GLOBALIZATION, LABOR MARKET RIGIDITIES AND MULTIPLE EQUILIBRIA

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Abstract. This paper analyses the effects of globalization, stricter intellectual property rights protection and different labor market policies in a dynamic North-South general equilibrium model with non-scale growth. To this aim, we generalize the Schumpeterian product-lifecycle model of Dinopoulos and Segerstrom (2003) by adding frictional unemployment and firing costs to their framework. We find that the effects on North-South wage inequality, employment and growth depend qualitatively on the level of Northern firing costs. Contrary to the special case of perfect labor market flexibility studied by Dinopoulos and Segerstrom, globalization may not benefit anymore both the South in terms of a relative-wage catch up and the North in terms of a temporary innovation and growth push.

JEL Codes: F12, F43, O33, O34, O41
Key words: Economic Growth, North-South Trade, Globalization, Frictional Unemployment, Firing Costs
1 Introduction

For many people in Northern developed countries, a major concern of the current wave of “globalization” is the rising competition from low-wage Southern developing countries. In particular, the adoption of more liberal international trade laws by large countries like China and India seems to threaten Northern employment in import-competing industries. In addition, rising imitation of innovative Northern products by Southern countries seems to threaten technical progress and growth in the North. Another major concern of globalization critics in the North is that Southern developing countries, while hoping to catch up in terms of growth and living standards through integration into world markets, will actually lose in terms of well-being of their workers (e.g., due to poor working conditions). Hence the worst-case scenario of globalization is that it leads, on the one hand, to rising unemployment and declining growth in the North and, on the other hand, to rising North-South income inequality (by declining Southern wages rather than rising Northern wages).1

Among economists, the majority view is that globalization will almost surely help the South to raise their living standards, even relative to the North, and that Northern countries with more flexible labor markets will be better prepared to adjust to rising competition from the South. In particular, the view is that in Northern countries with severe labor market rigidities, globalization forces will ultimately result in an innovation and growth problem in addition to rising unemployment.2 To our best knowledge, a question rarely (if ever before) asked in a formal model is whether the degree of Northern labor market rigidities somehow drives the nature of the effects of globalization not only on Northern employment and growth, but also on the wage rate of Southern relative to Northern workers. The idea of this paper is therefore to analyze the interaction of globalization pressure coming from the South and several labor market rigidities in the North.

Our basic framework is taken from Dinopoulos and Segerstrom (2003), henceforth referred to as DS. They develop a North-South neo-Schumpeterian product-lifecycle model with non-scale endogenous growth. Globalization takes the form of the entry of a large Southern developing country (the “newly industrialized South”) into the world free-trade markets, where new Southern firms compete with the established Northern firms on the markets for qualitatively diversified consumer goods. The

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1 See Deardorff (2003) for an insightful discussion of the various charges against globalization by its critics and their supposed underlying views of the world. More specifically, Segerstrom (2003) debunks the flaws in the arguments of one of the leaders in the anti-globalization movement, Naomi Klein.

2 Arnold (2002a) analyses the effects of rising Southern imitation in a North-South product-cycle model on Northern growth and unemployment, and how these effects depend on the degree of Northern labor market flexibility. He finds that for a high (low) degree of labor market flexibility, rising Southern imitation stimulates (impedes) Northern growth, whereas for an intermediate degree of labor market flexibility, this relationship is hump-shaped. Furthermore, whenever rising Southern imitation reduces Northern growth, it also raises Northern unemployment. Arnold’s model differs from our setting in two important respects. First, we analyze a non-scale growth model, whereas his model belongs to the first generation of endogenous growth models and hence displays scale effects. Second, we fully model the consumption and production side of the Southern economy, and thereby we derive the Southern imitation rate endogenously.
entry of the South is formally modeled as a discontinuous rise in the Southern population size in this two-country general equilibrium framework. On the one hand, this form of globalization improves incentives for Northern quality follower firms to engage in R&D by raising the market size to which these firms (once becoming quality leaders) can sell their products. On the other hand, this form of globalization “steals the business” of established Northern quality leader firms whose products are driven from the world market since they are imitated at a lower wage cost by new Southern quality leaders. With intersectoral mobility of workers on perfectly flexible labor markets, the flow of production jobs from the North to the low-wage South implies that more Northern workers are available for doing R&D in quality follower firms, which results in a temporary rise in the Northern innovation and growth rate above its steady-state level. Since R&D difficulty rises with the innovation rate, this positive growth effect peters out in the long run, and the steady-state rates of innovation and growth are not affected. Finally, since globalization raises the reward for Southern imitation by more than the reward for Northern innovation, the relative Southern wage rate increases in the new North-South steady-state trade equilibrium. Therefore, DS (2003) depict a rather positive (best-case) scenario of globalization: it benefits both the North in terms of a temporary innovation and growth push and the South in terms of a rising wage rate (absolute and relative to the North), which decreases global income inequality. Thus, when viewed from the perspective of the model of DS (2003), both charges against globalization by its critics we referred to above seem to be unjustified.

The analysis in DS (2003) is very valuable for at least two reasons. First, this is among the first analytically tractable North-South non-scale growth models with endogenous Southern imitation that allows to analyze globalization effects in general equilibrium. Second, although necessarily highly stylized, it captures well the main economic forces currently at work, where newly industrialized countries enter the world markets for qualitatively diversified products. These economic forces tend to be overlooked by many globalization critics, and thus DS (2003) is a very useful template to start further robustness analysis.

However, the positive scenario of globalization in DS (2003) may hinge crucially on the assumption of a frictionless Northern labor market. This paper therefore asks whether their results change qualitatively for different degrees of Northern labor market rigidity. To this aim, we generalize their model by adding frictional unemployment of Northern workers as in Arnold (2002a) and firing costs for Northern firms as in Grieben (2004). We find three important things: first, the results of DS (2003) are not robust – in particular, they change qualitatively for relative large firing costs (in particular, relative to the wage component of total Northern R&D costs). Second, the degree of Northern labor market rigidities not only affects the propagation mechanism of a Southern globalization shock in the North, but it also affects the Southern imitation rate and the net effect on the Southern relative wage rate in general equilibrium. Third, instead of a unique steady-state equilibrium as in DS, our model has usually two steady-state equilibria, and qualitatively different policy conclusions follow for each of them.
More specifically, in our extended model we derive the main results of DS (2003) as a special case which applies for low enough firing costs and a sufficiently flexible Northern labor market. With firing costs exceeding a critical level, our model has usually two qualitatively different steady-state equilibria. The first is referred to as the “poor-South equilibrium”. This is characterized by a low level of Southern imitation and a low relative Southern wage rate, and it has the same policy implications as the unique steady-state equilibrium analyzed in DS (2003). In addition to the results of DS, globalization raises unambiguously Northern unemployment in this case, which somewhat qualifies the “best-case scenario”. The second steady-state equilibrium is referred to as the “rich-South equilibrium”. This is characterized by a high level of Southern imitation and a high relative Southern wage rate. There, some of the findings of DS are exactly reversed, and the effect on Northern unemployment is ambiguous. In particular, in the rich-South equilibrium, globalization never benefits both the South in terms of a relative-wage catch up and the North in terms of a temporary innovation and growth push. Moreover, as in DS, stricter intellectual property rights protection (IPRP) for Northern innovating firms tends to alleviate the effects of globalization – however, the effects are as case-sensitive as those of globalization. We also obtain the (at first sight) counterintuitive result that in the rich-South equilibrium, stricter IPRP even raises the Southern imitation rate (termed “IPRP paradox”).

Furthermore, we analyze the effects of a more flexible Northern labor market (more efficient matching between firms and unemployed workers), rising R&D subsidies in the North and declining firing costs. Starting from any level of firing costs, we find that in the poor-South equilibrium, all of these policies result in a temporary innovation and growth push in the North but declining Southern imitation and rising North-South wage inequality. In the rich-South equilibrium, these effects are exactly reversed.

With large developing countries like China and India about to enter the open world markets for qualitatively diversified products\(^3\), we are confident that our new results are highly relevant for discussing Northern and Southern gains and losses from globalization. In particular, it appears to be an empirical regularity that employment protection and openness are positively correlated. Using the job protection index of Blanchard and Wolfers (2000) and the measure of openness from Penn World Tables, Mark 5.6, Agell (2002) shows that within a sample of 20 OECD countries between the early 1960s and the late 1970s, “[...] job protection increased the most in those countries that got the most open” (ibid, p. 129).\(^4\) As argued in this paper, a high level of job protection (captured by firing costs)

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\(^3\) Wacziarg and Welch (2003) use an updated Sachs-Warner index to determine whether developing countries must be classified as “open” or “closed”, based on the well-known five Sachs-Warner criteria averaged over the 1990s. Based in this index, both China and India are still closed but approach progressively the threshold of becoming open. China “[r]emains closed based on the undivided power of the Communist Party and its black market exchange rate premium, which averaged 36% between 1990-1999” (ibid, p. 41). India “did not satisfy the tariff openness criteria until 1996 when its average tariff rate fell from 41.0% to 38.6%”, and “India’s nontariff barriers have been recently reduced below the 40% coverage rate, although these measures seem to have been replaced with a flurry of phytosanitary measures and antidumping duties” (ibid, p. 43).

\(^4\) A theoretical reasoning for why the voter's demand for employment protection rises with increasing openness
in open Northern economies is likely to be relevant for the effects of globalization shocks coming from the South.

The remainder of this paper is organized as follows: section 2 presents the building blocks of the model, which comprises household behavior, product markets, Northern innovation, Southern imitation, and labor market equilibrium conditions. Section 3 derives the multiple steady-state equilibria. We also derive the critical level of firing costs that determines the distinction between the special DS (2003)-case and the existence of multiple equilibria (with a poor-South and a rich-South equilibrium) in our generalization. In section 4 we derive our main results. We analyze the effects of globalization, stricter IPRP, and various labor market policies in the North on the Northern innovation rate, Northern unemployment, Southern imitation, and North-South wage inequality. Finally, section 5 offers some conclusions, whereas proofs and technical details are relegated to three appendices.

2 The Model

2.1 Household Behavior

The household side of our model combines the basic structure of DS (2003) with Arnold’s (2002b) extension of Segerstrom (1998). In both countries, there is a fixed number of households forming a dynastic family whose individual members have an infinite lifetime. Contrary to DS, the number of household members is fixed to \( L_N \) in the North and \( L_S \) in the South (there is no population growth).

Instead, following Arnold, each individual is endowed with \( h(t) \) units of human capital that can be used either for additional human capital accumulation in the sense of Lucas (1988), or for supplying labor (in goods production or in R&D, to be specified later). Initial levels of human capital at \( t = 0 \) (\( h_{N,0} \) in the North, \( h_{S,0} \) in the South) may differ, but for reasons to become clear later, we require equal rates of human capital accumulation in both countries (DS assume equal rates of population growth instead). The accumulation equation for human capital is

\[
\dot{h} = \eta_h \cdot h_v - \delta \cdot h , \tag{1}
\]

where \( \eta_h > 0 \) is an education productivity parameter, \( h_v < h \) is the fraction of human capital endowment that is used for further schooling, and \( \delta > 0 \) is the depreciation rate.\(^6\)

\(^5\) Subscripts "N" and "S" indicating Northern and Southern variables or constants will usually be avoided in equations that hold for both countries.

\(^6\) As discussed by Mauro and Carmeci (2003), this form of human capital accumulation neglects the learning-by-doing part (work experience), because human capital used for labor supply is negatively correlated with the production of new personalized knowledge. Accounting for the work-experience part would imply that unemployment reduces the rate of human capital accumulation.
Households in North and South have the same preferences and maximize discounted lifetime utility

$$Z = \int_{0}^{\infty} e^{-\rho t} \cdot \ln z_{i} dt$$

(2)

with constant time-preference rate $\rho > 0$ and individual instantaneous CES-utility function$^7$

$$z_{j} = \left\{ \int_{0}^{1} \left[ \sum_{j} \lambda^{j} \cdot d_{j}(j, \omega, t) \right]^{(\sigma-1)/\sigma} d\omega \right\}^{\sigma/(\sigma-1)} .$$

(3)

Equation (3) is a quality-augmented Dixit-Stiglitz consumption index, where $d(j, \omega, t)$ is the quantity of a vertically differentiated good with $j$ improvements of its quality in industry $\omega$ consumed at time $t$, $\lambda > 1$ is the size of each quality improvement in case of successful innovation, and $\sigma > 1$ is the constant elasticity of substitution between products across industries. As is a standard result in neo-Schumpeterian growth theory, within industries, consumers only consume products with the lowest quality-adjusted price, hence in (3), the sum over qualities $j$ vanishes. Across industries, consumers solve the static optimization problem

$$\max_{d(\omega)} \int_{0}^{1} \left[ \lambda^{j(\omega, t)} \cdot d(\omega, t) \right]^{(\sigma-1)/\sigma} d\omega \quad \text{subject to} \quad \int_{0}^{1} p(\omega, t) \cdot d(\omega, t) d\omega = c_{t} .$$

(4)

In (4), $t$ is fixed, $d(\omega, t)$ is the individual’s quantity demanded of the product with the lowest quality-adjusted price in industry $\omega$ at time $t$, $j(\omega, t)$ is the quality index (price) of this good, and $c_{t}$ is consumption expenditure at time $t$. The solution of (4) yields the individual’s consumption demand function$^8$

$$d(\omega, t) = \frac{q(\omega, t) \cdot p(\omega, t)^{-\sigma} \cdot c_{t}}{\int_{0}^{1} q(\omega, t) \cdot p(\omega, t)^{-\sigma} d\omega} ,$$

(5)

where $q(\omega, t) \equiv \lambda^{j(\omega, t)}$ measures product quality (of the good with the lowest quality-adjusted price) in industry $\omega$ at time $t$. The intertemporal budget constraint of a household is

$$\dot{a}_{t} = r_{t} \cdot a_{t} + w_{t} \cdot h_{y, t} + s_{c} \cdot w_{t} \cdot h_{r, t} - c_{t} ,$$

(6)

where $a$ is per-capita asset holdings, $r$ is the market interest rate, $w$ is the wage rate (which is the same for all production and R&D workers within a country due to the assumptions of perfect mobility across industries and between activities; however, due to the assumption of international labor immo-

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$^7$ Apart from DS (2003), the same type of preferences is assumed in e.g. Dinopoulos and Thompson (1998) and Li (2001, 2003).

$^8$ See Appendix A for a derivation.
bility, Northern and Southern wage rates usually differ), \( h_r < h \) is the fraction of human capital used for goods production, and \( s_c \geq 0 \) is the education subsidy paid by the government as a constant fraction of forgone wage income. Inserting (3) and (5) into (2) yields the household’s optimization problem can be written as

\[
\max_{\{c, a, h, \lambda\}} \int_0^\infty e^{-\rho t} \cdot \left\{ \ln c_t + \frac{\sigma}{\sigma - 1} \cdot \ln \left[ \int_0^\infty \frac{q(\omega, t) \cdot p(\omega, t)^{-\sigma}}{\int_0^\infty \frac{q(\omega, t) \cdot p(\omega, t)^{-\sigma}}{d\omega}} \right] \right\} \cdot d\omega \right] \cdot dt \tag{7}
\]

subject to (1), (6), and \( h = h_x + h_y \).

Note two things here: first, since the individual household takes prices and the evolution of product quality as given, the large second expression in curly brackets in (7) can be neglected for doing the optimization. Second, the individual human capital endowment constraint \( h = h_x + h_y \) has to be distinguished from the economywide constraint \( h = h_x + h_y + h_I \), where \( h_I \) is the amount of human capital supplied per R&D worker (the individual worker can only supply human-capital augmented labor to either production or R&D). The current-value Hamiltonian (with suppressed time-indices for simplicity) then looks like in Arnold (2002b):

\[
J(c, h_x, a, h, \mu_a, \mu_h, t) = \ln c + \mu_a \cdot \left\{ r \cdot a + w \left[ h - h_x \cdot (1 - s_c) \right] \right\} + \mu_h \cdot \left( \eta_h \cdot h_x - \delta \cdot h \right).
\]

The first-order conditions are:

\[
\frac{\partial J}{\partial c} = \frac{1}{c} - \mu_a = 0 \iff \frac{\dot{c}}{c} = -\frac{\mu_a}{\mu_a} \tag{8}
\]

\[
\frac{\partial J}{\partial h_x} = -\mu_a \cdot w \cdot (1 - s_c) + \mu_h \cdot \eta_h = 0 \iff \frac{\mu_a}{\mu_h} = \frac{\eta_h}{w \cdot (1 - s_c)} \tag{9}
\]

\[
\frac{\partial J}{\partial a} = \mu_a \cdot r = -\dot{\mu}_a + \rho \cdot \mu_a \iff -\frac{\dot{\mu}_a}{\mu_a} = r - \rho \tag{10}
\]

\[
\frac{\partial J}{\partial h} = \mu_a \cdot w - \mu_h \cdot \delta = -\dot{\mu}_h + \rho \cdot \mu_h \iff -\frac{\dot{\mu}_h}{\mu_h} = \frac{w \cdot \mu_a - \delta - \rho}{\mu_h} \tag{11}
\]

\[
\lim_{t \to \infty} \mu_a \cdot e^{-\rho t} \cdot a = 0, \quad \lim_{t \to \infty} \mu_h \cdot e^{-\rho t} \cdot h = 0 \tag{12}
\]

Conditions (8) and (10) together imply the usual intertemporal Euler equation

\[
\frac{\dot{c}}{c} = r - \rho, \tag{13}
\]

which hold for both Northern and Southern consumption expenditures per capita, \( c_N \) and \( c_S \). Conditions (9) and (11) together imply \(-\dot{\mu}_h/\mu_h = \eta_h/(1 - s_c) - \delta - \rho\), and using this, (10) and log-differentiating (9) yields the wage-growth rate.
\[
\frac{\dot{w}}{w} = r + \delta - \frac{\eta_h}{1 - s_e}. \tag{14}
\]

In order to solve for the household’s optimal choice of \( h_e \), we need a normalization \( w_N \cdot h_N \equiv k_N \) for the North, with \( k_N > 0 \) being a constant (given equal rates of human capital accumulation in both countries, for the South \( w_S \cdot h_S = \psi k_N \) with \( \psi > 0 \) will follow in equilibrium; thus, we will establish that the relative wage rate \( w_N/w_S \) is a constant). From (1) and \( \dot{w}/w = -\dot{h}/h \), we get \( h_e = \left[ \frac{\dot{h}/h + \delta}{\eta_h} \right] h/\eta_h \), and with (14)

\[
h_e = \left( \frac{1}{1 - s_e} - \frac{r}{\eta_h} \right) h \tag{15}
\]

holds. Hence, the fraction of human capital invested in further schooling rises with education subsidies \( s_e \) and schooling productivity \( \eta_h \), but declines with the interest rate because forgone wage income is more heavily discounted.

2.2 Product Markets, Innovation And Imitation

The industry side of our model is almost identical to DS (2003), hence our description will be as brief as possible. In any industry \( \omega \in [0,1] \), irrespective of the quality level of the corresponding goods, output equals human-capital augmented labor input: \( Y_N = L_N^Y \cdot h_N \) in the North and \( Y_S = L_S^Y \cdot h_S \) in the South (i.e., all production workers \( L^Y \) within a country have the same amount of human capital, respectively). We assume \( L_S = \bar{L}_S \) (there is full employment in the South) but \( L_N < \bar{L}_N \), hence there is unemployment in the North due to labor market rigidities as will be specified in section 2.3. The R&D process specified below results in a unique quality leader in each industry who is protected by an exclusive patent on his production technology, and who charges an unconstrained monopoly price derived below. This patent expires in case of two events: either another innovation (that is, an improvement of consumer good quality of size \( \lambda > 1 \) in terms of the utility function) occurs in the same industry by a Northern firm, or the leading technology is imitated by a Southern firm producing at lower marginal costs \( w_S < w_N \). In both cases, the previous incumbent immediately leaves the market and cannot credibly threaten to reenter (due to positive costs of reentering the market and zero profits in an equilibrium with Bertrand price competition). In the North, the current quality leader maximizes global monopoly profits \( \pi_N = (p_N - w_N)(d_N L_N + d_S \bar{L}_S) \) with respect to the price \( p_N \), where Northern and Southern demand functions are given by (5), respectively.\(^9\) It results the unconstrained monopoly price \( p_N = \left[ \sigma/(\sigma - 1) \right] w_N \) in each industry with a Northern quality leader. Similarly, the successful Southern imitating firm maximizes global monopoly profits \( \pi_S = (p_S - w_S)(d_N L_N + d_S \bar{L}_S) \) with respect to the price \( p_S \),

\(^9\) Note that Northern unemployed workers do not generate a positive demand since we abstract from unemployment benefits for simplicity.
which results in the monopoly price \( p_S = \frac{\sigma}{\sigma - 1} \cdot w_S \) in each industry with a Southern quality leader. We follow the notation in DS (2003) by denoting \( Q_t = \int_0^1 q(\omega,t) \, d\omega \) the average quality level across industries (some of which are producing in the North, some in the South) at time \( t \), \( E \equiv c_N L_N + c_S L_S \) the global consumption expenditure, and \( \bar{c} = E/(L_N + L_S) \) the global per-capita consumption expenditure. Then, from (5), the per-capita global demand for a Northern product with average quality level \( Q \) is

\[
\tilde{d}_{N,t} = \frac{Q_t \cdot p_{N,t}^{-\sigma} \cdot \bar{c}_t}{\int_0^1 q(\omega,t) \cdot p(\omega,t)^{-\sigma} \, d\omega ,}
\]

and the Southern equivalent \( \tilde{d}_S \) is found by simply replacing \( p_N \) by \( p_S \) in the nominator of (16). It follows that global monopoly profits of a Northern quality leader can be written as

\[
\pi_N(\omega) = \frac{w_N}{\sigma - 1} \cdot \tilde{d}_{N,t} \cdot (L_N + L_S) \cdot \frac{q(\omega)}{Q} ,
\]

which is the product of profit margin, total market size, and product quality relative to the average. The Southern equivalent \( \pi_S(\omega) \) is found by simply replacing \( w_N \) and \( \tilde{d}_{N,t} \) in (17) by \( w_S \) and \( \tilde{d}_S \).

Now we will consider Northern innovative and Southern imitative R&D activities. The R&D production function of a Northern innovating firm in industry \( \omega \) is

\[
I_i(\omega) = \eta_i \cdot L_{i,t} \cdot h_N \quad ,
\]

where \( I_i \) is a Poisson arrival rate, \( \eta_i > 0 \) is an R&D productivity parameter, and \( L_{i,t} \) is labor input of firm \( i \) (with each worker being endowed with the Northern human capital level \( h_N \)), with \( \sum_i L_{i,t} = L_N \) being the total number of Northern R&D workers. The quality level \( q(\omega,t) = \lambda^{(\omega,t)} \) in the denominator captures the idea that with rising product quality (thus with each innovation success), further improvement becomes increasingly difficult since products become more complex. Hence, an ever increasing amount of (in this case, human-capital augmented) R&D labor is needed to maintain a constant innovation rate \( I_i \). R&D returns are assumed to be independently distributed across firms, industries and over time, hence the industry-wide instantaneous probability of innovation is \( I(\omega) = \eta_i \cdot L_{i,t} \cdot h_N / q(\omega) \). Similarly, the Poisson arrival rate of Southern imitating firm \( j \) is defined as

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10 The principle underlying idea was first formalized in a neo-Schumpeterian growth model by Segerstrom (1998). The specification in (18) is a special case, also considered in DS (2003), of the more general formulation in Li (2003, p. 1010).
with R&D productivity parameter $\eta_C > 0$, and $\sum_j L_{S,j}^C = L_N^C$ being the total number of Southern R&D workers. Note that $1/\eta_C$ can also be viewed as a measure of the strictness of international property rights protection (IPRP for short). R&D difficulty of Southern copying is identical to Northern R&D difficulty because the technical knowledge for how to produce a particular quality of a given consumption good is the same.

Due to the assumption $w_N > w_S > w_N/\lambda^{(\sigma-1)}$, an imitation not only implies that the successful Southern firm replaces the previous Northern incumbent and serves the world market, but also that in case of a further innovation, the new Northern quality leader replaces the previous Southern monopolist in turn, which closes the Vernon-type product cycle. Denoting $m_N$ ($m_S$) the fraction of industries with a Northern (Southern) quality leader, in a steady state with constant $I$ and $C$, the flow of industries $\omega$ with a new Southern quality leader must equal the flow of industries with a new Northern quality leader, thus $m_N \cdot C = m_S \cdot I$ holds. With $m_N + m_S = 1$, it follows $m_N = I/(I + C)$ and $m_S = C/(I + C)$.

Northern firms optimally choose R&D intensity $I_i$ as to maximize expected benefits minus costs from engaging in R&D: $v_I(\omega) - (1-s_R)w_N \cdot I_N \cdot h_N$, where $v_I(\omega)$ is the reward for innovating (determined below), and $s_R \geq 0$ is an R&D subsidy. With free entry to R&D races, optimal R&D investment satisfies

$$ v_I(\omega) = \frac{(1-s_R) \cdot w_N \cdot q(\omega) / \eta_I}{\eta_I} . $$

Since product quality $q(\omega)$ stays constant during an R&D race, $v_I$ grows at the rate of $w_N$ given in (14).

The usual no-arbitrage condition on the world stock market equates the return from a completely diversified portfolio of the stocks of Northern R&D firms and the save interest rate for a riskless bond, both held for a time period $dt$:

$$ \frac{\pi_N(\omega,t)}{v_I(\omega,t)} \cdot dt + \frac{\dot{v}_I(\omega,t)}{v_I(\omega,t)} \cdot dt \cdot (1 - I \cdot dt - C \cdot dt) - \frac{v_I(\omega,t) + F(\omega,t)}{v_I(\omega,t)} \cdot (I + C) \cdot dt = r \cdot dt . $$

All terms are standard for neo-Schumpeterian growth models except for the third term on the LHS taken from Grieben (2004). We specify that in addition to suffering from full capital loss in case of either further Northern innovation or Southern imitation, the previous Northern incumbent firm has to pay firing costs, defined as $F = B \cdot w_N \cdot q(\omega)$ with $B > 0$ being a constant, each time it is replaced from the goods market and thus is forced to dismiss its workers. Firing costs are indexed to $w_N \cdot q(\omega)$ in order not to become negligible in the long run. Dividing (21) by $dt$, letting $dt \to 0$, using $\dot{v}_I / v_I = \dot{w}_N / w_N$ and (14) gives
We will later analyze how $B$ must be bounded from above to ensure the existence of an equilibrium. From (17), (20) and (22), we derive the following Northern “steady-state innovative R&D condition”

$$
\left( L_N + \bar{L}_S \right) \cdot \bar{d}_N = Q \cdot \left\{ \frac{1-s_R}{1-s_c} \cdot \left[ 1 - \frac{\delta - \eta_h/(1-s_c)}{I + C} \right] + B \right\}.
$$

(23)

The LHS is related to the expected discounted benefit from innovating, which rises with a larger market size and decreases with a higher elasticity of substitution between products (implying a lower markup price) as well as with a higher probability of being removed from the market via further innovation or imitation. The RHS is related to the expected discounted cost of innovating, which rises with higher average product quality (implying higher R&D difficulty), lower R&D subsidies or R&D productivity, a higher discounted wage growth rate\(^{11}\), and higher firing costs.

Similarly, Southern firms optimally choose R&D intensity $C_j$ as to maximize expected benefits minus costs from engaging in R&D: $v_C(\omega) \cdot C_j - w_S \cdot L_N^C \cdot h_S$, where $v_C(\omega)$ is the reward for imitating. With free entry to R&D races, optimal R&D investment satisfies

$$
v_C(\omega) = w_S \cdot q(\omega)/\pi_S ,
$$

(24)

with $v_C/\dot{v}_C = \dot{v}_S/w_S$ given in (14). The Southern no-arbitrage equation equivalent to (21) is\(^{12}\)

$$
\frac{\pi_S(\omega,t)}{v_C(\omega,t)} \cdot dt + \frac{\dot{v}_C(\omega,t)}{v_C(\omega,t)} \cdot dt \cdot (1-I \cdot dt)-I \cdot dt = r \cdot dt ,
$$

(25)

where global monopoly profits of a Southern quality leader are

$$
\pi_S(\omega) = \frac{w_S}{\sigma - 1} \cdot \bar{d}_S \cdot \left( L_N + \bar{L}_S \right) \cdot \frac{q(\omega)}{Q} ,
$$

(26)

similar to (17), with $\bar{d}_S = \bar{d}_N \cdot (p_N/p_S)$. From (25), the reward for Southern imitating is

$$
v_C = \frac{\pi_S}{[\eta_h/(1-s_c)] - \delta + I} .
$$

(27)

Then, from equations (24), (26) and (27) together we can determine the Southern “steady-state imita-

\(^{11}\) Note that due to our normalization $w_N h_N = k_N$, the wage growth rate in (14) is negative, hence $\delta \approx \eta_h/(1-s_c)$ in (23). This has to be discounted because after further innovation or imitation occurs, the firm shuts down and thus no wages have to be paid anymore.

\(^{12}\) Note that no Southern firm would engage in copying products with a Southern quality leader, because Bertrand price competition would result in zero profits.
tive R&D condition"\[28]\n
\[
\frac{\bar{d}_S \cdot (L_N + L_S)}{(\sigma - 1) \cdot \left( \eta_h / (1 - s) - \delta + I \right)} = \frac{Q}{\eta_c}.
\]

Similar to (23), the LHS (RHS) is related to the expected discounted benefit (cost) of imitating. The interpretation of terms is similar to before, with the wage growth rate now depreciating the benefit of imitation.

2.3 Quality Dynamics And Labor Markets

Before determining the labor market equilibrium for both countries, we need to derive (thereby reproducing results of DS, 2003) how product quality evolves in North and South, because this is closely related to the demand for production workers. From the definition \[29]\n
\[
\int_0^1 \lambda^{(\omega)} d\omega = \int_0^1 \lambda^{(\omega)} d\omega = (\lambda - 1) \cdot I = (\lambda - 1) \cdot Q
\]

since product quality jumps up from \(\lambda^j\) to \(\lambda^{j+1}\) with each innovation that occurs with constant instantaneous probability \(I\). As derived in DS (2003), in a steady state, a constant growth rate of Northern (Southern) average product quality \[30]\n
\[
\frac{Q_N}{m_N} = \frac{Q_S}{m_S}
\]

requires equal growth rates \(\dot{Q}_N = \dot{Q}_S\). Moreover, it holds

\[
Q_N = \frac{\lambda \cdot I}{\lambda \cdot I + C} \cdot Q \quad \text{and} \quad Q_S = \frac{C}{\lambda \cdot I + C} \cdot Q.
\]

From this and the industry fractions \(m_N\) and \(m_S\) derived before, it follows \(Q_N/m_N = (Q_S/m_S) \cdot \lambda\), i.e. average Northern product quality exceeds average Southern product quality by exactly one quality jump of size \(\lambda\).\[13\]

Now, we introduce frictional unemployment into the model of DS (2003). This is done similar to Arnold (2002a; see his motivation on pp. 455-56) by assuming that Northern production workers not only lose their jobs because of Southern imitation (which forces the previous Northern incumbent to shut down), but it also takes time to reenter the labor market. More precisely, the unemployed production worker’s instantaneous probability of re-entering the Northern labor market equals an exogenously fixed constant \(\beta > 0\), which implies an expected duration \(1/\beta\) of unemployment.\[14\] This means

\[13\] This latter result makes clear that the South in our model should not be thought of as an economically backward low-developed country, but rather as a newly industrializing country that closely follows the Northern (quality-)growth path.

\[14\] A microeconomically founded version of frictional unemployment within a neo-Schumpeterian growth model is developed by Şener (2001) and used in Grieben (2004). The simpler version used here is more tractable.
that Northern employment \( L_N < \bar{L}_N \) follows

\[
\dot{L}_N = \beta \cdot (\bar{L}_N - L_N) - C \cdot L_N^\alpha . \tag{31}
\]

The only difference to Arnold (2002a) with respect to (31) is that the imitation rate is endogenous here. Note in particular that in case of Northern innovation, production workers of the previous incumbent firm are also laid off. However, this does not cause additional frictional unemployment since we assume that the new incumbent firm instantaneously offers an equal amount of \( L_N^\alpha \)-type jobs.\(^{15}\)

Goods market clearing implies that global per-capita demand for a Northern product with average Northern quality must equal Northern supply of goods, hence

\[
\bar{d}_N \cdot \frac{Q_N}{Q} \cdot (L_N + \bar{L}_S) = \bar{d}_N \cdot \frac{\lambda \cdot I}{\lambda \cdot I + C} \cdot (L_N + \bar{L}_S) = Y_N = L_N^r \cdot h_N , \quad \tag{32}
\]

with \( \bar{d}_N \) given in (16). Equilibrium in the Northern market for human capital implies \( L_N^r(h_N - h_{N,c})/h_N = L_N^\alpha + L_N^r \): employed Northern labor times the fraction of Northern human capital per capita used for labor supply must be equal to effective Northern labor demand in production and R&D. Using \( L_N^r \cdot h_N = I \cdot Q/\eta_I \) from aggregating (18) over all industries \( \omega \) (since innovative R&D takes place in both industries with a Northern and a Southern quality leader), (15) and (32) gives

\[
\frac{h_N - h_{N,c}}{h_N} = \frac{\rho}{\eta_h} \cdot \frac{1}{1-s_e} = \bar{d}_N \cdot \frac{\lambda \cdot I}{\lambda \cdot I + C} \cdot \frac{I}{\eta_I} \cdot \frac{x_N}{L_N} \tag{33}
\]

as the steady-state equilibrium condition for Northern human capital, where we already used the steady-state result \( r = \rho \) which holds due to \( \acute{c}/c = 0 \) in (13).\(^{16}\) In (33), \( x_N \equiv Q/h_N \) is defined as the Northern relative R&D difficulty. Since both the LHS and the first term on the RHS of (33) are constant in steady state, \( x_N \) must also be a constant. This in turn requires \( \dot{Q}/Q = \dot{h}_N/h_N \), which by use of (29), (14), \( r = \rho \) and \( \dot{w}/w = -\dot{h}/h \) pins down the steady-state innovation rate:

\[
I = \left[ \frac{\eta_h/(1-s_e)}{\lambda} \right] - \rho - \delta \tag{34} .
\]

Similar to (32), Southern goods market clearing requires

\[
\bar{d}_S \cdot \frac{Q_S}{Q} \cdot (L_S + \bar{L}_S) = \bar{d}_S \cdot \frac{C}{\lambda \cdot I + C} \cdot (L_N + \bar{L}_S) = Y_S = L_S^{r'} \cdot h_S . \tag{35}
\]

\(^{15}\) By contrast, the case of non-instantaneous matching between new quality leaders and unemployed workers is covered by Şener (2001) and Grieben (2004).

\(^{16}\) We must have \( \acute{c}/c = 0 \) in steady state since we have normalized the wage income of Northern workers to a constant \( w_N h_N \equiv k_N \). Since (1) applies to both countries, and since we will later show that the relative wage rate \( w_N/w_S \) is a constant in steady state, it also holds \( \acute{c}/c_N = \acute{c}/c_S = 0 \) in steady state.
Equilibrium in the Southern market for human capital implies $L_s(h_s - h_{s,e})/h_s = L_s^C + L_s^C$, where the interpretation is the same as given for the North above. Using $L_s^C h_s = C Q_n/\eta C$ from aggregating (18) over the measure $m_n$ of all industries with a Northern quality leader (because copying takes place only there), (30), (15), $r = \rho$, (35) and the definition $x_n = Q/h_n$ gives

$$\frac{h_s - h_{s,e}}{h_s} = \frac{\rho}{\eta h} - \frac{s_e}{1 - s_e} = \frac{C}{\lambda - \Gamma + C} \left( \frac{d_s \cdot L_N + L_s}{h_s} + \frac{\lambda \cdot I \cdot x_n}{h_{s,0}} \right)$$

(36)
as the steady-state equilibrium condition for Southern human capital.

### 3 Multiple Steady-State Equilibria

In this section, we want to solve for a steady-state equilibrium with constant variables $L_N, I, C, x_N, c_N, c_S, E, \bar{c}, r = \rho$, and with growing variables $w_N, w_S$ (with constant relative wage $w_N/w_S$), $h_N, h_S$ (with $h_N / h_S = \tilde{h}_S / h_S = \tilde{w}/w$), $d_N, d_s$, and $Q$ (all three growing at the rate $\dot{h}/h$). In particular we will show that, for large enough firing costs, the steady-state equilibrium will usually not be unique. Instead, there are two distinct steady-state equilibria with qualitatively different policy implications, associated with two levels of Southern development. The unique equilibrium of DS (2003) is derived as a special case with a perfectly flexible labor market ($\beta \to \infty$) and no firing costs ($B = 0$).

Equation (31) can be rewritten by solving (32) for $L_N^1$, inserting (23) for $\bar{d}_N^1/h_N$ and using $x_n = Q/h_n$:

$$\dot{L}_N = \beta \cdot (L_N - L_N^1) - C \cdot \frac{(\sigma - 1) \cdot \lambda \cdot I \cdot x_n}{\lambda - \Gamma + C} \left[ \frac{1 - s_R}{\eta_l} \left( I + C - \delta + \frac{\eta h}{1 - s_e} \right) + (I + C) B \right],$$

(37)

which we denote the “Northern unemployment condition”. In steady state, $\dot{L}_N = 0$, and Northern steady-state employment $\bar{L}_N$ is given by

$$\bar{L}_N = \frac{C}{\beta} \left( \frac{(\sigma - 1) \cdot \lambda \cdot I \cdot x_n}{\lambda - \Gamma + C} \left[ \frac{1 - s_R}{\eta_l} \left( I + C - \delta + \frac{\eta h}{1 - s_e} \right) + (I + C) B \right] \right).$$

(38)

Given $I$ from (34) and $\bar{L}_N$ from (38), the equilibrium conditions (23), (28), (33) and (36) can be reduced to a set of two equations in two unknown variables $x_N$ and $C$. To this aim, we divide (23) by $h_N$, use the definition $x_n = Q/h_n$, solve the equation for $\bar{d}_N^1/h_N$ and plug this together with (38) for $L_N$ into (33). This gives the “Northern steady-state condition”

$$\frac{\rho}{\eta h} - \frac{s_e}{1 - s_e} = \frac{x_N}{\bar{L}_N - \frac{C}{\beta} \bar{L}_N} \cdot \frac{(\sigma - 1) \cdot \lambda \cdot I}{\lambda - \Gamma + C} \left[ \frac{1 - s_R}{\eta_l} \left( I + C - \delta + \frac{\eta h}{1 - s_e} \right) + (I + C) B \right] \frac{1}{\eta_l},$$

(39)
which can be more compactly written as

\[
\frac{\rho}{\eta_b} \frac{s_e}{1-s_e} = \frac{\bar{L}_N}{L_N} + \frac{x_N \cdot I / \eta_h}{(C \cdot \bar{L}_N / \beta)}.
\]

Note that not only \(L_N\) but also \(\bar{L}_N\) is increasing in \(x_N\) because consumer demand is rising with product quality. Similarly, solving (28) for \(d_S / h_S\), using \(Q / h_S = x_N \cdot h_{S,0} / h_{S,0}\), and inserting this into (36) gives the “Southern steady-state condition”

\[
\frac{\rho}{\eta_b} \frac{s_e}{1-s_e} = \frac{C \cdot x_N}{(\lambda \cdot I + C) \cdot \eta_C} \left\{ \left( \sigma - 1 \right) \frac{\eta_h / (1-s_e) - \delta + I}{L_S} + \frac{\lambda \cdot I}{h_{S,0}} \right\} \cdot \frac{h_{S,0}}{h_{S,0}}.
\]

Note that the Northern and Southern steady-state conditions in DS (2003) corresponding to (39) and (40) are obtained for the special case \(B = 0, \beta \to \infty, s_R = s_e = 0, \bar{h} / h = 0 \Leftrightarrow \eta_b = \rho + \delta, \delta = 0, h_t = 1 \forall t,\) with \(\dot{L}_N / L_N = \dot{L}_S / L_S = n > 0\). 17

Equations (39) and (40), together with (34) and (38), determine the steady state of our economy. However, since \(I\) in (34) is defined solely by exogenous parameters, and \(\bar{L}_N\) in (38) is fully determined by \(I, x_N\) and \(C\), it suffices to solve (39) and (40) jointly for \(x_N\) and \(C\). We begin by discussing (40). This represents a convex, downward-sloping curve in \((x_N, C)\)-space that is well-defined for \(x_N\) above some critical level \(K_1\) as illustrated in Figure 1 below. 18 The interpretation of the negative slope (restricting attention to the positive quadrant) is the same as in DS (2003). An increase in the Southern imitation rate \(C\) raises both the number of industries \(m_S\) with a Southern quality leader serving the world market (which requires an increase in production employment \(L_S^C\)) and the number of Southern R&D workers required. For given human-capital augmented labor supply, this requires \(x_N\) to decrease to ensure equilibrium on the market for Southern human capital. The decrease in \(x_N\) not only reduces R&D labor needed to maintain a given imitation rate \(C\), but it also reduces \(d_S\) (and thus \(L_S^C\)) needed for Southern monopolists to break even, which can be seen from (28) with both sides divided by \(h_N\).

The crucial difference to DS (2003) arises because contrary to their special case considered, the slope of the Northern steady-state condition (39) is no longer unambiguously positive. To see this, observe first that the RHS of (39) is increasing in \(x_N\). Then, we differentiate the RHS of (39) with respect to \(C\) and get

---

17 Note that we replaced population growth by human capital accumulation with a constant population size. In a strict sense, our model therefore is not a complete generalization of DS (2003). However, this deviation does not impact upon any of the following results, in particular, it does not affect our qualitatively different equilibrium properties. It only results in a steady-state innovation rate in (34) that can be affected by public policy (namely, by subsidizing education, as in Arnold, 2002b), whereas DS (2003) belongs to the class of “semi-endogenous” growth models with exogenously fixed \(I = n / (\lambda - 1)\).

18 A similar critical value \(K_1\) exists for the Southern steady-state curve in DS(2003), although this is not shown in their graph.
\[
\frac{\partial [RHS \ (39)]}{\partial C} = \frac{\partial \bar{E}_N}{\partial C} \left( \frac{\bar{E}_N + x_N \cdot I \cdot C}{\eta \cdot \beta} \right) + \frac{\partial \bar{E}_N}{\partial \bar{E}_N} \left( \frac{\bar{E}_N + x_N \cdot I}{\eta \cdot \beta} \right) \left[ \bar{E}_N - \left( C \cdot \frac{\bar{E}_N}{\beta} \right) \right]^2
\]

(41)

with

\[
\frac{\partial \bar{E}_N}{\partial C} = \frac{\sigma - 1 \cdot \lambda \cdot I \cdot x_N}{(\lambda \cdot I + C)^2} \left[ B \cdot I \cdot (\lambda - 1) - \frac{1 - s_R}{\eta} \cdot \rho \right] .
\]

(42)

In the model of DS (2003), with \( B = 0, \beta \to \infty \) and \( s_R = 0 \), there are two steady-state effects of an increase in \( C \) in the North, which are also present in our extension. First, with more Southern copying, the fraction \( m_N \) of industries with a Northern quality leader declines, which means that less production workers \( L_N^I \) are needed. For a given supply of workers, these formerly production workers must be absorbed as R&D workers, and rising R&D employment implies a temporary increase in the innovation rate, which results in a permanently higher level of relative R&D difficulty \( x_N \) (see footnote 22 below for how the size of this effect depends on \( s_R \)). Thus, the first effect contributes to a positive slope of the curve for (39). It is reflected in the term \((\partial E_N / \partial C) \left[ \bar{E}_N + (C \cdot I \cdot C) / (\eta \cdot \beta) \right] \) in (41) with only the negative part of \( \partial E_N / \partial C \) in (42) (second term in square brackets).\(^\text{19}\) Second, more Southern copying means a higher effective discount rate on benefits from innovating in (23), which requires a larger market size for given \( x_N \) such that the innovating firms break even. Given the total number of consumers \( \bar{L}_N + \bar{L}_S \), this requires an increase in global demand for Northern products with average quality \( \bar{d}_N \). Hence, output and demand for production workers \( L_N^I \) must increase, which works in the opposite direction (towards a lower level of \( x_N \)) to the first effect. Thus, the second effect contributes to a negative slope of the curve for (39).\(^\text{20}\)

In our more general case, however, there are two additional steady-state effects of an increase in \( C \) in the North, both working towards a negatively sloped Northern steady-state condition and therefore reinforcing the second effect described above. The third effect comes from the fact that more Southern copying means more dismissals of production workers in the North, which implies higher expected firing cost payments \( F^C \). This raises the costs of innovating in (23). Given \( x_N \), this again requires an increase in \( \bar{d}_N \) so that the innovating firms break even, hence an increase in \( L_N^I \) is needed. Since for given \( \bar{L}_N \) this means a required decline in R&D employment \( L_N^I \), the third effect again works toward a decline in relative R&D difficulty \( x_N \) after a rise in Southern copying \( C \). The second

\(^{19}\) In the case of DS (2003), the size of this effect is

\([-\frac{(\sigma - 1) \cdot \lambda \cdot I \cdot x_N \cdot \rho}{(\lambda \cdot I + C)^2 \cdot \eta} \].

\(^{20}\) In DS (2003), the size of this effect is \( \frac{(\sigma - 1) \cdot \lambda \cdot I \cdot x_N \cdot \eta}{(\lambda \cdot I + C)^2 \cdot \eta} \). With \( \rho > n \), the first effect dominates in their case, which implies a positively sloped Northern steady-state condition.
and third effect are jointly reflected in the term \((\partial \bar{L}_N^Y / \partial C) \cdot [\bar{L}_N + (x_N \cdot I) / (\eta \cdot \beta)]\) in (41) with only the positive part of \(\partial \bar{L}_N^Y / \partial C\) in (42) (first term in square brackets). Note that the third effect is small for low Southern copying \(C\) and for small \(B\) but becomes more significant for high levels of \(C\) and \(B\) since this means large expected firing costs which enter the innovating firms’ R&D decisions. Finally, the fourth effect works via the Northern unemployment condition (37). An increase in Southern copying raises the labor market turnover in the North, which for given expected length of unemployment spells \(1/\beta\) means a decline in total Northern employment \(\bar{L}_N\). This reduces the market size for Northern monopolists and thus the expected benefits from innovating in (23). To break even, this must be compensated by a rise in \(\tilde{d}_N\), implying an increase in \(\bar{L}_N^Y\) and thus a particularly strong decrease in \(\bar{L}_N\) (since not only workers are reallocated from R&D to production, but the total employed workforce also shrinks) and \(x_N\). This effect is reflected in the term \((\bar{L}_N^Y / \beta) \cdot [\bar{L}_N^Y + (x_N \cdot I / \eta)]\) in (41). It can be shown that if and only if \(\partial \bar{L}_N^Y / \partial C > 0\) in (42), then this fourth effect is also the more significant the higher the level of Southern copying is.\(^{21}\)

As becomes obvious from looking at (41) and (42), for sufficiently large \(\beta\), there is a critical level of firing costs \(B^{crit}\) such that for all \(B > B^{crit}\) (\(B < B^{crit}\)), (41) takes a positive (negative) value (hence, the Northern steady-state condition is negatively (positively) sloped in \((x_N, C)\)-space), namely

\[
B^{crit} = \frac{1}{I \cdot (\lambda - 1)} \cdot \left[ \frac{(1-s_R) \cdot \rho}{\eta} \cdot \frac{\bar{L}_N \cdot \eta_i + x_N \cdot I}{(\beta \cdot \bar{L}_N \cdot \eta_i + x_N \cdot I \cdot C)} \cdot \frac{1}{(\sigma - 1) \cdot \lambda \cdot I \cdot x_N} \right].
\]

(43)

We see that for a flexible enough labor market (i.e., a high enough \(\beta\)), there surely exist a \(B^{crit} > 0\). In the case of a perfectly flexible Northern labor market (\(\beta \rightarrow \infty\)), \(B^{crit}\) takes the value that ensures \(\partial \bar{L}_N^Y / \partial C = 0\) in (42). \(\bar{L}_N^Y\) in (43) is itself an increasing function of \(B\), and we show in Appendix B that this equation can equivalently be rewritten as

\[
\frac{1-s_R}{\eta_i} \cdot \left\{ \rho \cdot \left[ \frac{\beta}{(\rho / \eta_h) - (s_c / 1 - s_c)} + C \right] - (\lambda \cdot I + C) \cdot \left[ I + C - \delta + \eta_h / (1-s_c) \right] \right\} = B^{crit} \cdot \left\{ (\lambda \cdot I + C) \cdot (I + C) + (\lambda - 1) \cdot I \cdot \left[ \frac{\beta}{(\rho / \eta_h) - (s_c / 1 - s_c)} + C \right] \right\}.
\]

(44)

\(^{21}\) The intuition for this finding is that if more Southern copying leads to more Northern production employment (and thus we have a high stock of production workers at high levels of \(C\)), an additional increase in \(C\) would imply a large amount of dismissals. Hence, the negative market size effect for Northern monopolists would be particularly large. Formally, the condition for this result is \(\partial^2 (C \cdot \bar{L}_N^Y / \beta) / \partial C^2 > 0\) in (38). Calculating this second derivative and applying (34) reveals that this is equivalent to the condition \(\partial \bar{L}_N^Y / \partial C > 0\) in (42), which in turn requires \(B \cdot I \cdot (I-1) > (1-s_R) \rho / \eta_h\), hence firing costs \(B\) must lie sufficiently above \(B^{crit}\) given in (43). With such high firing costs, dismissals are particularly costly for Northern monopolists, which is taken into account by innovating follower firms, implying low R&D investment and thus relatively more production workers.
Equation (44) defines for given policy parameters $s_R$ and $s_e$, and for given model parameters $\eta_i$, $\eta_h$, $\rho$, $\delta$, $\lambda$ and $\beta$, the levels of firing costs $B$ and Southern imitation $C$ at which the slope of the Northern steady-state condition (39) is infinite, i.e. a marginal change in $C$ does not affect $x_N$ at $B = B^{crit}$. This combination is unique: first, for given $C$, equation (44) defines $B = B^{crit}$ uniquely since the LHS of (44) is a positive constant (given a large enough $\beta$), whereas the RHS is strictly increasing in $B$. Second, we show in Appendix B that for given $B$, only one level of Southern copying $C$ is satisfying (44).

Taken together, our discussion of the Northern steady-state condition (39) reveals that for sufficiently large (small) firing costs $B \geq \bar{B} > B^{crit}$ ($B < B^{crit}$), this curve will be downward (upward) sloping in the entire positive $(x_N, C)$-quadrant, whereas for $B^{crit} < B < \bar{B}$, there will be two differently-sloped segments, with the turning point defined by (44). As illustrated in panel B of Figure 1 below (drawn for the interesting case $B > B^{crit}$), with rising $B$, the curve for the Northern steady-state condition (39) shifts inward, and the turning point is reached for lower $C$. $\bar{B}$ is defined as that level of firing costs at which the turning point of (39) is reached for $C = 0$, given all other parameters.

\[ x_N = C \cdot (1 - \eta_s) \cdot \theta + \eta_s \cdot \eta_h \cdot \lambda - \rho \cdot B \]

\[ B = B^{crit} \]

\[ C = C^{crit} \]

\[ x_N = x_N^{crit} \]

$\bar{B}$ is defined as that level of firing costs at which the turning point of (39) is reached for $C = 0$, given all other parameters.

\[ x_N^{crit} = \frac{C^{crit} \cdot (1 - \eta_s) \cdot \theta + \eta_s \cdot \eta_h \cdot \lambda - \rho \cdot \bar{B}}{x_N^{crit}^{crit}} \]

Figure 1: Two Steady-State Equilibria for $B^{crit} < B < \bar{B}$

22 Taking $s_e$ as given, and $s_R$ and $B$ as policy parameters, we see that for given $C$, a continuum of $(s_R, B)$-combinations satisfies (44). Note also that for R&D subsidies $s_R$ close to one, $B = B^{crit}$ is close to zero. In equations (41) and (42), this means that the first effect described above of an increase in Southern imitation on the Northern steady-state condition (39) becomes very small – employment changes in the Northern R&D sector induced by rising Southern imitation have only a marginal effect on R&D costs. This can be seen from the RHS of the steady-state innovative R&D condition (23): for high $s_R$, the decline in R&D costs induced by an increase in $C$ [remember that $\delta < \eta_s/(1-\eta_s)$] is relative small. Therefore, innovation incentives improve only marginally, the increase in skilled labor demand for R&D is small, hence the induced rise in $x_N$ is small.
In panel A of Figure 1, we show the case of two steady-state equilibria E₀ and E₁ in the positive \((x_N, C)\)-quadrant\(^{23}\): at these two points, both the Northern and the Southern steady-state conditions are fulfilled. However, we may also have one equilibrium (tangent point of both steady-state conditions) or none at all. For obvious reasons, we will restrict attention to the case of two equilibria from now. In panel B of Figure 1, we show how the curve for the Northern steady-state condition (39) shifts if firing costs \(B\) increase successively, with the turning points 1, 2, 3 shifting downwards (at point 3, \(B = B\)).

Panel A of Figure 1 also illustrates the dynamics of the adjustment process toward both steady-state equilibria that results from the assumption of the following dynamical system:\(^{24}\)

\[
\begin{align*}
\dot{x}_{N,t} &= \phi_1 \left[ \bar{x}_N (C_t) - x_{N,t} \right] \\
\dot{C}_t &= \phi_2 \left[ \bar{C} (x_{N,t}) - C_t \right],
\end{align*}
\]

where \(\phi_1 > 0\) and \(\phi_2 > 0\) are standard velocity of convergence parameters. E.g., we assume that when the relative R&D difficulty \(x_N\) is below its steady-state level \(\bar{x}_N\) for a given level \(C\) of Southern copying at any point in time \(t\), then \(x_N\) increases (thus, incentives for innovating improve) until \(x_N = \bar{x}_N\) holds again. Similarly, the rate of Southern copying is assumed to converge toward its steady-state value \(\bar{C}\) for any given level of relative R&D difficulty \(x_N\) at any point in time \(t\). We see from the left panel of Figure 1 that equilibrium E₁ is stable only along a saddle path, whereas the equilibrium at E₀ is globally stable for all starting values below this saddle path.

Given the steady-state solution \((x_N, C)\) in either E₀ or E₁, all other variables are also determined. \(I\) is determined by exogenous parameters in (34), \(\bar{L}_N\) is determined by \(x_N\) and \(C\) in (38). Given \(h_{N,0}\) (\(h_{S,0}\)), the entire growth path of \(h_N\) (\(h_S\)) is defined by (1) together with (15) and \(r = \rho\). With our definition \(x_N = Q/h_N\), the equilibrium path for \(Q\) is determined by \(x_N\) and \(h_N\). Given \(\bar{L}_N\), \(Q\) and \(C\), \(\bar{d}_N\) is defined by (23) and \(\bar{d}_S\) by (28). As shown by DS (2003), global per-capita consumption expenditure \(\bar{\sigma}\) is found by noting first that it holds

\[
\int_0^1 q(\omega, t) \cdot p(\omega, t)^{-\sigma} \, d\omega = p_N^{-\sigma} \cdot Q_N(t) + p_S^{-\sigma} \cdot Q_S(t),
\]

which can be used together with (30) in (16) to derive

\[
\bar{d}_N = \frac{p_N^{-\sigma} \cdot \bar{C}}{p_N^{-\sigma} \cdot \frac{\lambda \cdot I}{\lambda \cdot I + C} + p_S^{-\sigma} \cdot \frac{C}{\lambda \cdot I + C}} , \quad \bar{d}_S = \frac{p_S^{-\sigma} \cdot \bar{C}}{p_S^{-\sigma} \cdot \frac{\lambda \cdot I}{\lambda \cdot I + C} + p_S^{-\sigma} \cdot \frac{C}{\lambda \cdot I + C}}.
\]

\(^{23}\) Inserting (40) into (39) gives a cubic equation which has three roots. The third root (not shown in Figure 1) implies \(0 < x_N < K_1\) and \(C < 0\), which is not economically meaningful.

\(^{24}\) Obviously, this assumes stability rather than proves it. However, our model is far too complex to allow a formal proof of stability, and the assumptions in (45) seem to be rather natural. The same method to analyze stability can be found in e.g. Etro (2003).
With \( p_N = [\sigma/(\sigma - 1)]w_N \) and \( p_S = [\sigma/(\sigma - 1)]w_S \), \( \tilde{d}_N \) and the wage rates determine \( \bar{c} \), which then determines global consumption expenditure \( E = \bar{c} \cdot (L_N + L_S) \). The paths for the wage rates are given by the paths for human capital together with our normalization \( w_N \cdot h_N \equiv k_N \). It remains to be shown that the relative wage rate \( w_N/w_S \) is constant in equilibrium as claimed earlier, and for this we again follow DS (2003). Dividing the Northern steady-state innovative R&D condition (23) by the Southern steady-state imitative R&D condition (28) and solving for \( \tilde{d}_N/\tilde{d}_S \) gives the “mutual R&D condition”

\[
\frac{\tilde{d}_N}{\tilde{d}_S} = \frac{\eta_c}{\eta_h/(1-s_c)} - \delta + \left[ 1 - \frac{s_R}{\eta_I} \left( I + C - \delta + \frac{\eta_h}{1-s_c} \right) + (I + C) \cdot B \right] = \left( \frac{w_S}{w_N} \right)^\sigma. \tag{46}
\]

Here, the second equality follows because equation (16), its Southern equivalent and the monopolists’ markup pricing rule give \( \tilde{d}_N/\tilde{d}_S = (p_S/p_N)^\sigma = (w_S/w_N)^\sigma \). (46) defines the relative Southern wage rate as an increasing function of the imitation rate \( C \) and firing costs \( B \) (hence, it rises whenever the reward for Southern imitating rises relative to the reward for Northern innovating), thus it is constant in a steady-state equilibrium. Finally, our assumption \( w_N > w_S > w_N/\lambda^{(\sigma-1)} \) that is necessary for the postulated Vernon-type product cycle requires

\[
1 > \frac{w_S}{w_N} = \left[ \frac{\eta_c}{\eta_h/(1-s_c)} - \delta + \left[ 1 - \frac{s_R}{\eta_I} \left( I + C - \delta + \frac{\eta_h}{1-s_c} \right) + (I + C) \cdot B \right] \right] > \lambda^{\sigma-1} \tag{47}
\]

to be fulfilled. To complete our description of the steady-state equilibria, we derive the amount of effective production labor demand relative to effective R&D labor demand in the North as

\[
\frac{\tilde{p}_N}{\tilde{d}_N} = \frac{\tilde{p}_N}{I \cdot s_N/n} = \frac{(\sigma - 1) \cdot \lambda \cdot \eta_c}{\lambda \cdot I + C} \left[ 1 - \frac{s_R}{\eta_I} \left( I + C - \delta + \frac{\eta_h}{1-s_c} \right) + (I + C) \cdot B \right]. \tag{48}
\]

In Appendix C, we derive the following steady-state utility growth rate that holds for both countries:

\[
\frac{z}{\dot{z}} = \frac{\sigma}{\sigma - 1} \cdot (\lambda - 1) \cdot I = \frac{\sigma}{\sigma - 1} \left( \frac{\eta_h}{1-s_c} - \rho - \delta \right). \tag{49}
\]

Note four things here. First, as in Arnold (2002b), this growth rate can only be influenced by changing education subsidies \( s_c \). Second, growth is ultimately tied to human capital accumulation, because this determines the growth rate of the market size (i.e., of the purchasing power of all consumers) for any quality leader. In “pure” semi-endogenous growth models like Segerstrom (1998) or DS (2003) where the steady-state growth rate is fully insensitive to public policy changes, exogenous population growth instead of human capital growth takes this role. Third, \( z/\dot{z} \) is declining in \( \sigma \) (the elasticity of substitution between products across industries) because for higher \( \sigma \), markup prices of all quality leaders are lower, which reduces monopoly profits and therefore expected discounted benefits from innovation and imitation. With lower R&D intensities in both countries for any given growth rate of human capi-
and R&D difficulty, product quality growth is slower. Fourth, contrary to the first-generation endogenous growth model of Arnold (2002a) that still contains the scale-effect property, a rise in Southern imitation has no long-run growth effects in the North. This is because any change in R&D incentives (other than $\sigma$) is finally offset by a corresponding change in R&D difficulty in these non-scale growth models.

4 Policy Analysis

The two steady-state equilibria illustrated in Figure 1 (with $B^{crit} < B < \bar{B}$) differ qualitatively: the globally stable equilibrium $E_0$ is characterized by a relatively high R&D difficulty $x_N = Q/h_N$ (hence, productivity of Northern human capital in terms of average consumer goods quality is high) and a relatively low level of Southern copying (hence, average Southern product quality $Q_S$ is low, see (30), although Southern R&D employment may actually be high due to the high $x_N$, see (36)) and a low relative Southern wage rate (since $w_S/w_N$ and $C$ are positively correlated, see (47)). This equilibrium is termed the “poor-South equilibrium”. Conversely, the steady-state equilibrium $E_1$ that features saddlepath stability is characterized by low $x_N$, high $C$ and high $w_S/w_N$, and it is therefore termed the “rich-South equilibrium”.

However, a caveat is in order: Figure 1 does not show the transition from a poor-South to a rich-South equilibrium. Therefore, this kind of graph does not help to visualize how a developing country ‘climbs up’ in terms of growth and the relative wage rate $w_S/w_N$. Moreover, either a poor-South or a rich-South equilibrium can emerge in our model with one and the same Southern country entering the open world markets. However, Figure 1 illustrates that Northern and Southern parameters together determine the stage of Southern development as measured by the level of Southern imitation. Even for given parameters (with $B > B^{crit}$), the model features multiple equilibria associated with two levels of Southern development. Furthermore, Figure 1 allows us to do a steady-state policy analysis which will reveal qualitatively different conclusions in all three types of steady-state equilibria.

Globalization (a rise in $\bar{L}_S$) implies an outward shift of the curve for the Southern steady-state condition (40) as shown in Figure 2 below. Note that the same happens in case of an exogenous increase in Southern human capital (a rise in $h_{S,0}$ given the Northern start-off level $h_{N,0}$). We first look at panel A of Figure 2. Starting from $E_0$ ($E_1$), globalization in the poor-(rich-)South equilibrium leads to a

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25 As can be inferred from Figure 1, there is also the possibility of two steady-state equilibria that are both located on the negatively sloped branch of the Northern steady-state condition, see Figure 2 below. There, the same characterization with respect to $x_N$ and $C$ holds true, but as will be discussed later, policy conclusions with respect to equilibrium $E_0$ differ relative to the case considered here.

26 See Currie et al. (1999) and Arnold (2003) for endogenous growth models that focus on phases of Southern development (in particular, the switch from imitation to innovation).

27 The third type of steady-state equilibria refers to the situation where $E_0$ lies on the negatively sloped segment of (39).
move of the steady-state equilibrium to $E_0'$ ($E_1'$) and thus to a rise in the steady-state level of R&D difficulty $x_N$ and an increase (decrease) in the Southern imitation rate $C$. The rise in $x_N = \frac{Q}{h_N}$ means that in both cases, the growth rate of average product quality exceeds temporarily the long-run steady-state level given by (29) and (34) as $\dot{Q}/Q = \left[\eta_h/(1-s_e)\right] - \rho - \delta$. This in turn means that R&D employment must increase permanently. Starting at the poor-South equilibrium, these additional Northern R&D workers come from the production sector, because rising Southern imitation leads to a decrease in the fraction $m_N = I/(I+C)$ of industries with a Northern quality leader and thus to a decrease in Northern production employment (same effect as in DS, 2003). However, starting at the rich-South equilibrium, this channel does not work since the Southern imitation rate decreases. Here, the other three effects outlined above that work towards a negatively sloped curve of the Northern steady-state condition (39) drive the result. First, a lower Southern imitation rate means both a lower discount rate and lower expected costs $C \cdot B$ of dismissals for Northern R&D firms. This raises expected profits so that they need a smaller market size for given $x_N$ to break even, which in turn reduces Northern goods production and thus production employment. The workers not needed for goods production anymore are available for R&D which has become more profitable. Second, a lower Southern imitation rate implies lower frictional unemployment in the North, which raises total supply of workers $\tilde{L}_N$ available for both production and R&D.

It remains to explain why the Southern imitation rate declines with rising Southern labor supply in the rich-South equilibrium. On the one hand, a larger Southern population raises the market size for Southern quality leaders, thereby raising the expected benefits for imitation (LHS of (28)). On the other hand, average product quality (and thus R&D difficulty) rises permanently due to the rise in Northern R&D intensity, which raises the cost of imitation (RHS of (28)). These two effects are also present in DS (2003), and the net effect is still a rise in imitation incentives. In our more general case, however, there is a third effect that Southern R&D firms must consider: any increase in $C$ ceteris pari-
bus implies more Northern unemployment due to higher labor market turnover, given the expected duration of unemployment $1/\beta$. This reduces the Northern market size for Southern quality leaders (formally, $\partial \hat{L}_N / \partial C < 0$ in (38)) and thus weakens imitation incentives. All three effects are valid no matter from which steady-state equilibrium we start. However, the first effect is the smaller the higher $C$ is. This is because $\hat{L}_N$ is small for large $C$, hence the positive marginal effect of rising $\bar{L}_S$ on the expected discounted benefit of imitating (LHS of (28)) is small. Since $C$ is relatively large in a rich-South equilibrium, the net effect of globalization on $C$ is negative in this case.

Panel B of Figure 2 shows the possibility of a third type of steady-state equilibrium, with $E_0$ lying on the negatively sloped branch of the curve for (39). Starting there, globalization leads to an increase in Southern imitation. This is because there, the positive effect of an increase in $\bar{L}_S$ on Southern imitation incentives is reinforced by the decrease in $x_N$ (discussed below), and both effects together overcompensate for the negative imitation incentive that comes from the rise in Northern unemployment. Relative R&D difficulty $x_N$ decreases, which means a temporary decline in the quality-growth rate $\dot{Q}/Q$ below its steady-state level, and therefore Northern R&D employment declines permanently.

Hence, starting in this equilibrium, the rise in Northern unemployment (induced by the reduction in the fraction $m_N$ of industries with a Northern quality leader due to a higher $C$) is reflected by a decrease in both production and R&D employment. Innovation activity is discouraged because in this case, the negative effects of the rise in $C$ on Northern innovation incentives in (23) more than offsets the positive effect of the initial increase in $\bar{L}_S$.

Finally, to determine the effects of globalization on the Northern steady-state unemployment rate, we note that this is derived as

$$u = \frac{\bar{L}_N - \hat{L}_N}{\bar{L}_N} = \frac{C \cdot \bar{L}_N}{\beta \cdot \bar{L}_N} \left[ \frac{(\sigma - 1) \cdot \lambda \cdot I \cdot x_N}{\bar{L}_N \cdot ([\lambda \cdot I/C] + 1)} \left[ 1 - \frac{s_R}{\eta_I} \left( I + C - \delta + \eta_h \frac{1}{1 - s_c} \right) + (I + C) \cdot B \right] \right],$$

(50)

where (38) has been used. Hence, the Northern unemployment rate $u$ unambiguously rises (declines) whenever both Southern imitation $C$ and Northern R&D difficulty $x_N$ increase (decrease). Bearing in mind that the level of Southern imitation $C$ and the relative Southern wage rate $w_S/w_N$ are positively correlated according to (46), we can summarize our findings in

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28 The initial increase in $\bar{L}_S$ raises expected discounted profits from innovating on the LHS of (23). The induced rise in $C$ has one positive and two negative effects on innovation incentives. On the one hand, the discount factor for growing wage payments in the future increases [RHS of (23)], which tends to improve innovation incentives. This effect tends to be small for large $s_R$ (if firms have to pay only a small fraction of R&D labor costs, they do not care much about a smaller discount rate on future wage payments) and for large $B$ (since for large firing costs, the wage component of total R&D costs becomes relatively unimportant, too). Large values for $s_R$ and $B$ are exactly the ceteris-paribus conditions for the Northern steady-state condition (39) to have a negatively sloped segment, see our discussion of (43) and (44). On the other hand, an increase in $C$ reduces the expected discounted benefits from innovating [LHS of (23)], and it raises Northern unemployment due to higher labor market turnover, which reduces the Northern market size $\hat{L}_N$ for Northern quality leaders.
Proposition 1: (i) In the poor-South equilibrium, globalization ($\overline{L}_S \uparrow$) or a rise in the relative Southern human capital level ($h_{S0}/h_{N0}\uparrow$) leads to a permanent increase in the rate of Southern copying ($C \uparrow$), a permanent increase in relative R&D difficulty ($x_N \uparrow$), a short-run increase in the innovation and quality-growth rates ($I \uparrow$, $Q \uparrow$) above their steady-state levels, no change in the long-run innovation rate given in (43), a permanent decrease in North-South wage inequality ($w_N/w_S \downarrow$), and an increase in the Northern unemployment rate ($u \uparrow$).

(ii) In the rich-South equilibrium, globalization ($\overline{L}_S \uparrow$) or a rise in the relative Southern human capital level ($h_{S0}/h_{N0}\uparrow$) leads to a permanent decrease (increase) in $C$ and a permanent increase (decrease) in $w_N/w_S$ whenever $x_N$ increases (decreases). In both cases, the net effect on $u$ is ambiguous, and globalization never benefits both the South in terms of a relative-wage catch up and the North in terms of a temporary innovation and growth push.

Part (i) of Proposition 1 replicates the first main result of DS (2003). However, part (ii) of Proposition 1 establishes that this is not robust in our generalized setting: once one accounts for frictional unemployment and firing costs in the North, globalization still may but need not reduce North-South wage inequality. More specifically, in case of $B > B^{crit}$ and a relatively advanced Southern trading partner with a high imitation rate $C$ (and therefore a high relative wage $w_S/w_N$), the result of DS is reversed. Moreover, in case of a Southern trading partner at a medium stage of development (with a medium level of $C$, illustrated by the $E_0$-equilibrium in panel B of Figure 2), the North may not gain from globalization in terms of a temporary increase in innovation and growth, depending in particular on the level of firing costs relative to the other model parameters. Therefore, with $B > B^{crit}$, the ‘optimistic’ finding in DS (2003) that globalization benefits both the South (in terms of a catch up of the relative wage rate $w_S/w_N$) and the North (in terms of a temporary growth push that may last for a long time due to the low speed of convergence that is typically found in non-scale growth models) critically depends on the steady-state equilibrium from which we start.

Four other policy experiments are worth considering: $\eta_C \downarrow$ (stricter IPRP), $s_R \uparrow$ (rising R&D subsidies in the North), $B \downarrow$ (declining firing costs) and $\beta \uparrow$ (increasing flexibility of the Northern labor market). We consider first a decrease in $\eta_C$, i.e. stricter IPRP in favor of Northern quality leaders, implying a decrease in R&D productivity of Southern firms. By looking at (40) we see that a decrease in $\eta_C$ simply works opposite to globalization ($\overline{L}_S \uparrow$) or a rising relative Southern human capital level ($h_{S0}/h_{N0}\uparrow$), and therefore shifts the curve of (40) in opposite direction. Hence, as in DS (2003), stricter IPRP serves to moderate the effects of globalization. However, in our generalized setting, the effects are as case-sensitive as those in Proposition 1. It holds
Proposition 2: (i) In the poor-South equilibrium, stricter IPRP ($\eta_C \downarrow$) leads to a permanent decrease in the rate of Southern copying ($C \downarrow$), a permanent decrease in relative R&D difficulty ($x_N \downarrow$), a short-run decrease in the innovation and quality-growth rates ($I \downarrow, \dot{Q}/\dot{Q} \downarrow$) below their steady-state levels, no change in the long-run innovation rate given in (34), a permanent increase in North-South wage inequality ($w_N/w_S \uparrow$), and a decrease in the Northern unemployment rate ($u \downarrow$).

(ii) In the rich-South equilibrium, stricter IPRP leads to a permanent increase (decrease) in $C$ and a permanent decrease (increase) in $w_N/w_S$ whenever $x_N$ decreases (increases). In both cases, the net effect on $u$ is ambiguous, and stricter IPRP never benefits both the South in terms of a relative-wage catch up and the North in terms of a temporary innovation and growth push.

Note in particular two important findings. First, the surprising result of DS (2003) that Northern innovation and growth slows down temporarily with the introduction of stricter IPRP ceases to hold in case of a Southern trading partner at a medium stage of development on the downward-sloping segment of the Northern steady-state curve (shift from $E_0'$ to $E_0$ in panel B of Figure 2). There, the decline in Northern unemployment (due to lower labor market turnover) is reflected by an increase in both production and R&D employment. Innovation activity is encouraged because in this case, the positive effects of the decline in $C$ on Northern innovation incentives in (23) more than offsets its negative effects (see footnote 27 above for a discussion of incentive effects of a change of $C$).

Second, in the rich-South equilibrium, stricter IPRP even raises the Southern imitation rate (panel A or B of Figure 2, shift from $E_1'$ to $E_1$)! We refer to this as the “IPRP paradox”. The intuition for this (apparent) paradox is as follows. On the one hand, a decrease in $\eta_C$ of course raises the cost of imitating (RHS of (28)) and therefore tends to reduce $C$. On the other hand, two positive effects on $C$ arise. One is that average product quality (and thus R&D difficulty) declines permanently due to the decline in Northern R&D intensity $^{29}$, which reduces the cost of imitation again. The other is that the relative global demand for Southern goods $\tilde{d}_S/\tilde{d}_N$ rises with declining $\eta_C$ as can be seen from (46). This is because with lower R&D productivity of Southern workers, the relative wage rate $w_S/w_N$ declines, see again (46), which implies a lower relative price $p_S/p_N$ for Southern goods. The relative demand shift in

$^{29}$ The decline in $\bar{L}_N = l \cdot x_N/\eta_N$ is explained similar to the discussion of globalization effects in Figure 2 when starting from equilibrium $E_1$. An increase in $C$ means a higher discount rate and higher expected costs of dismissals for Northern R&D firms. This reduces expected profits such that a larger market size is needed for given $x_N$ to break even, which in turn requires an increase in Northern goods production and thus production employment. These additional workers must be subtracted from R&D, thus $x_N$ decreases. In addition, a higher $C$ implies higher frictional unemployment in the North, which reduces total labor supply $\bar{L}_N$ available for both production and R&D.
favor of Southern goods raises the expected discounted benefit from imitating (LHS of (28)). As can be seen from (46) or (47), ceteris paribus this second positive effect is larger the higher firing costs $B$ and Southern imitation rate $C$ are (formally, the relative wage response $\partial(w_S/w_N)/\partial \eta_C > 0$ is rising in $B$ and $C$). This is explained by noting that Northern steady-state employment $\tilde{L}_N$ given in (38) is declining in $B$ and $C$. Hence, the required increase in $\tilde{d}_S$ in (28) for a Southern quality leader to break even is larger. Finally note that $C$ is relatively high at $E_1'$ in Figure 2 ($B > B^{cr}$ is assumed throughout our analysis), thus it is there where stricter IPRP leads to an increase in the Southern imitation rate (whereas the opposite holds true for type-$E_0'$ equilibria).

We now consider the cases of rising R&D subsidies $s_R$, increasing labor market flexibility $\beta$ and declining firing costs $B$ (while still assuming $B^{cr} < B < \bar{B}$ to hold thereafter). Figure 3 below shows the case of rising $\beta$ which leads to an outward shift of the Northern steady-state curve (39) without affecting the Southern steady-state curve (40). It turns out that the only difference in case of rising $s_R$ is that the abscissa intercept $K_2$ also shifts to the right (in the same way as a decrease in firing costs $B$ would do in panel B of Figure 1), but this yields the same steady-state results. Also observe that contrary to the effects of globalization considered before, there is no qualitative difference between the cases of one or two equilibria on the negatively-sloped segment of the Northern steady-state condition. The results do not differ because the curve for the Southern steady-state condition (40) does not shift, and hence its position relative to curve for the Northern steady-state condition (39) does not matter (as long as there are two intersections which we keep on assuming).

As is obvious from (31), $\tilde{L}_N$ declines with rising $C$. $\tilde{L}_N$ declines with rising $B$ because a rise in $B$ shifts Northern workers from R&D to production, see (48), which makes more Northern workers vulnerable to Southern imitation.
Starting from the poor-South equilibrium $E_0$, an increase in Northern labor market flexibility leads to a move of the steady-state equilibrium to $E_0'$ and thus to a rise in the steady-state level of R&D difficulty $x_N$ and a decrease in the Southern imitation rate $C$. The rise in $x_N = \frac{Q}{h_N}$ means that the growth rate of average product quality exceeds temporarily the long-run steady-state level $\frac{\dot{Q}}{Q} = \left[\eta / (1 - x_s)\right] - \rho - \delta$. This in turn means that R&D employment must increase permanently. These additional Northern R&D workers do not come from the production sector, because decreasing Southern imitation leads to an increase in the fraction $m_N = I / (I + C)$ of industries with a Northern quality leader and thus to an increase in Northern production employment. However, both directly by a larger $\beta$ and indirectly by a lower $C$, total Northern steady-state employment $\tilde{L}_N$ given in (38) increases, and this is used both for additional production and R&D employment.

There are two effects on the Southern imitation rate. On the one hand, the increase in $\tilde{L}_N$ enlarges the Northern market size for Southern quality leaders, which raises expected benefits from imitating (LHS of (28)). The size of this effect critically depends on the level of total Northern employment $\tilde{L}_N$: the lower $\tilde{L}_N$, the larger is the marginal effect of an increase in $\beta$ on employment in (31). That is, at a high level of Northern unemployment, an increase in labor market flexibility is most effective for job creation. We see from (38) that $\tilde{L}_N$ is high (i.e., unemployment is low) for a low level of $C$ which we have in the poor-South equilibrium. On the other hand, the rise in relative R&D difficulty increases the cost of imitating (RHS of (28)). In the poor-South equilibrium, the positive effect on $C$ is relatively weak, hence the negative effect dominates and $C$ further declines. Note that in this case, the net effects on $x_N$ and $C$ (and therefore also the effects on $I$ and $w_N/w_S$) are qualitatively identical to those of either globalization in the rich-South equilibrium as illustrated in Figure 2, or stricter IPRP in case of a Southern trading partner at a medium stage of development (move from $E_0'$ to $E_0$ in panel B of Figure 2).

In the rich-South equilibrium, by contrast, starting at $E_1$ where $C$ is relatively high, the positive effect on $C$ is relatively strong (the marginal effect of reducing $\beta$ on $\tilde{L}_N$ is large) and dominates the negative one, thus Southern imitation incentives improve further. In this case, the rise in $C$ tends to offset the positive effect of the rise in $\beta$ on total Northern employment $\tilde{L}_N$. Although a large $C$ implies a high discount rate on future wage payments (RHS of (23)), this positive effect on Northern innovation incentives is more than outweighed by the negative effect on the expected benefits from innovating given on the LHS of (23) (large discount factor). Hence, innovation activity is discouraged, thus $x_N$ declines with a more flexible Northern labor market. Note that in this case, the net effects on $x_N$ and $C$ (and therefore also the effects on $I$ and $w_N/w_S$) are qualitatively identical to those of either stricter IPRP in the rich-South equilibrium (opposite move to globalization effects shown in Figure 2), or globalization in case of a Southern trading partner at a medium stage of development (move from $E_0$ to $E_0'$ in panel B of Figure 2). We can summarize our findings in
Proposition 3: (i) In the poor-South equilibrium, a more flexible Northern labor market ($\beta \uparrow$), a rise in R&D subsidies ($s_R \uparrow$) or a decrease in firing costs ($B \downarrow$) lead to a permanent decrease in the rate of Southern copying ($C \downarrow$), a permanent increase in relative R&D difficulty ($x_N \uparrow$), a short-run increase in the innovation and quality-growth rates ($I \uparrow, Q/Q \uparrow$) above their steady-state levels, no change in the long-run innovation rate given in (34), and a permanent increase in North-South wage inequality ($w_N/w_S \uparrow$).

(ii) In the rich-South equilibrium, a more flexible Northern labor market, a rise in R&D subsidies or a decrease in firing costs lead to a permanent increase in $C$, a permanent decrease in $x_N$, a short-run decrease in $I$ and $Q/Q$ below their steady-state levels, no change in the long-run innovation rate, and a permanent decrease in North-South wage inequality.

(iii) With $B > B_{crit}$, a more flexible Northern labor market, a rise in R&D subsidies or a decrease in firing costs never benefit both the South in terms of a relative-wage catch up and the North in terms of a temporary innovation and growth push.

As stated in this proposition, a rise in R&D subsidies or a decrease in firing costs have qualitatively the same effects as an increase in labor market flexibility. Technically, this is because all these policies shift the Northern steady-state curve in the same way without affecting the Southern steady-state curve. Economically, both a rise in $s_R$ and a decrease in $B$ imply a decrease in R&D costs given on the RHS of (23) and therefore stimulate Northern R&D in the same way as an increase in $\beta$ (which raises R&D benefits by increasing the Northern workforce on the LHS of (23)). If Northern R&D intensity increases temporarily (which is only true when starting in a poor-South equilibrium), this results in a higher R&D difficulty level that tends to decrease Southern imitation incentives (RHS of (28)) as in the case of rising $\beta$. Finally, we saw that the positive effects of a rising $\beta$ on Southern imitation incentives work through an increase in the Northern market size $\tilde{L}_N$ for Southern quality leaders (LHS of (28)), and this effect is strongest for a relatively high level of $C$. Again, this logic works very similar in the case of rising $s_R$ or declining $B$. For a high level of $C$, both work particularly effectively towards an increase in Northern employment $\tilde{L}_N$ in (38) (formally, $\partial^2 \tilde{L}_N/\partial s_R \partial C > 0$ and $\partial^2 \tilde{L}_N/\partial B \partial C > 0$). Total Northern employment increases with rising $s_R$ and declining $B$ because it improves R&D incentives (decline in R&D costs on the RHS of (23)) and thus induces an increase in the proportion of Northern R&D employment ($\tilde{E}_N^R/\tilde{E}_N^I$ decreases in (48)). Since only production worker become unemployed according to (31), this reduces vulnerability of the Northern labor market to Southern competition and therefore raises $\tilde{L}_N$. To see that this effect is stronger for high $C$, multiply
both sides of (23) by \((C + I)\). Then it is obvious that the marginal effect of a rise in \(s_R\) or a decline in \(B\) for reducing R&D costs is larger for a high level of \(C\).

5 Conclusions

In this paper, we generalize the contribution of DS (2003) in order to analyze whether globalization effects on growth, employment and North-South wage inequality depend qualitatively on the level of Northern labor market rigidity and firing costs. Whereas the simpler model of DS with perfectly flexible labor markets predicts a “best-case” scenario of globalization (a temporary innovation and growth push in the North and a declining North-South wage gap), we show that a rigid Northern labor market may overturn this optimistic view. With firing costs below a critical level, the best-case scenario is preserved (although frictional unemployment arises), but for larger firing costs, two steady-state equilibria with qualitatively different properties emerge. In the “poor-South equilibrium” (with a low rate of Southern imitation and a large North-South wage gap), globalization effects still follow the best-case scenario. However, in the “rich-South equilibrium” (with a high rate of Southern imitation and a small North-South wage gap), globalization never benefits both the South in terms of a relative-wage catch up and the North in terms of a temporary innovation and growth push, whereas the effect on Northern unemployment is ambiguous.

As in DS (2003), stricter IPRP serves to mitigate the effects from globalization. However, since those effects tend to be uncertain due to multiple equilibria with qualitatively different policy implications, it is not obvious which globalization effects are mitigated. In the poor-South equilibrium, stricter IPRP slows down Southern imitation, raises the relative Northern wage rate and decreases unemployment. In the rich-South equilibrium, two situations may arise: stricter IPRP either increases Southern imitation (“IPRP paradox”) and decreases the relative Northern wage rate (this holds true for a large Southern starting level of imitation) or the other way around (this holds true for a medium Southern starting level of imitation). In both cases, the net effect on Northern unemployment is ambiguous. Similarly, increasing labor market flexibility or decreasing firing costs in the North (while decreasing obviously Northern unemployment) may be helpful to spur Northern growth temporarily, to reduce competition from Southern imitation and thereby to raise the relative Northern wage rate. However, these effects only occur in a poor-South equilibrium and are turned upside down in a rich-South equilibrium.

These results let us conclude that if the North faces competition from a poor South, a more flexible Northern labor market and lower firing costs indeed would be useful instruments to attenuate the negative globalization effects on Northern employment and its relative wage rate while speeding up Northern innovation and growth at the same time. Moreover, this would be preferable to stricter IPRP since the latter slows down Northern innovation and growth. However, if the North faces competition from a (relatively) rich South, it is not clear whether globalization is bad at all for Northern employment and its relative wage rate. Furthermore, in this case, a more flexible Northern labor market or
lower firing costs have the same qualitative effects as stricter IPR on Southern imitation, Northern innovation and growth, and the relative Northern wage rate.

Appendices

Appendix A: Derivation Of The Individual’s Consumption Demand Function (5)

With the definition of a new state variable Φ with Φ(0) = 0, Φ(1) = c(t) and dΦ(ω)/dω = p(ω, t)·d(ω, t), the corresponding Hamiltonian is

\[ H = [λ^{(ω-1)/σ}]·d(ω, t) + Ψ(ω)·p(ω, t)·d(ω, t), \]

where Ψ(ω) is the costate variable that belongs to Φ(ω). The f.o.c. are

\[ \frac{\partial H}{\partial Φ} = 0 = -dΨ/dω \iff Ψ(ω) = Ψ(∀ω), \quad (A.1) \]

\[ \frac{\partial H}{\partial d} = \left[\frac{(σ-1)/σ}{\int \frac{1}{σ}·p(ω, t)^{1-σ}·q(ω, t) dω = c(t). \quad (A.3) \]

Inserting (A.2) into the budget constraint from (4) yields

\[ \left[-\frac{(σ-1)/σ·Ψ}{\int \frac{1}{σ}·p(ω, t)^{1-σ}·q(ω, t) dω = c(t). \quad (A.3) \]

Using (A.3) in (A.2) then gives (5).

Appendix B: Proof That (44) Follows From (43), And Uniqueness Of \{B^{crit}, C\} Satisfying (44)

We first rewrite (44) as

\[ \frac{1-s_r}{η_l} \cdot \rho \cdot \left(\frac{η_l·β·L_N+x_N·I·C}{η_l·L_N+x_N·I}\right) - (λ·I+C) \cdot \left(I+C-δ + \frac{η_h}{1-s_e}\right) \]

\[ = B^{crit} \cdot \left(λ·I+C\right) \cdot \left(\frac{η_l·β·L_N+x_N·I·C}{η_l·L_N+x_N·I}\right), \quad (B.1) \]

where the compact form of (39) is used. Multiplying both sides with \((σ-1)·λ·I·x_N/(λ·I+C)^2\) gives

\[ \frac{1-s_r}{η_l} \cdot \rho \cdot \left(\frac{η_l·β·L_N+x_N·I·C}{η_l·L_N+x_N·I}\right) \cdot \frac{(σ-1)·λ·I·x_N}{(λ·I+C)^2} - \frac{(σ-1)·λ·I·x_N}{λ·I+C} \cdot \left(I+C-δ + \frac{η_h}{1-s_e}\right) \]

\[ = B^{crit} \cdot \left(\frac{σ-1)·λ·I·x_N}{λ·I+C} + \frac{(σ-1)·λ·I^2·x_N(λ-1)}{(λ·I+C)^2} \cdot \frac{η_l·β·L_N+x_N·I·C}{η_l·L_N+x_N·I}\right) \quad (B.2) \]

Recognizing that for the second large term in square brackets in the first line of (B.2) it holds

\[ \frac{(σ-1)·λ·I·x_N}{λ·I+C} \cdot \left(I+C-δ + \frac{η_h}{1-s_e}\right) = \frac{η_l·β·L_N+x_N·I·C}{λ·I+C} \cdot B^{crit} \cdot \frac{η_l}{1-s_r} \]
from the definition of \( \bar{L}_N \) in (38), we can rewrite (B.2) after canceling and regrouping terms as

\[
\begin{align*}
\frac{\eta_I \cdot \beta \cdot \bar{L}_N + x_N \cdot I \cdot C}{\eta_I \cdot \bar{L}_N + x_N \cdot I} \cdot \frac{(\sigma - 1) \cdot \lambda \cdot I \cdot x_N}{(\lambda \cdot I + C)^2} \cdot \left[ \rho \cdot \frac{1 - s_R}{\eta_I} - B_{\text{crit}} \cdot (\lambda - 1) \cdot I \right] = \bar{L}_N.
\end{align*}
\]

(B.3)

By solving (B.3) for \( B_{\text{crit}} \), one immediately derives (43).

Q.e.d.

To show that (44) is fulfilled for only one particular value of \( C \), we rewrite this equation as

\[
\frac{\beta}{(\rho / \eta_I)^{-s_s} / (1 - s_s)} \cdot \left[ \frac{1 - s_R}{\eta_I} \cdot \rho - B_{\text{crit}} \cdot (\lambda - 1) \cdot I \right] = (\lambda \cdot I + C) \cdot \left[ B_{\text{crit}} \cdot (I + C) + \frac{1 - s_R}{\eta_I} \cdot \left( I + C - \delta + \frac{\eta_h}{1 - s_v} \right) \right] + C \cdot \left[ B_{\text{crit}} \cdot (\lambda - 1) \cdot I - \frac{1 - s_R}{\eta_I} \cdot \rho \right],
\]

(B.4)

where the LHS is positive and the last term on the RHS is negative due to (43). Obviously, the LHS of (B.4) is strictly decreasing in \( B_{\text{crit}} \), while the RHS of (B.4) is strictly increasing in \( B_{\text{crit}} \). Therefore, it suffices to show that the RHS is strictly increasing in \( C \) (implying a strictly monotone negative relationship between \( B_{\text{crit}} \) and \( C \) as illustrated in panel B of Figure 1). Then, for given \( B_{\text{crit}} \), only one value of \( C \) can fulfill (B.4). To this aim, we rewrite the RHS of (B.4) as follows:

\[
C \cdot \left( B_{\text{crit}} + \frac{1 - s_R}{\eta_I} \right) \cdot (C + 2 \cdot \lambda \cdot I) + \lambda \cdot I \cdot \left[ B_{\text{crit}} \cdot I + \frac{1 - s_R}{\eta_I} \cdot \left( I - \delta + \frac{\eta_h}{1 - s_v} \right) \right],
\]

where we have used (34). Hence, the RHS of (B.4) is strictly increasing in \( C \).

Q.e.d.

Appendix C: Derivation Of Equation (49)

Inserting (5) into (3) and using the fact the households only consume goods with the lowest quality-adjusted price gives individual instantaneous utility in the North as

\[
\begin{align*}
z_N(t) &= c_N(t) \cdot \left[ \frac{1}{\Lambda} \cdot \int_{0}^{1} q(\omega) \cdot p_{N}^{-\sigma} \cdot \frac{\sigma^{-1}}{\sigma} \cdot d\omega \right]^{\frac{1}{\sigma - 1}} \\
&= c_N(t) \cdot Q(t) \cdot \left[ \frac{w_N(t) \cdot \sigma}{\sigma - 1} \right]^{-\sigma} \cdot \lambda \cdot I \cdot Q(t) + \frac{w_S(t) \cdot \sigma}{\sigma - 1} \cdot \frac{C \cdot Q(t)}{\lambda \cdot I + C} \\
&= \frac{c_N(t) \cdot Q(t) \cdot \left[ \frac{w_N(t) \cdot \sigma}{\sigma - 1} \right]^{-\sigma} \cdot \left[ \frac{w_N(t) \cdot \sigma}{\sigma - 1} \right]^{\sigma} \cdot \left( \frac{\lambda \cdot I}{\lambda \cdot I + C} \right) \cdot \frac{C \cdot Q(t)}{\lambda \cdot I + C}}{\sigma \cdot \left[ w_N(t) \cdot \sigma \cdot \lambda + w_S(t) \cdot \sigma \cdot C \right]},
\end{align*}
\]

(C.1)

where we have used monopoly markup prices \( p_{N,S} = \left[ \sigma / (\sigma - 1) \right] \cdot w_{N,S} \), the definition of average quality level \( Q \equiv \int_{0}^{1} q(\omega) d\omega \equiv \int_{0}^{1} q(\omega) d\omega \cdot \int_{0}^{1} q(\omega) \cdot p(\omega)^{\sigma} d\omega = p_N \cdot Q_N + p_S \cdot Q_S \) and (30). Using the facts that \( w_S \) is a constant fraction of \( w_N \) (see (47)) and that \( I \) and \( C \) are constant in a steady-state equilibrium, logarithmic differentiation of the last line of (C.1) gives
\[
\frac{\dot{z}_N}{z_N} = \frac{\dot{c}_N}{c_N} + \frac{1}{\sigma - 1} \cdot \frac{\dot{Q}}{Q} - \frac{w_N}{w_N}. \quad \text{(C.2)}
\]

Inserting \(\dot{c}_N/c_N = \dot{\omega}/c\), (13), (29), (34), (14) and \(r = \rho\) into (C.2) gives (49).

References


Mauro, Luciano and Carmeci, Gaetano (2003): “Long-Run Growth and Investment in Education: Does


