Innovation, Intellectual Property Rights, Imitation, and Income Distribution

Joachim Stibora*

Kingston University

This version July 2003

Abstract

We employ a North-South endogenous growth model with two factors of production in which the North invents new products and the South imitates. We use this model to explore the impact of stronger IPRs on interregional as well as intraregional distribution of welfare. We find that the overall losses are smallest when the policy shock is implemented gradually. With regard to intraregional welfare effects, we show that tighter IPRs reduce the welfare of all individuals but that the welfare losses of laborers are smaller than those of capital owners.

*Mailing address: Faculty of Social Sciences, School of Economics, Kingston University, Penrhyn Road, Kingston upon Thames, Surrey KT1 2EE, UK; email: j.stibora@kingston.ac.uk. The majority of this paper was written while working at the Nijmegen School of Managment, University of Nijmegen, which I would like to thank for their kind hospitality. I would also like to thank Marcia Schafgans and participants of seminars at the Universities of Nijmengen and Rotterdam for their valuable comments.

1 Introduction

The last two decades have witnessed a period of increasing economic activities. Falling trade barriers and increasing market integration facilitated by lower transportation cost and improved modes of communication have pathed the way for domestic firms to expand their economic activities beyond local markets. For firms to extend their market shares they recourse to more inventive and innovative products to outpace their competitors. Evidence indicates that a growing share of trade consistent of trade in technology (see, for example, Maskus (2002)). At the same time as the cost of development of these products steadily rise, they becoming increasingly easier to copy, making infringement easier and more prevalent. Anecdotal evidence suggests that "the American Pharmaceutical industry, for example, loses $500m in India alone each year because of poor patent protection."[1] Given this environment, there has been a rising international demand for the strengthening of intellectual property rights system, principally in major developing economies which do not adhere to the same standards of intellectual property protection as in the richer countries. As the information gathered by Prima Braga (1995) shows, among the ninety-eight developing member countries of the GATT twenty-five developing countries did not provide patents for pharmaceutical products and thirteen did not allow patents for chemical products by 1994. It came to no surprise, that the United States, the European Union, and Japan have been demanding for stronger and more harmonized global standards of protection to limit the cost of expropriation faced by their property owners when exploiting their technological advantage on an international scale.

Eventually and despite the opposition of a rising number of developing countries, the issue of protection of intellectual property rights has been one of the negotiating topics of the so-called Uruguay Round of multilateral trade negotiation. The resulting Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) administered by the World Trade Organization (WTO) constitutes the most comprehensive international agreement on intellectual property rights so far negotiated. The agreement lays down a list of ground rules describing the protection that country's system must provide. These extend IPRs to include pharmaceutical products and processes, plant varieties, and trade secrets, all of which were unprotected in many developing countries until the agreement.

As the primary purpose of patents is the encourage innovation, the balance tilts toward stronger rights for knowledge intensive economies, those firms trading in knowledge-based products are expected to see their competitive edge and income generating activities increasing over the short-term. On the other hand, infringement activities in many countries will

[1] The Economist June 23rd 2001, Special report Patents and the poor, p. 28.

be pressured to close down and to restructure. This might raise temporarily unemployment and might have potentially adverse social and economic consequences in those economies where copying and imitation were tolerated so far. Over the longer term, however, TRIPS will change the incentives for innovation and imitation and gains should be expected to be more evenly spread by improving access to new technologies and boosting foreign direct investment in poor countries.[2]

The principal objectives of this paper are to analyze the induced changes in the income distribution between the North (advanced regions) and the South (less advanced regions), on the one hand, and within the North, on the other hand, assuming that tighter intellectual property rights are gradually introduced. With regard to interregional welfare effects, using a one factor endogenous growth model, Helpman (1993) has shown that a tightening of intellectual property rights accelerates Northern innovation on impact but reduces the rate of innovation in the long run. This equilibrium shift in the time profile of innovation to a slower rate of technical change harms the South, as does a 'trade diversion effect' caused by the shift away in production from the low cost Southern producers and deteriorating terms of trade. Helpman concludes that the South has to lose from tighter intellectual property rights. Underlying this statement is the assumption that the policy change is introduced abruptly and without any anticipation. However, policy changes hardly ever come as a surprise. This certainly applies to TRIPs. The eventual TRIPs' outcome had been a compromise between Northern nations securing a minimum standards for the legal protection of their intellectual property rights on a global scale in return for generous transition periods for the Southern nations. In particular, the TRIPs agreement provides for transitional periods largely according to the level of economic development. Developed countries were given one year from the entry into force of the World Trade Organization (WTO) to comply with all TRIPs requirements. This transitional period ended for those countries in January 1996. Developing countries and countries in transition were given five years, while least-developing countries were allowed an eleven year period to comply with their TRIPs obligations. For example, under the TRIPs agreement, the developing countries that are member of the WTO and that did not provide patent protection for pharmaceutical products must do so by 2005.[3]

An analysis that considers the economic consequences of a gradual implementation of tighter intellectual property rights therefore seems to be warranted. We show that a gradual tightening of IPRs not only accelerates the rate of innovation on impact - as it does in Helpman - but also during subsequent periods before it eventually saddles on a lower

[2]For an analysis considering the welfare effect of tighter intellectual property rights in the presence of multinationals in an endogenous growth context see Stibora (2002b).

[3]See Primo Bragga (1995) and in particular Maskus (2000).

equilibrium rate. The induced welfare gains of the higher rate of innovation that are spread over a longer initial period counterbalance welfare losses on account of worsening terms of trade and the production reallocation effect. We show analytically that the South still loses from tighter IPRs but that the welfare losses are smaller the more gradual the policy shock is implemented.

The existing literature on innovation and imitation has shown that there exists a conflict of interest between the Northern and the Southern region. Though, little is known how tighter IPRs affect the intra-regional income distribution. This applies in particular to the North. It is suggested that lax imitation laws lead to the loss of monopoly rents of Northern firms and assuming that these firms are relatively labor-intensive the loss of markets implies the loss of wage income and unskilled jobs. This would suggest that Northern firms and unskilled labor would have a common interest in demanding tighter intellectual property rights laws. In order to improve our understanding and the sources of conflicts and coalitions within a region explore systematically how individuals or groups of individuals will be affected when developing countries tighten their stance against intellectual property rights infringements. We approach the issue of intra-regional income distribution by assuming not only that individuals may own more than one factor but that they may also differ in their factor ownership shares. As a consequence, individuals within the same region are differently affected when the South applies tighter IPRs. We show that this coincidence of interest between large cooperations and unskilled workers has little economic support. When intellectual property rights are tightened, individuals encounter identical changes in the number of varieties available and goods prices, but in general different effects on their income share. Due to differences in factor-ownership some will benefit while others will be hurt. We show that the gains on account of the income share, however, are not large enough to foster such a coalition.

For the analysis at hand we extend the one factor, endogenous growth model developed in Helpman (1993). Our model considers two regions, the developed North and the developing South. They differ in their relative factor endowments: the relatively capital abundant North and the relatively labor abundant South. In the Northern region both factors are used in the final goods sector while the R&D sector employs capital only. In contrast, the Southern region does not innovate but instead imitates the technologies developed in the North. Both factors should be interpreted as a very broad measure of capital and labor. Capital includes all capital that can be produced and accumulated by allocating resources to economic activities, such as human capital, physical capital, and proprietary technology; while labor stands for unskilled labor (see e.g. Alesina & Rodrik (1994)). In this paper several channels are considered through which intellectual property rights affect individual welfare in each region: (1) the amount of varieties available, (2) the terms of trade; (3) product allocation between regions; (4) intertemporal allocation of consumption; and (5) the individual factor income share.[4]

Whereas the consideration of two factors of production in endogenous growth models with imitation is not new (see, for example, Grossman & Helpman (1991), Lai (1995)), we do not restrict the analysis to the comparison of steady states.[5] On the contrary, we analytically compute the entire dynamic adjustment path towards a balanced growth path enabling us to perform a proper welfare analysis. To compute the transition to a new steady state analytically, we follow the log-linearization approach suggested by Judd (1982, 1999). We extend this approach to endogenous growth models and to welfare functions with nonstationary arguments.

The structure of the paper is as follows. Section 2 develops the model and specifies it underlying assumptions. Section 3 describes the initial balanced growth path. Section 4 provides the comparative dynamics of a number of variables and the analytical solutions, including rate of innovate, share of Northern goods not yet imitated, terms of trade, and the share of income. Section 5 turns to welfare analysis by investigating the consequences for the inter-regional and intra-regional distribution of welfare. Finally, Section 6 contains a few concluding remarks.

2 The Model

Consumers. We consider two regions: the developed North, N, and the developing South, S. Each individual i in region k, $(k = N, S)$ has an objective function represented by

$$U_i(t) = \int_t^\infty e^{-\rho(\tau - t)} \log u_i(\tau) d\tau, \tag{1}$$

where $\rho(> 0)$ denotes the time preference rate and

$$u_i(t) = \left[\int_0^{n(t)} x(j)^\alpha dj \right]^{1/\alpha} \qquad \text{with } \ 0 < \alpha < 1, \tag{2}$$

instantaneous utility, $x(j)$ denotes the consumption of good j, and $n(t)$ represents the number of varieties available at time t. At each point in time t, an individual maximizes instantaneous

[4] The first four channels were introduced by Helpman (1993) to analyze aggregate welfare effects in a one factor endogenous growth model.

[5] Lai (1995) does not only restrict his analysis to the steady state but he also concentrates on changes in factor supply.

utility spending an amount E_i by purchasing

$$x(j) = p(j)^{-\varepsilon} \frac{E_i}{P^{1-\varepsilon}}, \tag{3}$$

units of variety j and paying price $p(j)$. P is the weighted price index

$$P \equiv [\int_0^{n(t)} p(j)^{1-\varepsilon} dj]^{1/(1-\varepsilon)}. \tag{4}$$

The expression $\varepsilon = 1/(1-\alpha) > 1$ denotes the elasticity of substitution between any two invented goods which is constant. A person's income consists of several sources and depends on the regions where s/he lives in. For instance, a person located in the North may potentially receive income from three sources: income from labor, income from capital and income from profits generated by Northern firms owing a patent. Total income of individual i located in regions k is

$$E_i^k = w_l^k L_i^k + w_h^k H_i^k + \pi_i^k, \qquad \text{for} \quad k = N, S$$

where w_l^k and w_h^k denote the returns to labor and human capital, respectively, and π_i^k represents the profits generated by the final goods producers and received by individual i. We assume that the ith individual's share of total profits is identical to the ith person's income share from factor ownership, φ_i^k; that is[6]

$$\pi_i^k = \varphi_i^k \pi^k,$$

where π^k represents total profits generated by all firms located in either North or South and

$$\varphi_i^k = \frac{w_l^k L_i^k + w_h^k H_i^k}{w_l^k L^k + w_h^k H^k} \qquad \text{with} \quad \sum_{i=1}^{I^k} \varphi_i^k = 1. \tag{5}$$

The variables H^k and L^k are the aggregated endowments of capital and labor, respectively, in region k, and $\sum_{i=1}^{I^k} H_i^k = H^k$ and $\sum_{i=1}^{I^k} L_i^k = L^k$. An individual's income in region k can now be expressed as

$$E_i^k = \varphi_i^k E^k. \tag{6}$$

By substituting (6) into (3) and this in turn into (2) yields an expression for the current flow of utility of individual i as the logarithm of real spending; this is

$$\log u_i^k = \log \varphi_i^k E^k - \log P. \tag{7}$$

The advantage in choosing this specification of preferences is that the heterogeneity among individuals does not affect aggregate demand for variety j.

[6] This formulation is related to Mayer (1984) who links factor ownership to the level of a tariff. Our model extends his results to a endogenous growth model.

Product markets. A typical Northern firm owning a patent to produce a good competes with other Northern firms. Such a firm faces an aggregate demand like (3) - but with E then representing aggregate spending - and maximizes profits by charging a monopoly price

$$p^n = \frac{c^n(w_h^n, w_l^n)}{\alpha}. \tag{8}$$

For firms in the North the pricing strategy yields operating profits per unit of time of

$$\pi^n = \left(\frac{1-\alpha}{\alpha}\right) x^n c^n, \tag{9}$$

where c^n denotes the unit production cost of a Northern firm.

In the event that a Northern firm's variety is imitated, it loses its monopoly position and the inherent knowledge of the product becomes available to all Southern firms. Perfect competition in Southern's product market then forces firms to price imitated products according to unit costs, c^s[7]

$$p^s = c^s(w_h^s, w_l^s). \tag{10}$$

Note, this assumption implies that $\pi^s = 0$. We concentrate on parameter values that yield a steady-state equilibrium in which the unit cost in the North are higher than in the South, $c^n > \alpha c^s$.

In both countries the manufacturing sector employs both capital and labor. In particular, the production function and unit cost function, respectively, of a firm in both regions is given by the following CES technology

$$\begin{aligned} x^k(j) &= \left[\left(b^k\right)\left(H_j^k\right)^{\nu^k} + \left(1-b^k\right)\left(L_j^k\right)^{\nu^k}\right]^{1/\nu^k} \\ c^k(j) &= \left[\left(b^k\right)^{\sigma^k}\left(w_h^k\right)^{1-\sigma^k} + \left(1-b^k\right)^{\sigma^k}\left(w_l^k\right)^{1-\sigma^k}\right]^{1/1-\sigma^k}, \end{aligned} \tag{11}$$

where $k = N, S$. The parameter b^k denotes the share of capital in total product and we assume $0 < b^s < b^n < 1$. H_j^k and L_j^k are the quantity of capital and labor employed in the production in good j located in region k, $\nu \in (-\infty, 1]$, and $\sigma = 1/(1-\nu)$, is the elasticity of substitution between labor and capital. If $\nu = 1$, the production function is linear so that factors of production substitute perfectly with each other and implies that the production of final goods can be done with one factor only (infinite elasticity of substitution); while

[7] Alternatively, one could also assume that the technology of a Northern product that has been imitated becomes available only to the imitator in the South. Assuming price competition between the Nothern and Southern firm and that the Southern firm has a cost advantage, if follows that the imitator takes over the entire market. If the cost advantage is large enough he engages in monopoly pricing. Under this alternative specification, the results do not change essentially.

if $\nu = 0$, the production function approaches the Cobb-Douglas form and the elasticity of substitution is 1. For $\nu \to -\infty$ the production function approaches the Leontief form of fixed factor proportions, where the elasticity of substitution is zero. For the remainder of the analysis we are particularly interested in the consequences where both factors are essential inputs in manufacturing, that is $\nu < 1$.

Since there are only two prices the price index given in (4) can now be specified as:

$$P = n^{1/1-\varepsilon} \left[\zeta (p^n)^{1-\varepsilon} + (1-\zeta)(p^s)^{1-\varepsilon} \right]^{1/1-\varepsilon}, \tag{12}$$

where $\zeta = n^n/n$ denotes the fraction of Northern goods not imitated and n^n is the number of products the South has not yet imitated. As can be seen from (7), real spending and therefore welfare is higher the lower is the price index. Due to our assumption that $p^n/p^s > 1$, an increase in ζ reduces *ceteris paribus* welfare of all individuals in both regions. The resulting increase in factor demand by manufacturing firms in the North affects the relative factor reward, among others.

Innovation and imitation. We assume that new products are solely developed in the North and that the South imitates only. To rule out problems related to factor-intensity reversal we also assume that innovation requires only capital as input. Let a denote the input coefficient in this activity. This implies that a/n units of capital are required to develop a new patent per unit of time, n reflecting the available stock of knowledge capital. In the absence of barriers into R&D, each R&D firm chooses its input such that the value of a firm, ϑ^n, holding a blueprint is no higher than the development cost and equal when development takes place. It then follows that only when

$$\vartheta^n(t) = w_h^n a/n \tag{13}$$

it is profit maximizing for firms to devote a positive (finite) amount of capital to innovation, and thus $\dot{n} > 0$.

The stock market valuation of monopoly profits provides another equilibrium condition that relates the expected discounted profits to the flow of profits, the instantaneous interest rate, and the rate of imitation. Over a time interval dt, a Northern firm owning a blueprint for producing a variety earns profits $\pi^n dt$, and the value of the monopolist appreciates by $\dot{\vartheta}^n\, dt$. Northern firms, however, are targeted by Southern firms to imitate their products. In case of imitation, a Northern firm will lose its monopoly position and suffer a capital loss of size ϑ^n. This event occurs with probability mdt $(= [\dot{n}^s/n^n]dt)$, whereas no imitation occurs with probability $(1 - mdt)$. Efficiency in capital markets ensures that the expected total return on equity holding of size ϑ^n has to be equal the nominal interest rate, r^n, on a riskless loan available during the same time interval. Summing these components of the equity return and taking limits as dt approaches zero, the no-arbitrage condition in Northern capital market becomes

$$\frac{\pi^n}{\vartheta^n} + \frac{\dot{\vartheta}^n}{\vartheta^n} = r^n + m. \tag{14}$$

The right hand side of (14) reflects the risk premium in excess of the rate of return demanded by shareholders of the firm to compensate them for the risk that their product is being imitated and their corresponding investment destroyed. Note, the rate of imitation, m, is exogenous and treated as a policy variable in section 4.

Labor markets. We close the model by equating factor demand to factor supply requiring

$$\begin{aligned} ag + x^n n^n a_h^n(w_h^n, w_l^n) &= H^n \\ x^s n^s a_h^s(w_h^s, w_l^s) &= H^s \end{aligned} \tag{15}$$

and

$$x^k n^k a_l^k(w_h^k, w_l^k) = L^k, \tag{16}$$

where a_h^k (a_l^k) is the per unit input of capital (labor) in the production of final goods in region k ($k = N, S$). Recall that n^n is the number (measure) of products the South has not yet imitated, and n^s the number of products the South knows how to produce; $n = n^n + n^s$. The left hand side of (15) gives the derived demand for capital by the final goods sector in both regions and the demand for capital by the research sector, if any. We use $g \equiv \dot{n}/n$ to represent the endogenous rate at which new products are introduced. Similarly, the left hand side of (16) expresses the derived demand for labor by the final goods sector in North and South.

3 Long-run Equilibrium

Let ϕ_h^k denote the factor cost share of capital in region k's final goods sector then the total cost of final goods can be expressed in terms of factor cost shares (see Lai (1995)). Combining (9) and (15) the no-arbitrage condition (14) can be rewritten as

$$\left(\frac{1-\alpha}{\alpha}\right)\frac{(H^n - ag)}{\zeta \phi_h^n a} + \frac{\dot{\vartheta}^n}{\vartheta^n} = r^n + m. \tag{17}$$

In order to determine the interest rate r^n we must analyze a household's savings behavior. Each individual maximizes utility (1) and (7) subject to an intertemporal budget constraint so that it is indifferent at the margin between saving and consuming. Inasmuch as ρ and r_t^n do not differ among agents the time path of aggregate spending evolves according to $r^n = \dot{E}^n / E^n + \rho$. With no capital flows taking place between the two regions, the trade account is balanced at every moment of time and requires that the value of spending equals national income $E^n = p^n n^n x^n$. Using this relationship in combination with (11), (13), (15), and (17) we derive an expression for the time path of the rate of innovation (see Appendix):[8]

$$\dot{g} = \left(\frac{H^n - ag}{a(1-\phi_l^n \nu^n)}\right)\left[g + \rho + m - \left(\frac{1-\alpha}{\alpha}\right)\frac{(H^n - ag)}{a\phi_h^n}\frac{1}{\zeta}\right], \tag{18}$$

for $0 < g < H^n/a$. At any point in time, the North introduces new varieties at rate g. These products are targeted by the South for imitation at an exogenous rate m implying that the fraction of goods not yet imitated is $\zeta = n^n/n$. Differentiating ζ with respect to time provides a second differential equation linking the fraction of goods not been imitated ζ and the rate of imitation m:[9]

$$\dot{\zeta} = g - (g+m)\zeta. \tag{19}$$

Equations (18) and (19) provide two equations in two unknowns, g and ζ. The rate of innovation is considered to be a control variable while the share of Northern goods that have not been imitated is considered to be a state variable and therefore historically predetermined. We first look at the characteristics of the steady state of the model.

Figure 1[10] represents the phase diagram associated with the model. The intersection of the $\dot{g} = 0$ and the $\dot{\zeta} = 0$ line yields a unique, saddle-point stable equilibrium, with roots $\lambda_1 > 0$ and $-\lambda_2 < 0$ (point A). The unique stable saddle path is depicted by the $g = g(\zeta)$ line.[11] The stable root $-\lambda_2 < 0$ determines how rapidly the economy converges to the new long-run equilibrium. The steady state long-run equilibrium values of g and ζ can be calculated from

$$(g + \rho + m) = \left(\frac{1-\alpha}{\alpha}\right)\left[\frac{H^n}{a} - g\right]\frac{1}{\phi_h^n \zeta} \tag{20}$$

$$\zeta = g/(g+m). \tag{21}$$

[8]The reader is referred to the appendix for a description of the solution technique and all mathematical derivations. This appendix can be downloaded from ???

[9]We derive equation (17) by differentiating $\zeta = n^n/n$ with respect to time and making use of $\dot{n}/n^n = \dot{n}^s/n^n + \dot{n}^n/n^n$, and the definitions of g and m; see Helpman (1993).

[10]The values of the parameters and exogenous variables underlying Figure 1 are: $H^n = 70$, $L^s = 50$, $H^s = 40$, $L^n = 50$, $b = 0.7$, $b^s = 0.4$, $\alpha = 0.5$, $a = 1$, $\rho = 0.053$, $\nu^n = \nu^s = 0$.

[11]The $g = g(\zeta)$ function is calculated by the time elimination method as proposed by Mulligan & Sala-i-Martin (1991) and Barro & Sala-i-Martin (1995).

The left hand side of (20) reflects the real effective cost of capital. This cost includes in excess to the interest cost, the growth rate at which the value of a Northern firm depreciates due to ongoing innovation, and a premium for the risk of being imitated by a Southern firm. The right hand side represents the profit rate for a Northern manufacturing firm, that is, the inverse of the price earning ratio.

For any steady-state configuration of (ζ, g) to be feasible various restrictions have to be satisfied. First, the equilibrium value of ζ is limited to be smaller than unity. Second, the amount of capital employed in the R&D sector is constrained by the total supply of Northern capital. Furthermore, Northern firm's unit cost have to be larger than the unit cost of Southern firms. This requires the rate of innovation to be larger than (see Appendix)

$$g > \frac{H^n}{a} - \frac{1}{a}\left\{\left[\alpha^{\varepsilon}\left(\frac{b^s}{b^n}\right)^2 \frac{\zeta}{1-\zeta}\right]^{\nu^n} \frac{1}{b^n}\left(\frac{b^s (H^s)^{\nu^s}}{\phi_h^s}\right)^{\frac{\nu^n}{\nu^s}} - \frac{(1-b^n)}{b^n}(L^n)^{\nu^n}\right\}^{1/\nu^n}. \qquad (22)$$

It is this condition, that requires the introduction of country-specific distributional shares in the production functions. The economic intuition for this condition is as follows: as the R&D sector employs capital only an increase in the rate of innovation increases the demand for this factor, which must be attracted from the final goods sector. For a given supply of capital, excess demand for capital raises its factor reward to clear the corresponding factor market. For $\nu < 1$, the relative wage rate of human capital increases so that the unit cost of final goods producers in the North remains above the unit cost of the final goods producers in the South for a g satisfying (22), which, in turn, is satisfied if the relative share of capital in total product is larger in the North, $b^n > b^s$. Alternatively, the area below this curve represents the region in which the unit cost of a variety produced in the North is lower than in the South.

Comparing (21) and (20) with (22), we see that the latter does not dependent on the rate of imitation while the former two shift, ceteris paribus, to the right and down if m falls. This implies that, for given parameter combinations, there exist values of $m \in (0, m_{\max})$ such that the long-run steady-state equilibrium falls into the feasible region. For the remainder of the paper, we confine the analysis to values of m within this range.

4 Tighter intellectual property rights

This section explores the effects of tighter intellectual property rights. To analyze the model, we log-linearize equation (18) and (19) around the initial steady state. A per-unit deviation of a variable relative to the initial steady state is denoted with a tilde ("~"), e.g. $\widetilde{\zeta} \equiv d\zeta(t)/\zeta$.

For the time rate of change of a variable we use in addition to the tilde a dot: $\dot{\tilde{\zeta}} \equiv d\dot{\zeta}(t)/\zeta$. We normalize time so that the policy shock occurs at time $t = 0$.Intellectual property rights can either be reduced abruptly or gradually. Inspirit by Bovenberg & Heijdra (2002), we assume that the shock takes the following form:

$$\widetilde{m}(t) = (e^{-\beta t} - 1)\kappa, \tag{23}$$

where $\beta > 0$, and $A(\lambda_2, t) \equiv (e^{-\beta t} - 1)$ is a single adjustment term which is negative and decreasing for $t > 0$ and approaches minus one for $t \to \infty$ (see Lemma 1 in Stibora (2003a)). The variable $\kappa > 0$ represents the extent of which IPRs are tightened. The motivation for this simple assumption is that the stronger legal and administrative actions taken by the Southern government to protect the Northern IPRs, the lower is the rate of imitation. A lower m can therefore be interpreted as a change in the attitude of Southern governments to prosecute more seriously intellectual property rights infringements. If $\beta \to \infty$, intellectual property rights are permanently tightened instantaneously; there are no anticipation effects. A more realistic case is when $\beta \ll \infty$ it then follows that intellectual property rights are tightened only gradually after announcement, and anticipation effects arise.

4.1 Rate of innovation and the number of goods not yet imitated

In this section we assume that $\nu = 0$ $(\sigma = 1)$ which is characteristic of the Cobb-Douglas function. This is an innocuous assumption since the qualitative results do not depend on the chosen functional form of the unit cost function. When Southern governments strengthen IPRs the rate of innovation raises on impact (see Lemma 2 in Stibora (2002)):

$$\widetilde{g}(0) = \frac{\beta}{\lambda_1(\lambda_1 + \beta)} \frac{(H^n - ag)m}{ag} \frac{(\lambda_1 - \rho)}{(\lambda_1 + g + m)} \kappa > 0. \tag{24}$$

Stricter enforcement of property rights causes, on impact, the profit rate to exceed the effective cost of capital as on average the duration of a monopoly position increases, for a given rate of innovation (see (20)). The relative higher profit opportunities stimulate innovation and g increases mitigating the initial gap between the effective cost of capital and the profit rate. The impact effect on the rate of change of the fraction of varieties not yet imitated is unambiguously positive:

$$\frac{1}{m} \dot{\tilde{\zeta}}(0) = -\widetilde{m}(0) + \frac{\beta}{\lambda_1(\lambda_1 + \beta)} \frac{(H^n - ag)m}{ag} \frac{(\lambda_1 - \rho)}{(\lambda_1 + g + m)} \kappa. \tag{25}$$

If the policy is introduced without prior announcement, i.e. $\beta \to \infty$ and $\widetilde{m}(0) = -\kappa$, the rate of change in the fraction of goods not yet imitated increases.

If, on the other hand, the policy is announced at $t = 0$ to be implemented in some future time (i.e. $\widetilde{m}(0) = 0$ since $\beta < \infty$) the rate at which the share of Northern varieties not yet imitated also increases but at a smaller rate. Southern imitators already adjust their behavior and become more reluctant to imitate Northern goods in anticipation of possible tougher prosecution.

As time goes by, however, the initial development in the rate of innovation is reversed and starts to decline as ζ increases. A higher fraction of Northern goods not yet imitated reduces the profit rate over time since more firms in the North compete for a given amount of resources. Eventually, the rate of innovation settles at a lower rate than before the policy shock. The transition path for the rate of innovation follows the following time path:

$$\begin{aligned} \widetilde{g}(t) = \; & \widetilde{g}(0)\left[1 + A(\lambda_2, t)\right] - \widetilde{g}(\infty) A(\lambda_2, t) \\ & + \frac{\kappa}{(\lambda_1 + \beta)} \left\{(a_{11} + \beta)\delta_g - a_{21}\delta_m\right\} T(\beta, \lambda_2, t), \end{aligned} \tag{26}$$

where $A(\lambda_2, t)$ denotes a single adjustment term and $T(\beta, \lambda_2, t)$ represents a transition term:

$$T(\beta, \lambda_2, t) \equiv \begin{cases} \frac{e^{-\beta t} - e^{-\lambda_2 t}}{\lambda_2 - \beta} & \text{for } \beta \neq \lambda_2 \\ \\ t e^{-\lambda_2 t} & \text{for } \beta = \lambda_2, \end{cases} \tag{27}$$

and $\widetilde{g}(\infty)$ stands for the long-run effect on the rate of innovation:

$$\widetilde{g}(\infty) = -\frac{\kappa}{\lambda_1 \lambda_2} \frac{(H^n - ag)m}{ag} \rho < 0. \tag{28}$$

The first two terms on the right hand side of (26) reflect the path of transition when the policy is implemented permanently and without prior announcement. The third term in (26) is the transition term $T(\beta, \lambda_2, t)$ reflecting modifications to the transition path brought about by gradually implementing stronger IPRs. The transition term is bell-shaped and zero at impact and in the long-run, and positive during the transition (see Bovenberg & Heijdra (2001)). The transition term is zero in case the policy shock is introduced without prior announcement, i.e. $\beta \to \infty$. For a finite β intellectual property rights are tightened gradually. Suppose the Southern government announces at $t_0 = 0$ that the rate of imitation will fall permanently at some point in the future, say, t_1. The anticipation of future changes in the rate of imitation will have an effect on today's rate of innovation and the fraction of goods not yet imitated. When Northern firms learn at $t_0 = 0$ that the rate of imitation will decrease in the future, they expect to stay longer on the market which boosts the return to innovation. The rate of innovation the world economy experiences at exactly t_1 increases. Since the higher R&D activities result in an increasing demand for capital, it will be relatively more expensive to increase R&D activities right before the reduction in the rate of imitation. Hence, R&D activities will start to increase today even though the rate of imitation is still unchanged. This is reflected in the last term on the right hand side of (26).

The fraction of Northern goods not yet imitated starts increasing from $t_0 = 0$ because newly developed goods are less likely imitated in anticipation of stricter property rights policy. In particular, the fraction of Northern goods not yet imitated follows the following time path:

$$\widetilde{\zeta}(t) = -\widetilde{\zeta}(\infty)A(\lambda_2, t) + \frac{\kappa}{(\lambda_1 + \beta)}\left\{(a_{22} + \beta)\delta_m - a_{12}\delta_g\right\}T(\beta, \lambda_2, t), \tag{29}$$

where

$$\widetilde{\zeta}(\infty) = \frac{\kappa}{\lambda_1\lambda_2}\left\{(g + \rho + m)\left\{\tfrac{b^n}{1-b^n}\tfrac{\alpha}{1-\alpha}\zeta + 1\right\} + \tfrac{(H^n - ag)m}{ag}\right\}m > 0 \tag{30}$$

denotes the long-run effect on the number of goods not yet imitated.

The phase diagram for the rate of growth and the fraction of goods not imitated, see Figure 2, illustrates the transition towards the new steady state. In terms of Figure 2, a reduction in the rate of imitation reduces the rate of innovation and increases the fraction of goods not yet imitated and shifts the new long-run equilibrium down and to the right to point E_1. Hence, the long-run fraction of Northern goods that have not been imitated increases while the rate of innovation declines. The arrows denoted by '0' show the dynamic forces associated with the old equilibrium, and $g(\zeta)$ denotes the saddle path that passes through the new equilibrium E_1.

If the rate of imitation changes abruptly ($\beta \rightarrow \infty$), the growth rate jumps at time $t_0 = 0$ from E_0 to A (see equation (24)) onto the saddle path, after which the economy gradually adjusts toward E_1. The first two terms in (26) and the first term in (29) describe this path. A more relevant analysis in terms of the TRIPs agreement is to look at the effect of tighter IPRs announced at time t_0, to be undertaken at some time t_1 in the future ($\beta < \infty$). The initial equilibrium is shown at point E_0. Once the policy has changed, the two curves will shift to the right and down. As before, the rate of innovation changes discretely but not all the way to the new stable arm. To see this, suppose g jumps all the way to the new stable arm. The old dynamics say that both g and ζ will start to increase after the initial jump. Hence, not only will we leave the new stable arm but also we will get further away from it. This implies that we cannot be on the stable arm at t_1. Hence, g will jump but not all the way to the new stable arm. Say g jumps from E_0 to C. Between the announcement and the actual implementation of the policy the fraction of goods not yet imitated increases and we move -governed by the old dynamics- from C to D. After implementation, the new dynamics take over and we move gradually along the new stable arm from D to E_1. The smaller is β, the slower Southern governments adopt a stronger intellectual property rights regime, the lower is the jump in g and the longer is the transition period during which the growth rate accelerates.

The dynamic forces in Figure 2 also show that the adjustment of the rate of innovation is not necessarily monotonic. An application of the initial value theorem describes the initial development in the rate of innovation as (Spiegel (1965))

$$\frac{ag}{m(H^n - ag)} \dot{\tilde{g}}(0) = \widetilde{m}(0) + \frac{\beta(\lambda_1 - \rho)}{\lambda_1(\beta + \lambda_1)}\kappa. \tag{31}$$

If the policy change is announced without being implemented yet at $t_0 = 0$, (i.e. $\widetilde{m}(0) = 0$ since $\beta < \infty$), the time rate of change in the rate of innovation is positive. The dynamic forces of the old equilibrium forces g and ζ to increase after the initial jump and that after a period of time we land on the new stable arm. In contrast, if the shock is introduced abruptly (i.e. $\widetilde{m}(0) = -\kappa$ since $\beta \to \infty$) the time rate of change in the rate of innovation is negative. The rate of innovation g jumps all the way to the new stable arm and decreases toward the new balanced growth path.

PROPOSITION 1: *The solution paths for the rate of innovation and the share of varieties not yet imitated, given by (26) and (29) can be characterized in the following way: (i) After an initial increase at the time of the policy shock, the adjustment path of the rate of innovation is non-monotonic unless the policy is implemented unannounced and abruptly. (ii) The adjustment path of the share of varieties that have not been imitated is monotonic. Proof: Stibora (2003a).*

Note, it is this non-monotonicity in the adjustment path of the rate of innovation positive welfare effects for the South might originate from.

4.2 Factor prices and good prices

In this section we turn to the effects of tighter IPRs on prices. Since results of this section depend crucially on the degree of factor substitution we adopt the CES specification. Under these circumstances the factor-market clearing relative wage rate prevailing in the North is calculated as[12]

$$\omega^n \equiv \frac{w_l^n}{w_h^n} = \left(\frac{1 - b^n}{b^n}\right)\left(\frac{H^n - ag}{L^n}\right)^{(1-\nu^n)}. \tag{32}$$

[12] Note, the factor market clearing relative wage rate in the South is unaffected by the change in the growth rate.

Note, we choose as numeraire $w_h^n = w_h^s = 1$. A differentiation of (32) and substituting (26) into the resulting expression yields the following time path for the relative wage rate:

$$\widetilde{\omega}^n(t) = -(1-\nu^n)\left[\frac{ag}{H^n - ag}\right]\widetilde{g}(t) \qquad \nu^n \in [-\infty, 1). \tag{33}$$

Equation (33) shows that the adjustment path of the relative wage rate is inversely related to the adjustment path of the rate of innovation as long as factors of production are imperfect substitutes and is amplified by the elasticity of substitution in production. An instantaneous introduction of the policy (i.e. $\beta \to \infty$) leads to a drop in the relative wage of labor on impact according to

$$\widetilde{\omega}^n(0) = -(1-\nu^n)\frac{\beta(\lambda_1 - \rho)}{\lambda_1(\beta + \lambda_1)(\rho + \lambda_1 + m)}.$$

Thereafter the relative wage rate starts to increase. If, on the contrary, the policy is gradually introduced, the relative wage rate in the North also falls on impact. In comparison to the abrupt policy change the fall in the relative wage is of lower magnitude, though. Between the announcement and the actual implementation of the policy the relative wage of capital increases; peaks exactly at t_1 -the time the shock is implemented- and starts to decline gradually along the stable saddle path. By substituting the steady-state growth rate (28) into (33) the long-run effect on the relative wage rate is obtained:

$$\widetilde{\omega}^n(\infty) = (1-\nu^n)\frac{m\kappa}{\lambda_1\lambda_2}\rho \geq 0. \tag{34}$$

The relative wage rate prevailing in the new steady state is higher the more capital and labor are complements in manufactures. Intuitively, stricter intellectual property rights improve profit opportunities and stimulate innovation for which more capital is required to accommodate the higher research activities. The increase in the demand for capital in the North leads to an increase in the relative wage of capital and, therefore, to a fall in ω^n as long as $\nu^n < 1$ (i.e. $\sigma < \infty$). The lower the elasticity of substitution, the larger the change in the relative price of capital required to clear factor markets. Over time when g falls and the share of Northern goods not yet imitated expands, the demand by manufacturing firms for labor increases. Since R&D is relatively capital-intensive the relative Northern wage rate starts rising and raises above the initial rate in the new steady state as long as factors are imperfect substitutes. The rise in the relative price of labor is an incentive for Northern firms to substitute capital for labor at a given level of output. By raising the marginal cost of producing output, a rise in the relative price of labor leads to a lower output reducing the demand for both capital and labor. The more both factors are complements in the production of manufactures the less they will substitute capital for labor. As a consequence, the relative wage of labor prevailing in the new steady state will be higher. Of course, if factors are perfect substitutes (i.e. $\nu^n = 1$) manufactures will reduce the quantity of labor demanded and increase the demand for capital at any particular output level such that the quantity of capital demanded will rise leaving the relative wage rate unchanged.

Changes in the Northern relative wage rate have a direct bearing on the price of manufactures. The time path of the Northern terms of trade is a weighted combination of the induced effect on the share of varieties not yet imitated and the induced effect on the rate of innovation:

$$\varepsilon \widetilde{\left(\frac{p^n}{p^s}(t)\right)} = \frac{1}{(1-\zeta)}\widetilde{\zeta}(t) + \frac{\phi_h^n a g}{(H^n - ag)}\widetilde{g}(t). \tag{35}$$

It is apparent from (35) that the relative change Northern's terms of trade is determined by a shift in the interregional distribution of varieties and the change in the rate of innovation, which in turn is determined by the reallocation of resources between R&D and manufactures. On impact, stricter IPRs improve Northern terms of trade regardless of the value of β. As time goes by, ζ starts rising while g increases temporarily if the policy is announced to be implemented in the future, but decreases otherwise. As production shifts to the North, manufactures demand relatively more labor. At the same time, the temporarily acceleration in the rate of innovation increases the demand for capital by the R&D sector. Both effects lead to relative higher product prices in the North. Eventually, while ζ still rising, g starts to fall. As a result, there will be an excess supply of capital and an excess demand for labor in the North. The former requires a drop in the return to capital while the latter an increase in the return to labor, rendering the long-run effect on Northern's terms of trade ambiguous. Combining (30), (28), and (35), we obtain the following expression for the long-run effect of Northern's terms of trade:

$$\varepsilon \widetilde{\left(\frac{p^n}{p^s}(\infty)\right)} = \frac{\kappa m}{\lambda_1\lambda_2(1-\phi_l^n\nu^n)}\left\{\frac{(g+\rho+m)}{(1-\zeta)}\left(\phi_h^n(\nu^n + \frac{\alpha}{(1-\alpha)}[\zeta+1]) + (1-\nu^n)\right) - \phi_h^n\rho\right\}.$$

We show in the appendix that in the new steady state the terms of trade improve for the North. (Proof: see Stibora (2003a)) That is, the increase in the return to labor due to higher ζ is larger than the drop in the return to capital caused by the reduction in the rate of innovation. The discussion of this section is summarized in numerical form in Table 1, which reports simulation results for some key variables assuming different values of the elasticity of factor substitution in production.

		$\nu^n = \nu^s = 0.8$	$\nu^n = \nu^s = 0$	$\nu^n = \nu^s = -5$
$\widetilde{g}(0)$	β small	38.32	30.8	36
	β large	430	306	348
$\widetilde{g}(\infty)$		-0.254	-0.243	-0.288
$\widetilde{\zeta}(\infty)$		0.100	0.108	0.114
$\widetilde{\omega}(0)$	β small	-21.5	-65.9	-335
	β large	-242.55	-656	-3250
$\widetilde{\omega}(\infty)$		0.142	0.519	2.63
$(\widetilde{\frac{p^n}{p^s}}(\infty))$		0.22	0.24	0.17

Table 1: Parameter values are $\alpha = 0.4$, $a = 1$, $b^n = 0.7$, $b^s = 0.4$, $\rho = 0.05$, $H^n = 70$, $H^s = 40$, $L^n = 45$, $L^s = 50$, $m = 8$, β small $= 10$, β large $= 10^5$.

So far we have shown that if the shock is unannounced and instantaneously implemented, i.e. $\beta \to \infty$, (i) the rate of innovation and therefore the number of available varieties increases at impact and subsequently decrease; (ii) capital owners gain in the beginning but lose over time relative to labor; However, if the policy shock is introduced gradually, i.e. $\beta < \infty$, (i$'$) after an initial jump, the rate of innovation increases gradually and subsequently decreases; (ii$'$) capital owners gain over a longer period of time but lose eventually relative to labor. All consumers temporarily gain from the increase in product availability but are affected differently by the change in the relative reward to labor over time. In addition, all consumers lose from the relative higher prices of Northern produced varieties. Northern region gains from improved terms of trade which is a deterioration of Southern's terms of trade. For a complete welfare evaluation, we have to add the time profile of all the relevant variables. This is to what we turn next.

5 Welfare analysis

We divide the discussion on welfare into two sub-section. In the first part we consider how tighter intellectual property rights affect inter-regional income distribution, that is, we compare aggregate welfare effects. We thereby distinguish between gradual and abrupt implementation of the policy shock. In the second part we turn to intra-regional welfare effects when individuals differ in their factor endowment. The expression for the change in the present value flow of utility due to tighter TRIPs is derived by totally differentiating (1) as of time $t = 0$ and making use of (26) and (29).[13]

5.1 Inter-regional Income Distribution

5.1.1 Welfare evaluation for the South

Assuming that the policy shock is abrupt and unannounced (i.e. $\beta \to \infty$), the change in the discounted flow of Southern utility can be calculated as:

$$\begin{aligned}(\rho+\lambda_2)dU^s(0) = \quad & -\frac{(H^n - ag)m\kappa}{\rho(\varepsilon-1)\lambda_1 a(1-\phi_l^n \nu^n)}\left(\frac{\rho+g+m}{\lambda_1+g+m}\right) \\ & +\frac{\alpha\zeta\phi_h^n m\kappa}{(\varepsilon-1)\left[\zeta+(1-\zeta)\theta^\alpha\right]\lambda_1(1-\phi_l^n\nu^n)}\left(\frac{\rho+g+m}{\lambda_1+g+m}\right) \\ & -\frac{\zeta\lambda_2\alpha}{(\varepsilon-1)\rho\left[\zeta+(1-\zeta)\theta^\alpha\right](1-\zeta)}\widetilde{\zeta}(\infty) \\ & -\frac{\zeta\lambda_2(\theta^\alpha-1)}{(\varepsilon-1)\rho\left[\zeta+(1-\zeta)\theta^\alpha\right]}\widetilde{\zeta}(\infty),\end{aligned} \tag{36}$$

where $\widetilde{\zeta}(\infty)$ is given by (30), $\theta > 1$, and $p^n/p^s \equiv \theta^{1/\varepsilon}$. The first line in (36) represents the product availability effect, which is negative. The initial increase in the amount of varieties available is more than compensated by the subsequent drop in the rate of innovation. In case consumer value varieties per se their flow of utility decreases. The second and third line reflects the change in South's terms of trade holding constant, the weights $\zeta(t)$ and $(1-\zeta(t))$. The change in the relative prices is influenced by the change in the rate of innovation (the first part of this expression) and by the change in the share of goods produced in the North. The initial increase in the rate of innovation leads to a deterioration of South's terms of trade which is reversed by the subsequent drop in g. In present value terms, discounted with the subjective rate of time preference, ρ, the South's terms of trade improve due to changes in the rate of innovation. However, this is counterbalanced by higher Northern prices of manufactures brought about by the higher share of goods manufactured in the North as well as by the increase in the duration Northern goods are able to produce varieties without being imitated. The resulting increase in the demand for production factors causes the Northern relative price of labor to increase. Because Northern production of manufactures is relatively labor intensive, prices for Northern final goods go up. This renders the total effect of the change in Southern terms of trade on Southern welfare ambiguous. As shown the overall effect is negative. The last line of (36) represents the interregional product reallocation effect, holding constant relative prices. A lower rate of imitation lowers the share of goods

[13] A detailed description of all expressions discussed in this section is given in the appendix that is available on request.

produced in the South. Since this implies a shift from the low cost producing South towards the high cost producing North, this effect enters negatively into the welfare expression. The total effect of tighter intellectual property rights on Southern welfare is negative, a result derived by Helpman (1993) though in a different way.

Next consider the effects on Southern welfare if the policy is introduced gradually, i.e. $\beta \ll \infty$. In this case anticipation effects become relevant and expression (36) simplifies to

$$\begin{aligned}(\rho+\lambda_2)dU_a^s(0) = \; & \frac{\beta}{(\lambda_1+\beta)}\{(\rho+\lambda_2)dU^s(0) \\ & -\frac{a^s}{\rho(\beta+\rho)}\left[\lambda_1\lambda_2\widetilde{\zeta}(\infty)-\kappa m\rho\right]\right\},\end{aligned} \tag{37}$$

where

$$\begin{aligned}a^s = \; & \frac{\zeta\alpha}{(\varepsilon-1)\rho\left[\zeta+(1-\zeta)\theta^\alpha\right](1-\zeta)} \\ & +\frac{\zeta\lambda_2(\theta^\alpha-1)}{(\varepsilon-1)\rho\left[\zeta+(1-\zeta)\theta^\alpha\right]} > 0, \\ & \left[\lambda_1\lambda_2\widetilde{\zeta}(\infty)-\kappa m\rho\right] > 0,\end{aligned}$$

and where $(\rho+\lambda_2)dU^s(0)$ is given by (36). The variable a^s consists of two parts: (1) is that part of the terms of trade effect accounting for the increase in Northern relative prices due to the increase in ζ and (2) the product reallocation effect. Both effects reduce Southern welfare. The expression (37) shows that the change in the discounted flow of Southern utility when the policy shock is gradually introduced can be decomposed into two parts: the discounted flow of Southern utility when the shock is not announced, $dU^s(0)$, and a transition term reflecting the movement of ζ along the transition path, both weighted by a factor of proportionality $\beta/(\beta+\lambda_1) < 1$.

It is apparent from (37) that even in the case of a gradual implementation of the policy tighter IPRs exert a negative influence on Southern's discounted flow of utility. In contrast to the case when the shock is implemented without announcement, however, the welfare loses turn out to be lower. When the shock is introduced gradually, the initial jump in the rate of innovation is smaller and in addition the rate of innovation subsequently increases before decreasing eventually. The smoother time path in the rate of innovation leads to a relatively lower increase in the return to human capital and a smaller initial deterioration in the Southern's terms of trade leading to lower welfare losses (see Figure 2). This is captured in the first part of (37). Even when the policy shock is implemented slowly though production starts to reallocate immediately to the North and Southern terms of trade deteriorate, reducing Southern welfare. This is captured in the second part of (37). For a low enough β the welfare improving effect brought about by the positive growth rate along the transition path dominates the welfare reducing effect in the development of the share of products not yet imitated, ζ, along the transitional path and reduces the welfare losses experienced by the South.

On should expect that the long-run losses experienced by the South to be more than compensated by the short-run gains if the subjective discount rate had been high. For a positive value of the rate of time preference, ρ, means that utils are valued less the later they are received. Thus, one should expect that the welfare loss experienced by the South is lower for high ρ. In case the shock is introduced abruptly, this conclusion is not correct. A higher subjective discount rate only leads to a smaller increase in the rate of innovation on impact (see (24)) and a lower speed at which production reallocates from South towards the North (see (25)), while the long-run rate of innovation declines by more (see (28)) and the long-run share of varieties not yet imitated increase by more (see (30)). However, when the shock is introduced gradually transition effects now become important. Since the transition effects occur in the earlier periods of the policy shock, higher subjective discount rates should raise welfare. Since the rate of innovation accelerates succeeding the impact effect, the product availability effect enters with a lower weight in the welfare expression the higher is ρ. This also implies that the positive effect of g on Southern's terms of trade is also larger. A higher subjective discount rate also leads to a smaller change in ζ on impact. Thus, the negative welfare effect brought about by the interregional allocation of varieties gets smaller for higher ρ as does the effect of ζ on Southern's terms of trade (see (37)). The more myopic are individuals in the South the more value they attach to the transitional gains coming from the temporary acceleration in the rate of innovation and less to the negative effect of the increase in the share of Northern goods not yet imitated.

PROPOSITION 2: *For economies that begin in the steady state, (i) the South loses from tighter intellectual property rights regardless of β. (ii) The losses experienced by South are mitigated, however, when the policy is introduced sufficiently slowly. Proof: Stibora (2003a)*

5.1.2 Welfare evaluation for the North

We next turn the aggregate welfare effects of tighter intellectual property rights in the North. As before we distinguish between abrupt ($\beta \to \infty$) and gradual ($\beta \ll \infty$) implementation of the policy shock. In case the change is introduced without announcement the present value of North's utility flow can be expressed as

$$
\begin{aligned}
(\rho+\lambda_2)dU^n(0) = & -\frac{\kappa(H^n-ag)m}{\rho(\varepsilon-1)\lambda_1 a(1-\phi_l^n\nu^n)}\left(\frac{\rho+g+m}{\lambda_1+g+m}\right) \\
& +\frac{\kappa m\phi_h^n}{\lambda_1(1-\phi_l^n\nu^n)\varepsilon}\left(\frac{\rho+g+m}{\lambda_1+g+m}\right) \\
& -\frac{\kappa m\phi_h^n}{\lambda_1(1-\phi_l^n\nu^n)}\frac{(1-\zeta)\theta^\alpha}{\varepsilon[\zeta+(1-\zeta)\theta^\alpha]}\left(\frac{\rho+g+m}{\lambda_1+g+m}\right)+\frac{\lambda_2}{\rho}a_\theta^n\widetilde{\zeta}(\infty) \\
& -\frac{\lambda_2\zeta(\theta^\alpha-1)}{(\varepsilon-1)\rho\left[\zeta+(1-\zeta)\theta^\alpha\right]}\widetilde{\zeta}(\infty).
\end{aligned}
\tag{38}
$$

where $\widetilde{\zeta}(\infty)$ is given by (30) and $a_\theta^n > 0$. The first line in (38) represents the by now familiar product variety effect. The second line denotes the effects of intertemporal reallocation of R&D spending on welfare. This effect turns out to be positive. The third line represents the welfare effect brought about by the change in the terms of trade. Since South's terms of trade deteriorate, Northern's term of trade improve. The last line in (38) denotes the interregional product allocation effect holding constant relative prices, which is negative. Adding up the individual components renders the change in the discounted flow of Northern utility ambiguous. However, combining the product availability effect with the savings effect results in a the reduction in North's welfare. In addition, for rates of imitation close to zero, the negative production allocation effect more than compensates the positive terms of trade effect (see appendix). For m sufficiently small, the relative price of Southern's product is very small and also their share in the price index rendering the negative production reallocation effect dominant. This confirms the result derived by Helpman (1993) though in a different form.

When the shock is introduced gradually, i.e. $\beta < \infty$, the change in the discounted flow of Northern utility simplifies to

$$
\begin{aligned}
(\rho+\lambda_2)dU_a^n(0) = & \frac{\beta}{\beta+\lambda_1}\Big\{(\rho+\lambda_2)dU^n(0) \\
& +\frac{a_\theta^n+a_\zeta^n}{\rho(\beta+\rho)}\left[\lambda_1\lambda_2\widetilde{\zeta}(\infty)-\kappa m\rho\right]\Big\}.
\end{aligned}
\tag{39}
$$

where $(\rho+\lambda_2)dU^n(0)$ is given by (38), $a_\theta^n > 0$, and $a_\zeta^n < 0$. The first term in (39) reflects the change in life time utility when the policy shock is implemented without prior information; this term is negative for m sufficiently small. The second term reflects the influence exerted by the movement of ζ on the terms of trade and the production reallocation along the transition path (movement from C to D, for example, in Figure 2). While the increase in the share of goods that have not yet been imitated improves Northern terms of trade,

$a^n_\theta > 0$, the reallocation of products from the low cost producing South towards the high cost producing North, $a^n_\zeta < 0$, reduces North's welfare. For m sufficiently small, however, the negative product reallocation effect dominates the terms of trade effect along the transition path rendering the expression in (39) negative. Similar to the discussion of (37) Northern welfare losses are smaller the more gradual tighter intellectual property rights are introduced in the South. We summarize the result of this section in the following proposition.

PROPOSITION 3: *For economies that begin in the steady state and small rates of imitation (i) the North loses from tighter intellectual property rights regardless of β. (ii) The losses experienced by North are mitigated, however, when the policy is introduced sufficiently slowly. Proof: Stibora (2003a)*

5.2 Intra-regional welfare effects.

So far we have established conditions under which regions might benefit and lose from tighter intellectual property rights in the South, thereby providing insights into conflicts between regions. However, it is also interesting to consider the question of which individuals have an vested interest in such a policy change. This applies in particular to the relative capital abundant North. By restricting the free use of one inventor's ideas secures primarily the monopoly rent of large corporations. At the same time, the increase in the expected duration of monopoly of each Northern firm raises the demand for labor and wages thereby providing a common platform for these groups to exert political pressure on Northern governments to push for global protection of IPRs.

In order to assess those political economy arguments we relax the assumption that agents have identical endowments. We allow a person to own more than one factor and that factor ownership shares differ between individuals. If intellectual property rights are tightened, all individuals are facing identical changes in the rate of innovation, the relative factor prices and goods prices. However, they are differently affected with regard to their income share. Some will gain while others will lose depending on the inequality in the factor ownership distribution. Assuming that production function is Cobb-Douglas and the policy shock is implemented abruptly and without announcement, the change in life-time utility can be compactly expressed as

$$(\rho+\lambda_2)dU^n_i(0) = (\rho+\lambda_2)dU^n(0) + \frac{\kappa m}{\lambda_1}\frac{\omega^n(h^n-h^n_i)}{(\omega^n+h^n)(\omega^n+h^n_i)}\left(\frac{\rho+g+m}{\lambda_1+g+m}\right) \qquad (40)$$

where $h^n \equiv H^n/L^n$ and $h^n_i \equiv H^n_i/L^n_i$. The first term represents the expression derived for the aggregate welfare change, (38), consisting of variety effect, intertemporal savings effect, the terms of trade effect, and the production reallocation effect. The last expression in

(40) represents the effect of the change in the individual's income share on welfare due to tighter intellectual property rights. The direction of the change of a person's income share is determined by the individual's relative factor endowment compared to the region as a whole. Equation (40) reveals that tighter intellectual property rights decreases (increases) the income share for the ith person if the individual, compared to the region, is relatively well (poorly) endowed with capital, $h_i^n > h^n$ ($h_i^n < h^n$). When unannounced, tighter intellectual property rights lead to a drop in the relative wage of unskilled labor in the immediate aftermath of the policy change. Subsequently the growth rate slows down and production shifts to the North causing an increase in demand for production factors and hence to a rise in the relative wage of unskilled labor. As it turns out, a laborer endowed with relatively little capital experiences an improvement in its income share; that is, initial losses are more than compensated by future gains.

As is apparent from (40), the relationship between the level of imitation and a person's income share does not only depend on that person's endowments but also on the production structure through which the relative wage rate and the rate of innovation are linked. In case production factors are perfect substitutes the factor income effect is absent. In the appendix we show that the income share expression also approaches zero when the factor of production become perfect complements. The less capital and labor can be substituted in the production process, the larger the volatility in the relative wage rate to clear the factor markets over time. The long-run relative wage rate is higher the lower the substitutability (see ()) such that the income of an individual increases but since total income increases by more the person's factor income share falls. As a consequence there exists a non-monotonic relationship between the degree of factor substitution and the change in the income share as depicted in Figure 3. The income share effect is zero for perfect substitutes, positive for constant unitary elasticity of substitution, and falling for lower values of the elasticity of substitution.

In case the production function is Cobb-Douglas and the ith person's relative factor endowment falls short of the nation's average ($h_i^n < h^n$) the total effect on this person's discounted flow of welfare, however, is ambiguous. The smaller the rate of imitation, the smaller the welfare gains on account of changes in the income share and as a consequence the previously discussed welfare losses dominate the total welfare effect of a person.

PROPOSITION 4: *For economies that begin in the steady state with small rates of imitation, tighter intellectual property rights benefit all those individuals in the North whose capital-labor ratio is below the national average given that the elasticity of substitution is unitary and hurt all those individuals in the North whose capital-labor ratio is above the national average on account of changes in the income share.*

For economies that begin in the steady state with small rates of imitation, tighter intellectual property rights hurt both labor and capital owners whereby the welfare losses are smaller for laborers. Proof Stibora (2003a)

The analysis shows that both human capital and labor lose from tighter intellectual property rights if the initial rate of imitation is small. The economic foundation of a common interest between unskilled labor and large corporations for in tighter intellectual property rights therefore is very weak.

6 Concluding remarks

During the 1990s, the global regime of IPRs protection strengthened dramatically, primarily through the TRIPs (Trade-Related Aspects of Intellectual Property Rights). The TRIPs is an international agreement that sets out minimum standards for the legal protection of intellectual property rights. The agreement is not only about reform in developing nations. Several developed countries have also changed their intellectual property laws to comply with TRIPs. However, the TRIPs accord places much higher demands for reform of the IPRs regimes in many developing countries. To comply with the obligations of the agreement transition periods were granted mainly according to the level of economic development. The world's poorest countries were given until 2006 to obey in full with the requirements of the agreement. This paper examines the welfare consequences of tighter intellectual property rights for less developed countries in an endogenous growth model. We thereby distinguish between a gradual and an abrupt implementation of tighter intellectual property rights.

We show that an abrupt change in the policy regime results in a welfare loss for less developed countries. Tighter IPRs lead to a deterioration of Southern's terms of trade and reallocates production from the lower cost producing South to the higher cost producing North, which hurts the South. Tighter IPRs also affect the growth rate. The rate of innovation initially accelerates before it subsequently slows down. The initial acceleration, however, is insufficient to compensate for the eventual decline. On account of these three effects the South is worse off. By introducing tighter IPRs gradually, however, welfare losses are mitigated. The anticipation of the policy change leads to a prolonged period of higher growth rate before it eventually settles on a lower time path. The smoother transition path of the rate of innovation in itself is beneficial and mitigates also the adverse effect on Southern's terms of trade and the reallocation of production, thereby reducing Southern welfare losses.

The welfare changes brought about by tighter IPRs in the South are less clear cut for the innovating North. Stronger enforcements of IPRs lead to a higher savings rate in the

North which is welfare enhancing. However, the adjustment path in the savings and R&D investment rate is not sufficient to compensate the loss brought about the decline in time profile of product varieties and therefore reducing North's welfare on account of these two effect. Moreover, the reallocation of production toward the higher cost producing North is welfare reducing and dominates the improved terms of trade for small rates of imitation. Overall, tighter IPRs have a negative effect on the aggregate welfare of the North when the rate of imitation is small. If IPRs are gradually changed North's welfare losses are mitigated. As a result, generous transition periods may not only be justified on the grounds of the time required to develop a proper administration but may also be justified on grounds of economic reasons.

The second purpose of this paper is to look into possible sources of conflicts of interests within a region. To this end we introduce besides labor a second factor of production, capital. It is assumed that both factors substitute only imperfectly with each other. As a result, when factor ownership differs among individuals in a region, their welfare is not affected uniformly if intellectual property rights infringements are more rigorously enforced. Assuming that the North is relatively human capital abundant and Northern manufactures are relatively labor intensive the initial acceleration in the rate of innovation generates a drop in North's relative wage rate. The subsequent decline in the growth rate and the increase in the expected duration of Northern manufacturers increases the demand for labor leading to an increase in the relative wage. The more complementary labor and capital, the higher the long-run relative Northern wage rate. It than follows that a person's welfare is raised on account of the change in the income share if the individual, compared to the nation as a whole, is relatively well endowed with labor. The total welfare of tighter intellectual property rights for this individual, however is not clear and depends on the degree of the elasticity of substitution and the initial rate of imitation.

REFERENCES

Alesina, A., and Rodrik, D. 1994, Distributive Politics and Economic Growth, Quarterly Journal of Economics 109(2), p 465.

Bovenberg, A.L. and B. J. Heijdra, 2002, Enviromental abatement and intergenerational distribution, Environmental and Resource Economics, 21, 317-342.

Bovenberg, A.L. and B. J. Heijdra, 2001, Enviromental abatement and intergenerational distribution: Mathematical appendix. Mimeo, University of Groningen. Download from: http://www.eco.rug.nl/medewerk/heijdra/download.htm.

Grossman, G. M. and E. Helpman, 1991, Innovation and Growth in the Global Economy, Cambridge, MA: MIT Press.

Helpman, E., 1993, Innovation, Imitation, and Intellectual Property Rights, Econometrica 61, 1247-1280.

Judd, K. L., 1999, Numerical Methods in Economics, Cambridge, MA: MIT Press.

Judd, K. L., 1982, An Alternative to Steady-State Comparisons in Perfect Foresight Models. Economics Letters 10, 55-59.

Lai, E.L.C., 1998, International intellectual property rights protection and the rate of product innovation, Journal of Development Economics, 55, 133-153.

Lai, E. L.C., 1995, The Product Cycle and the World Distribution of Income. A Reformulation, Journal of International Economics 39, 369-382.

Maskus, K.E., 2000, Intellectual Property Rights in the Global Economy, Institute for International Economics, Washington D.C.

Mayer, W., 1984, Endogenous Tariff Formation, American Economic Review 74, 970-985.

Mulligan C. B. and X. Sala-i-Martin, 1991, A Note On The Time-Elimination Method For Solving Recursive Dynamic Economic Models, Cambridge, MA: NBER Technical Working Paper Series No. 116.

Primo Braga, C.A., 1995, Trade-Related Intellectual Property Issues: The Uruguay Round Agreement and its Economic Implications, Presented at The Uruguay round and the Developing Economies, A World Bank Conference, Washington D.C.

Spiegel, M.R., 1965, Theory and Problems of Laplace Transforms, Schaum's outline series, McGraw-Hill, New York.

Stibora, J., 2003a, Innovation, Intellectual Property Rights, Imitation, and Income Distribution: Mathematical appendix. Mimeo, Kingston University. Download from: http://not yet available.

Stibora, J., 2003b, Multinationals, Imitation, and Welfare in a Model of Endogenous Growth. In progress.

The Economist, 2001, June 23rd, p. 28.

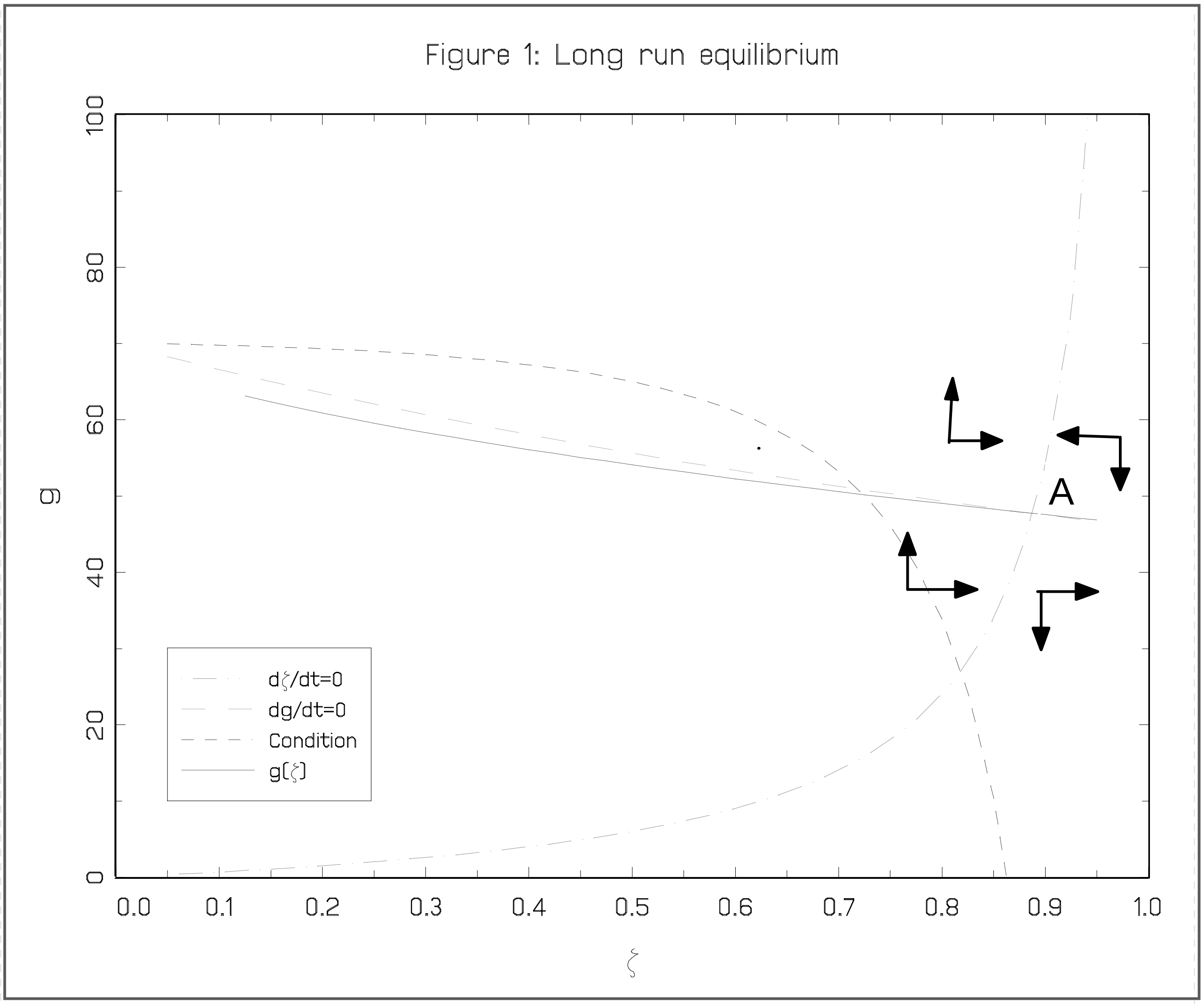
Figure 1: Long run equilibrium
g
ζ
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
20
40
60
80
100
A
dζ/dt=0
dg/dt=0
Condition
g(ζ)

Figure 2: Tighter IPRs

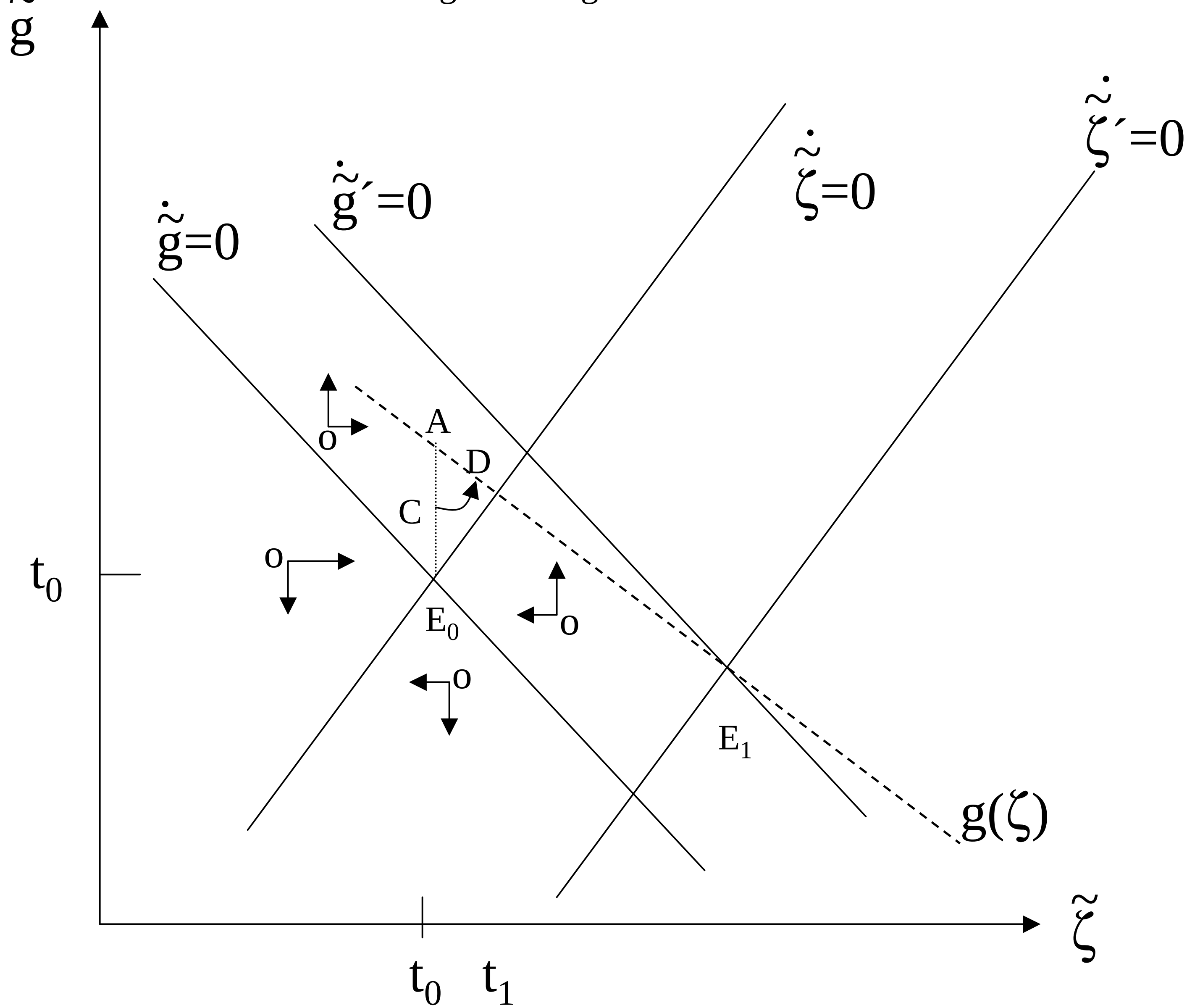

Figure 3: Change in factor income share: North