota, \mu)$ is unambiguously decreasing in τ_S:

$$\frac{\partial c_N}{\partial \tau_S} = -\frac{\iota s_N \lambda\left\{A_\mu[\rho-n+\iota]+A_\iota[\rho-n+2(\iota+\mu)]\right\}(1+\tau_N)\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]}{(\lambda-1)\left\{(\iota+\mu)\frac{1}{\alpha}[1+(1-\alpha)\tau_N]+\tau_S\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]\right\}^2} < 0. \tag{F.5}$$

$c_S(\iota, \mu)$ is also unambiguously increasing in τ_S:

$$\frac{\partial c_S}{\partial \tau_S} = \frac{\iota s_N \lambda\left\{A_\mu[\rho-n+\iota]+A_\iota[\rho-n+2(\iota+\mu)]\right\}(1+\tau_N)\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]}{\eta_S(\lambda-1)\left\{(\iota+\mu)\frac{1}{\alpha}[1+(1-\alpha)\tau_N]+\tau_S\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]\right\}^2} > 0. \tag{F.6}$$

To determine the sign of $\partial L_Z/\partial \tau_S$, we need to evaluate the following expression:

$$\frac{\partial\left(\frac{c_N}{\eta_S}+c_S\right)}{\partial \tau_S} = -\frac{\iota s_N \lambda\left\{A_\mu[\rho-n+\iota]+A_\iota[\rho-n+2(\iota+\mu)]\right\}\tau_N\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]}{\eta_S(\lambda-1)\left\{(\iota+\mu)\frac{1}{\alpha}[1+(1-\alpha)\tau_N]+\tau_S\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]\right\}^2} < 0. \tag{F.7}$$

Appendix G: Proof Of Proposition 3

Using (38), (F.1), (F.2) and our expression for $Q_S(c_N, c_S)$ in (39) gives the new **LABS**(ι, μ):

$$\frac{\mu s_N\left\{A_\iota\lambda[\rho-n+2(\iota+\mu)]+A_\mu(\rho-n+\iota\lambda)\right\}}{\eta_S(\lambda-1)(\iota+\mu)} + \frac{(1-\alpha)s_N\lambda\left\{A_\iota[\rho-n+2(\iota+\mu)]+A_\mu(\rho-n+\iota)\right\}K(\iota,\mu,\tau_N,\tau_S)}{\alpha\eta_S(\lambda-1)} = 1 \qquad \textbf{LABS}(\iota,\mu) \tag{G.1}$$

$$\text{with} \qquad K(\iota,\mu,\tau_N,\tau_S) \equiv \frac{\iota(1+\tau_N)+(1+\tau_S)\left[\mu+\frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N)\right]}{\iota\left[1+\frac{1-\alpha}{\alpha}(1+\tau_N)(1+\tau_S)\right]+\frac{\mu}{\alpha}\left[1+\tau_N(1-\alpha)\right](1+\tau_S)} \equiv \frac{num}{den},$$

where the special case (32) is obtained for $\alpha = 1$ again. For sufficiently low τ_N and τ_S, the LABS(ι, μ) curve is again strictly downward sloping if

$$\mu > \alpha(\rho-n)\left(\frac{1}{\lambda}+\frac{A_\iota}{A_\mu}\right), \tag{G.2}$$

which due to $\alpha < 1$ is actually a weaker condition than (33). Given this, uniqueness of the steady-state equilibrium is established. Existence of this equilibrium is ensured by the facts that, as in Figure 3, the LABS curve (G.1) does not intersect the vertical axis even for $\iota \to \infty$ because (G.2) ensures $\mu > 0$, and the LABN curve (31) for $\mu \to 0$ is solved by a $\iota > 0$.

Differentiating the K-function with respect to the tariff rates yields [1]

$$\frac{\partial K(\bullet)}{\partial \tau_N} = \frac{\iota + \frac{1-\alpha}{\alpha}(1+\tau_S)(\iota+\mu)(1-K)}{den} > 0 \ , \tag{G.3}$$

$$\left.\frac{\partial K(\bullet)}{\partial \tau_S}\right|_{(\tau_N > 0)} = \frac{\mu + \frac{1-\alpha}{\alpha}(\iota+\mu)(1+\tau_N) - \frac{K}{\alpha}\left\{\iota(1+\tau_N)(1-\alpha) + \mu\left[1+\tau_N(1-\alpha)\right]\right\}}{den} < 0 \ .^2 \tag{G.4}$$

A decrease in τ_N unambiguously reduces the LHS of (G.1), hence μ must increase to restore Northern labor market equilibrium for any given ι, i.e. a reduction of the Northern import tariff shifts LABS(ι, μ) to the right, whereas LABN(ι, μ) still given by (31) is not affected. This results in a joint increase in both ι and μ. A decrease in τ_S has the opposite effects: according to (G.4), the LHS of (G.1) increases, hence μ must decrease to restore Northern labor market equilibrium for any given ι, i.e. a reduction of the Northern import tariff shifts LABS(ι, μ) to the left, whereas LABN(ι, μ) is again not affected. This results in a joint decrease in both ι and μ, which completes the proof.

[1] Despite the fact that $K(.) > 1$ for $\tau_N > 0$, the sign of (G.3) follows unambiguously (irrespectively of the value for τ_S) from plugging in $K(.)$ and simplifying terms, and similarly for the sign of (G.4).

[2] However, for $\tau_N = 0$, $\partial K(.)/\partial \tau_S = 0$.

"APPENDIX H: MATHEMATICA PROGRAM
BILATERAL TRADE LIBERALIZATION WITH TRADITIONAL SECTOR IN THE SOUTH ";

"- Objective: To understand the impact of bilateral trade liberalization
- Notes: In this program, for convenience we enter the subscripts and superscripts of the main model in regular format. Define dr = ρ-n. The elimination of minus terms help Mathematica to obtain more tidy expressions.";

"To capture bilateral trade liberalization, we consider a simultaneous decline in both τN and τS in the same amount: dτN= dτS. We allow for differences in the levels of tariffs though";

```
Clear[i, μ, dr, ηS, λ, Σi, Σμ, Ai, Aμ, sN, τN, τS]
```

"Recall that only the FLABS expression has tariffs in it";

$$\text{FLABS} = \frac{1}{\eta S}\left(sN\left(\frac{A\mu\, i\, \mu}{i+\mu} + \frac{\mu\,(A\mu\,(dr+i) + Ai\,\lambda\,(dr+2\,(i+\mu)))}{(-1+\lambda)\,(i+\mu)} + (\beta\,\lambda\,(A\mu\,(dr+i) + Ai\,(dr+2\,(i+\mu)))\,(\mu\,(1+\beta+\beta\,\tau N)\,(1+\tau S) + i\,(1+\tau N)\,(1+\beta+\beta\,\tau S)))\,/\,((-1+\lambda)\,((i+\mu)\,(1+\beta+\beta\,\tau N) + (\mu+\beta\,(i+\mu)\,(1+\tau N))\,\tau S))\right)\right) - 1;$$

"We totally differentiate FLABS with respect to τN and τS and impose dτN=dτS=dτ ";

```
dFLABS = (D[FLABS, τN] + D[FLABS, τS]) dτ // FullSimplify
```

$$-(d\tau\, i\, sN\,\beta\,\lambda\,(A\mu\,(dr+i) + Ai\,(dr+2\,(i+\mu)))\,(i\,(-1+\beta\,(-1+\tau N+\tau N^2-\tau S)) + \mu\,(-1+\tau N+\beta\,(-1+\tau N+\tau N^2-\tau S)-\tau S)))\,/\,(\eta S\,(-1+\lambda)\,((i+\mu)\,(1+\beta+\beta\,\tau N) + (\mu+\beta\,(i+\mu)\,(1+\tau N))\,\tau S)^2)$$

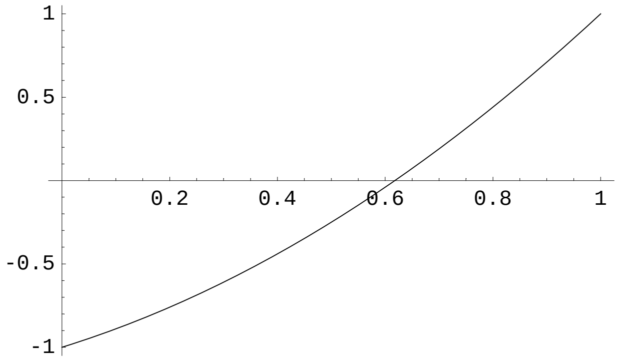
"For dFLABS>0, we need $-1+\beta\,(-1+\tau N+\tau N^2-\tau S)<0$ as a sufficient condition. This then requires $\tau N(1+\tau N)<(1+\tau S)$. A sufficent condition for this is that $\tau N(1+\tau N)<1$. To see the range for which this condition holds, we solve the quadratic equation below and plot it on a graph";

```
y = τN^2 + τN - 1;
```

```
Solve[y == 0, τN]
```

$$\left\{\left\{\tau N \to \frac{1}{2}\left(-1-\sqrt{5}\right)\right\}, \left\{\tau N \to \frac{1}{2}\left(-1+\sqrt{5}\right)\right\}\right\}$$

Plot[**y**, {τ**N**, **0**, **1**}]



- Graphics -

N$\left[\frac{1}{2}\left(-1+\sqrt{5}\right)\right]$

0.618034

"Hence, we conclude that for τN ∈ (0, 0.618034), the expression $-1+\tau N+\tau N^2-\tau S$ is negative. Thus, in this range, which is pretty reasonable, a fall in τN leads to a fall in FLABS. To restore equilibrium, there must be an increase in μ and thus a rightward shift of the LABS curve. Consequently, the levels of both μ and i increase.

The bottomline is that bilateral trade liberalization in the form of equal tariff reductions (dτS=dτN) is equivalent to unilateral Northern tariff reduction in terms of its qualitative effects.
However, quantitatively it is less effective than unilateral Northern tariff reduction since we know from Proposition 3 that Southern unilateral tariff reduction works to reduce both μ and i. ";

Additional References For The Appendices

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