

Technology Transfer with Competitive Markets in the South

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Abstract

This paper develops a model of technology transfer in an environment where firms in developing countries are unable to recover the costs of imitation and adaptation, because a competitive market structure in the South rules out any monopoly rents accruing to Southern firms. In such an environment, the technology transfer must be initiated by a Northern firm which risks its technology being copied widely throughout the South because of lower production costs in the South and because its markets in the North are protected by strong intellectual property rights or by natural means. We provide examples to show that we are studying the transfer of technology in an environment that is empirically important for large numbers of developing countries. The results of the paper demonstrate why reducing the explicit costs of technology transfer for Northern firms should be a key policy objective for developing countries faced with such an environment. Furthermore, the results suggest (in contrast to the previous work) that in such an environment, developing countries do not experience the endogenous increase in their relative wages from accumulating resources or improving labor productivity. While improvements in the productivity of the technology transfer process can restore the endogenous increase in relative wages over some range, the relative wage of the South will eventually fall.

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1 Introduction.

The common theme underlying existing models technology transfer based on imitation is that the technology transfer (involving the costs of imitation and adaptation) is carried out by imitating firms in the receiving country because it yields them a stream of monopoly profits.¹ However, the concept of monopoly profits for firms in developing countries (the South) is difficult to justify in environments where markets are very competitive, intellectual property rights are weak, and the “formula for imitation”, once successful, spreads rapidly to other entrepreneurs. In the absence of any rents or monopoly profits, it is difficult to imagine why the costs of imitation would be incurred. Indeed, under such an environment of competitive markets in the South, without any monopoly rents or profits for imitating Southern firms (and in the face of costly imitation), we are in need of an alternative explanation for technology transfer from North to South.²

This paper, therefore, develops a model of technology transfer in an environment where firms in developing countries are unable to recover the costs of imitation and adaptation, because a competitive market structure in the South rules out any monopoly rents accruing to Southern firms.³ We propose a model where the technology transfer is initiated by the Northern firm. The Northern firm risks its technology being copied widely in the South because of lower production costs in the South and because its market in the North is protected by strong patents or other natural means. Examples of technology transfer under such an environment include subcontracting by Northern firms to firms in the South and the adaptation of “freely observable” technologies that are difficult to keep proprietary without strong intellectual property rights (IPR) protection in the South. The results of the paper demonstrate why reducing the explicit costs of technology transfer for Northern firms is of crucial importance for developing countries faced with such an environment. Furthermore, the results suggest (in contrast to the previous work) that in such an environment, develop-

¹See, for example, Grossman and Helpman (1991) and Helpman (1993).

²As we will argue, such environments are pervasive in large parts of the developing world, and we do observe technology transfer with competitive markets in the South.

³The concept of technology transfer we use throughout this paper is the migration of additional production processes to developing country locations (the South). Thus, technology is specific to product lines and essentially reflects knowledge and expertise to competitively organize production of a particular product and deliver it to buyers on the world market.

ing countries do not experience the endogenous increase in their (effective) relative wages from accumulating resources (or from improving labor productivity). While improvements in the productivity of the technology transfer process can restore the endogenous increase in relative wages over some range, the relative wage of the South will eventually fall.

We believe that we are studying the transfer of technology in an environment that is empirically important for large numbers of developing countries. Even in industrial countries, it is well known that innovation activity is associated with spillovers—i.e. innovating firms are unable to appropriate all of the benefits accruing from their research and development. In developing countries, there is good reason to believe that such spillovers may be pervasive enough to deny the imitating or adapting firm any ex-post rents whatsoever. First, IPR protection—which allows a firm to extend control over the fruits of its research effort—are weak or nonexistent in many developing countries. Second, developing countries are mostly engaged in the adaptation of existing production processes (as opposed to the discovery of new products) and in such circumstances, IPRs clearly afford imitating firms little or no protection. Third, most research effort in developing countries is directed toward process innovations, to adapt existing production processes to local conditions—once adapted successfully, the “formula” is readily observable and spreads rapidly to other entrepreneurs.

Hausmann and Rodrik (2003) recognize this particular nonappropriability problem in developing countries and they construct a model to explore its welfare implications. In their model, firms in developing countries are able to appropriate the rents associated with their adaptation activity for a temporary period only, after which the adapted production process becomes common knowledge. They show that the amount of imitation or adaptation investment in the decentralized equilibrium is less than in the social optimum.

The debate over the issue of intellectual property rights (IPR) enforcement in developing countries has featured prominently in recent World Trade Organization (WTO) rounds. Industry representatives from developed countries and multinational corporations have complained about staggering losses resulting from the lack of IPR protection in developing countries. PhRMA—the US pharmaceutical industry association—has estimated that losses for US drug companies attributable to deficient IPRs amount to \$500m per year from India

alone.⁴ However, much of the recent work on this topic has focussed on how the lack of IPR protection in developing countries (the South) affects the incentives for innovation by firms in developed countries (the North).⁵ The model in this paper, on the other hand, allows us to focus instead on the effect of poor Southern intellectual property rights protection on firms located in the South. Existing models of transfer based on imitation abstract from this issue. In the imitation model, poor Southern IPR affects only Northern firms and hence affects only the incentives for innovation. There is no effect on firms operating in the South and hence no effect on the incentives to transfer technology.⁶ In this paper, poor Southern IPR protection has two types of effects on firms operating in the South: (i) it denies Southern imitating firms any profits; (ii) for Northern firms, it means producing in the South will lose them part of their profits. This paper is, therefore, able to capture the effect of poor Southern IPR protection on the incentives to transfer technology to the South.

We highlight three primary results that emerge from our analysis. First, for reasonably low costs of technology transfer, the potential for shifting production to the South raises the world rate of product development. Second, an exogenous decline in the costs of transfer (through, for example, a reduction in the bureaucratic hassles associated with investing in developing countries), raises the rate of innovation, the share of products in the South (i.e. the rate of technology transfer), and the relative wage of the South. This happens even though a higher share of products in the South implies a greater *Southern market loss* for Northern firms transferring their technology and even though a higher Southern relative wage implies less *cost reduction* for Northern firms transferring their technology. The ability to raise the rate of technology transfer and the relative wage of the South at the same time thus makes reducing the costs of transfer a key policy objective for developing countries faced with such an environment.

⁴PhRMA (1999).

⁵Lanjouw and Cockburn (1999) and Kremer (1999). US International Trade Commission (1993) estimates that global patent piracy reduces the R&D investment of US pharmaceutical firms by \$720–\$900 million per year.

⁶In the existing imitation model, while poor Southern IPR protection allows a Northern firm's technology to be imitated by the Southern firm, once the imitated technology is in place in the South, poor Southern IPR protection poses no problems for the firm producing in the South.

Third, an increase in the scale of the South (through, for example, accumulation of resources or improvements in productivity of Southern workers) lowers the Southern relative wage, in spite of increasing the share of products in the South. This result is in contrast to previous models of endogenously determined technology transfer based on imitation activity of indigenous firms, where an increase in the scale of the South not only increases the share of products in the South, but also raises the Southern relative wage.⁷ This comparison illustrates why the inability of indigenous firms to appropriate the benefits of their imitation activity may serve as an impediment in the development process.

2 Supporting Observations & Case Study.

There exists good empirical support for the kind of environment described above. Simple observations of the process of technology flow to developing countries suggest that in certain instances, the transfer is in the form of technologies or “production processes” which do not yield the Southern producer any particular monopoly profit or rent stream. Why not? For some reason or the other, such production processes become freely available to any Southern producer, with the result that tough competition between Southern firms producing the same product drives them to marginal cost pricing. We can think of a number of different situations where this is the case:

Production processes are often subcontracted out by Northern firms to firms in the South. In such arrangements, the Northern firm will make its technology freely available to the subcontractor. If the subcontractor fails to supply at marginal cost, the Northern firm can simply make the production processes available to another subcontractor who will supply at marginal cost. We can also look beyond purely subcontracting relationships: exporters in developing countries often receive product designs from their importers in industrialized countries and these designs are an important source of learning for exporting firms.⁸

Certain products are such that the production process is common knowledge. In such cases,

⁷See Grossman and Helpman (1991), chapter 11.

⁸See Tybout, et. al. (1998).

the cost of “technology transfer” can be thought of as an adaptation cost; that is, the cost of figuring out how to implement that production process under local conditions. Once someone adapts the technology to local conditions, the adapted production process also becomes common knowledge and hence, freely available to Southern producers. Suppose, for illustrative purposes, that everyone knows how the production process for cement is organized. However, cement is only produced in Japan and so, we only know how the production process is organized in Japan. In order to produce cement in Thailand, we need to figure out how to adapt the production process to local conditions in Thailand. However, once someone does figure out how to organize cement production in Thailand, the adapted production process becomes common knowledge, just as the original production process was common knowledge.

A case in point: In the early 1980s, Bangladesh had virtually no garments industry. Jute was the principal export. At the time, however, Daewoo Corporation of South Korea entered into a joint venture with a Bangladeshi entrepreneur to set up production units in Bangladesh for a small number of lines of apparel products. The new venture was called the Desh Garment Company. Soon, large numbers of Bangladeshi entrepreneurs flocked to the apparel industry and set up units for a diverse variety of product lines to serve the world market. Currently, the garments industry in Bangladesh employs one and a half million people and generates over \$4 billion worth of exports.^{9,10}

Why don't Bangladeshi entrepreneurs enter the export market for products in a wholly different industry? Why do they not produce such items as alarm clocks or lamps; items which have similarly labor-intensive production processes; items which are being produced in China, Indonesia, etc.? When asked such questions, the Bangladeshi entrepreneur will tell you that when he goes about entering a product line in the garments industry, there exists a well-established formula for how to go about doing it: he knows how to contact

⁹Rhee (1990) documents in great detail how the 115 Daewoo-trained managers, supervisors, and workers who left the Desh Garment Company after the middle of 1981 played a key role in the mushrooming of export-oriented garment factories in Bangladesh.

¹⁰Rhee also notes that the initial Daewoo-Desh venture was the result of a larger proposal put forth by Daewoo for producing tires, leather goods, cement, and apparel in Bangladesh. In other words, it was not necessarily motivated by an exhausted Korean quota for apparel exports to the United States (under the Multi-Fibre Agreement).

buyers in the U.S. and Europe, he knows how to set up shop, etc. If he were to enter a product line in a wholly different industry, he would have no idea how to go about doing it. The well established formula implies that the production processes for products in the garments industry are freely available or costlessly imitated (because of the initial transfer) whereas imitation of a product in a wholly different industry involves imitation and adaptation costs. Since imitating a wholly new product will not lead to any rents or profits, local entrepreneurs are reluctant to incur the imitation cost.

A crucial issue for the empirical environment examined in this paper is that firms are unable to charge markups in LDC markets but are able to do so in developed country markets. This is a simple result of the asymmetry in IPRs protection between North and South. Table A provides price comparisons for a number of “on-patent” drugs in India, the U.K. and the U.S. Quiet clearly, in India, firms are unable to charge the large markups that are common in US and UK markets. This suggests that markets in the South are competitive, whereas those in the North are well protected by strong IPR protection (or by natural means, such as the importance of marketing and advertising networks).

3 The Model.

Preferences.

There are two regions: North and South. Households in both North and South consume a variety of differentiated products. They have identical preferences so that we can really think of one representative world consumer.¹¹ A representative household's preferences are given by an infinite discounted sum of all future utility flows:

$$U_t = \int_t^\infty e^{-\rho(\tau-t)} \log(u_\tau) d\tau \quad (1)$$

where $\log(u_\tau)$ is instantaneous utility level at time τ and ρ is the subjective discount rate.

Utility at each point in time reflects a preference for product diversity and is given by the following standard function with a constant and equal elasticity of substitution between pairs of products:

$$u_\tau = \left[\int_0^n x(j)^\alpha dj \right]^{\frac{1}{\alpha}}, \quad 0 < \alpha < 1 \quad (2)$$

where $x(j)$ is consumption of brand j .¹² Note that the elasticity of substitution is $\varepsilon = \frac{1}{1-\alpha}$. These preferences give us a demand for each product. So, a household which maximizes instantaneous utility, spends amount E , and faces prices $p(j)$ will have the following resulting demand function:

$$x(j) = \frac{p(j)^{-\varepsilon}}{\int_0^n p(i)^{1-\varepsilon} di} E \quad (3)$$

Note that the price elasticity of demand for each product is simply given by ε .

Production.

There are two types of possible activities:

¹¹We will, however, see later that we need to think about consumption by Northern and Southern consumers separately. This is because, in the environment which we describe, consumers in the two regions face different relative prices for products produced in the North and South.

¹²We could have very well used an alternative interpretation of u_τ , where the CES function would be viewed as a production function for a final consumption good assembled from the (measure) n intermediate products.

- (1) Firms must figure out the production plan for a product by consciously investing resources in a research and product development effort.
- (2) Once a firm figures out the production plan, it can produce one unit of the product using one unit of labor.

Products are invented in the North. We assume that no innovation takes place in the South. Innovation involves a one time R&D fixed cost. Once invented, a product is manufactured in the North using one unit of labor per unit of output. The Northern economy has a standard monopolistic competition market structure. Each product is produced by one firm. A Northern firm faces competition only from other horizontally differentiated brands. Given the constant elasticity demand function (3) for each product, the typical Northern firm maximizes profits $\pi_N = p_j x_j - w_N x_j$ by charging the following price:

$$p_N = \frac{w_N}{\alpha} \quad (4)$$

The Northern monopolist's sales are x^N units of the product and its profits are given by the following:

$$\pi_N = (1 - \alpha) p_N x^N \quad (5)$$

Technology Transfer.

The production plan for any product may be transferred to the South. In principle, this transfer can be carried out either by the Northern firm, which has property rights over the technology, or by a Southern firm which imitates the product. We will, however, show that the latter will not take place in practice. In either case, the process of technology transfer involves resources: there is a cost associated with tailoring a production process to local conditions in the South.¹³

We will make the following assumptions:

(A1) Patent protection is very strong in the North, so much so that even if a Southern firm learns a production plan for a certain product, it cannot sell the product directly in

¹³We would expect the transfer costs to be greater (at least in terms of units of labor required) for an imitating Southern firm than for a Northern firm which is in possession of the technology. However, this difference does not matter for us.

the Northern market. Rather, it must sell back to the original Northern innovator. In this sense, the relationship between the Southern firm and the innovator North firm resembles a subcontracting relationship.

The inability of Southern firms to sell directly to the Northern market and capture market share in the North can also be motivated by an alternative interpretation of what constitutes a “brand” or “product”. We can reasonably think that developing a new product in the North also involves setting up an extensive marketing and advertising network. Thus, if a firm in Indonesia shipped Polo shirts without the official Polo labels and approached the U.S. market through channels outside of Polo’s distribution network, it would be hard pressed to find buyers at usual Polo prices.

(A2) On the other hand, patent protection is nonexistent in the South. In other words, once a South-tailored production plan is in operation in the South, knowledge about that production plan flows freely within the South. As discussed in section 2, the free availability of technology transferred to the South can also be motivated by either a subcontracting relationship or by thinking of technology transfer as essentially a process of adapting production processes to local conditions in the South.

Assumption (A2) implies that tough competition between Southern firms will drive them to marginal cost pricing so that market structure in the South will essentially be perfect competition. As such, all goods produced in the South (whether by a Southern or by a Northern firm) *and sold in the South* will be priced at marginal cost:

$$p_S = w_S \tag{6}$$

In addition, assumption (A1)–in conjunction with assumption (A2)–implies that any Southern firm wishing to sell its product in the North must sell to the original Northern innovator at a price given by (6). Competition between Southern firms supplying to the original Northern innovator drives prices down to marginal cost.

Marginal cost pricing by Southern firms implies that Southern firms are unable to capture any profits from production. As a result, Southern firms will *not* undertake any imitation investment. The transfer of technology from North to South can, therefore, only be initiated

by firms in the North. In fact, in our model, all production in the South will be the result of Northern firms transferring their technology to the South and hence becoming multinational corporations (MNCs).

What are the consequences for a Northern firm which shifts its production—or decides to subcontract production—to the South? First, it immediately loses its market share in the South. That is, it loses its profits from sales to Southern consumers. This is because a Southern firm can costlessly copy the transferred production process and start supplying the Southern market at marginal cost. The MNC, however, maintains its market share in the North and is able to continue to charge a markup over marginal cost in the Northern market. The price charged (in the Northern market) by a MNC is given by the following:

$$p_{NS} = \frac{w_S}{\alpha}, \quad (7)$$

which reflects the lower production costs in the South. The profits of a MNC firm are given by the following:

$$\begin{aligned} \pi_{NS} &= (p_{NS} - w_S) c_N^S \\ &= (1 - \alpha) p_{NS} * c_N^S \end{aligned} \quad (8)$$

where c_N^S denotes consumption of a product *produced in the South by consumers in the North*, with the superscript denoting the region in which the product was produced and the subscript denoting the region to which the consumers belong.

Demand Functions & Regional Expenditure. In arriving at a demand function for a purely Northern firm (x^N), we need to separate demand from Northern consumers (c_N^N) and demand from Southern consumers (c_S^N). While all consumers face the same price ($p_N = \frac{w_N}{\alpha}$) for a purely Northern good, the price paid by a Northern consumer for a Southern good is different from that paid by a Southern consumer. Since the two sets of consumers face different relative prices, their demand functions assume different forms. In particular, the demand functions are given by the following:

$$\text{(Northern Good).} \quad c_N^N = \left[\frac{p_N^{-\varepsilon}}{n_N p_N^{1-\varepsilon} + n_{NS} p_{NS}^{1-\varepsilon}} \right] E_N \quad (9)$$

$$c_S^N = \left[\frac{p_N^{-\varepsilon}}{n_N p_N^{1-\varepsilon} + n_{NS} p_S^{1-\varepsilon}} \right] E_S \quad (10)$$

$$\text{(Southern Good).} \quad c_N^S = \left[\frac{p_{NS}^{-\varepsilon}}{n_N p_N^{1-\varepsilon} + n_{NS} p_{NS}^{1-\varepsilon}} \right] E_N \quad (11)$$

$$c_S^S = \left[\frac{p_S^{-\varepsilon}}{n_N p_N^{1-\varepsilon} + n_{NS} p_S^{1-\varepsilon}} \right] E_S \quad (12)$$

where n_N and n_{NS} are respectively the number of products being produced in the North and South and E_N and E_S are respectively what the North and South spend on consumption goods.¹⁴ Note that $c_N^N + c_S^N = x^N$ and $c_N^S + c_S^S = x^S$. E_i is defined as country i 's income minus its investment expenditure where income in each country is simply wage income plus profits. We arrive at the following expressions for each country's expenditure¹⁵:

$$E_N = p_N n_N x^N + (1 - \alpha) p_{NS} n_{NS} c_N^S \quad (13)$$

$$E_S = w_S L_S = p_S n_{NS} x^S \quad (14)$$

where L_S is the size of the labor force in the South.

R&D Costs of Product Development and Technology Transfer.

Products are invented in the North by paying a one-time R&D fixed cost equal to $\frac{a}{K_n}$, where K_n rises with n , the total number of products ever developed ($n = n_N + n_{NS}$). This is simply the standard formulation to capture knowledge spillovers from R&D activity. We consider the simple case with $K_n = n$. Let v_N denote the present discounted value of the profit stream enjoyed by a typical Northern firm. Free entry into innovation R&D implies

$$v_N = \frac{a w_N}{n}. \quad (15)$$

¹⁴We use the subscript 'NS' on the number of products being produced in the South (n_{NS}) because these are really the result of Northern firms transferring their technology to the South.

¹⁵These expressions were obtained using resource constraints presented later in the paper.

Northern firms transfer their technology to the South by paying a one-time adaptation cost of $\frac{a_f}{K_{NS}}$, where K_{NS} rises with n_{NS} . If technology transfer is the process of adapting production processes to local conditions in the South, the rise of K_{NS} with n_{NS} captures the notion that the larger the number of products that have been adapted to Southern conditions, the easier it is to figure out how to adapt the next production process. In other words, each production process transferred to the South contributes to a knowledge pool about local conditions in the South and how to tailor production processes to such conditions. We consider the simple case with $K_{NS} = n_{NS}$. Let v_{NS} be the present discounted value of profits emanating from a MNC firm. Then, by paying a one-time cost of $\frac{a_f}{n_{NS}}$, a firm can give up v_N and acquire v_{NS} . Since all Northern firms are free to undertake this transaction, there will be no excess returns. This implies

$$v_{NS} - v_N = \frac{a_f w_N}{n_{NS}}. \quad (16)$$

Capital Market Equilibrium.

Capital market equilibrium requires that the returns to different assets be equated in each economy. Note that there is no investment in the Southern economy. In the North, there are three different assets: a riskless bond paying r_N , equity in a firm which has shifted its production to the South (the so-called “MNC” or “NS” firms), and equity in a firm which has not shifted to the South (the “N” firms). An “NS” firm will remain an “NS” firm forever whereas an “N” firm has the option to convert itself into an “NS” firm.

Let us first consider the simpler example of an “NS” firm. Equityholders in such a firm earn profits $\pi_{NS}dt$ during a time interval of dt and also experience a capital gain of $\dot{v}_{NS}dt$. The total return to the equityholders must equal the riskless return on the value of the firm $r_N v_{NS}dt$. We, therefore, have the following no-arbitrage condition:

$$\frac{\pi_{NS}}{v_{NS}} + \frac{\dot{v}_{NS}}{v_{NS}} = r_N. \quad (17)$$

Now, let us think of the “N” firm. During a time interval dt , equityholders in such a firm earn profits $\pi_N dt$ and experience a capital gain of $\dot{v}_N dt$. In addition, at every point in time, a “N” firm has the option to pay a cost $\frac{a_f w_N}{n_{NS}}$ in order to exchange v_N for v_{NS} . Suppose

that the Northern firm exercises the option with probability $\frac{\dot{n}_{NS}}{n_N} dt$ during a time interval dt .¹⁶ Then, the no-arbitrage condition for the Northern firm is

$$\pi_N dt + \frac{\dot{n}_{NS}}{n_N} dt \left(v_{NS} - v_N - \frac{a_f w_N}{n_{NS}} \right) + \left(1 - \frac{\dot{n}_{NS}}{n_N} dt \right) \dot{v}_N dt = r_N v_N dt$$

Substituting equation (16) and getting rid of second order terms, the no-arbitrage condition for the Northern firm simplifies to

$$\frac{\pi_N}{v_N} + \frac{\dot{v}_N}{v_N} = r_N . \quad (18)$$

Thus, we see that the option to shift to the South is valueless for the Northern firm. This makes sense because equation (16) tells us that there are no excess returns and because there is no uncertainty in the model.

Labor Market Equilibrium.

Finally, labor market clearing requires that the employment of labor resources in each country equals the available supply. In the South, labor is used only for manufacturing whereas in the North, labor is used for manufacturing as well as R&D activity in innovation and technology transfer. The labor market constraints are the following:

$$L_N = n_N x_N + a \frac{\dot{n}}{n} + a_f \frac{\dot{n}_{NS}}{n_{NS}} = n_N x_N + ag + a_f g_{NS} \quad (19)$$

$$L_S = n_{NS} x^S . \quad (20)$$

Intertemporal Optimization.

Intertemporal optimization by households in the North implies that expenditure in the North evolves according to

$$\frac{\dot{E}_N}{E_N} = r_N - \rho . \quad (21)$$

We normalize world spending $(E_N + E_S) = 1$ at each point in time.

¹⁶Though Northern firms are themselves in control of the decision to transfer to the South, equation (16) tells us that Northern firms will be indifferent between transferring to the South and remaining a Northern firm. Because of this indifference, we can assume that they undertake the transfer with probability $\frac{\dot{n}_{NS}}{n_N} dt$ during a time interval dt .

4 Steady-State Equilibrium with Technology Transfer

We will solve for a steady-state equilibrium with fixed intersectoral allocation of labor (between manufacturing, new product development, and product transfer) in the North and with a constant share of products ($\zeta^S = \frac{n_{NS}}{n}$ and $\zeta^N = \frac{n_N}{n}$) in each region. Note that a constant share of products in each region requires that both types of products grow at the same rate in steady-state: i.e. $g_{NS} (= \frac{\dot{n}_{NS}}{n_{NS}}) = g_N (= \frac{\dot{n}_N}{n_N}) = g (= \frac{\dot{n}}{n})$. Notice also that $\frac{\dot{\zeta}^S}{\zeta^S} = \frac{\dot{n}_{NS}}{n_{NS}} - \frac{\dot{n}}{n} = f * \left(\frac{1 - \zeta^S}{\zeta^S} \right) - g$, where $f = \frac{\dot{n}_{NS}}{n_N}$ is the rate of technology transfer. Then, with a constant steady-state share of products in the South, in steady-state, $\zeta^S = \left(\frac{f}{f+g} \right)$. We will solve for the steady-state values of g and ζ^S . This will then also give us the steady-state rate of technology transfer f .

We can show that in steady state, $\frac{E_N}{E_S}$ is constant. Then, given the normalization of aggregate world consumption expenditure to a constant, E_N will also be constant. This, together with (21), gives us that

$$r_N = \rho . \quad (22)$$

Differentiating the free entry condition (15), we get $\frac{\dot{v}_N}{v_N} = \frac{\dot{w}^N}{w^N} - \frac{\dot{n}}{n}$. With relative wages $\left(\frac{w^S}{w^N} \right)$ constant in steady-state and with nominal expenditure normalized to a constant, w^N must be constant in steady-state. Then, the value of Northern firms which have not shifted their production processes (henceforth, “N” firms or simply “Northern” firms) must diminish in steady-state at the rate of product development: $\frac{\dot{v}_N}{v_N} = -g$. Substituting this into the no-arbitrage condition (18) for “N” firms, and making use of (5), (15), and (22), we obtain the following expression:

$$\frac{(1 - \alpha)p_N x^N n}{a w^N} - g = \rho . \quad (23)$$

Substituting in for x^N from the labor resource constraint of the North (19) and for p^N from the pricing relation (4), it follows that

$$\frac{(1 - \alpha)}{\alpha a} (L_N - (a_f + a)g) \left(\frac{1}{1 - \zeta^S} \right) = \rho + g . \quad (24)$$

This gives us our first steady-state relation between g and ζ^S . The intuition behind this relation is clear: a higher share of products in the South (ζ^S) means that there are fewer

products being produced in the North. That in turn means that the output (and hence profits) of each particular Northern firm is higher. However, higher profits (π_N) for a typical Northern firm means that the value of a Northern firm (v^N) must also diminish at a faster rate to satisfy the asset arbitrage condition in equilibrium. In other words, we must have a higher rate of product development g to restore equilibrium in capital markets.

To obtain our second relation, we need to notice that the value of an NS (or MNC) firm which has transferred its production process to the South (v_{NS}) also declines at the rate g in steady state.¹⁷ Then, since the value of both types of firms decline at the same rate, their profit rates must also be equal to satisfy the asset arbitrage conditions. So, we have that

$$\frac{\pi_{NS}}{v_{NS}} = \frac{\pi_N}{v_N} . \quad (25)$$

Notice that in the case where technology transfer is costless ($a_f = 0$), this condition implies that profits for the two types of firms must be equal.¹⁸ Substituting in for profits using (5) and (8) and for firm values using (15) and (16), it follows that

$$\frac{x^N}{c_N^S} = \left(\frac{w^S}{w^N} \right) \left(\frac{1}{1 + \frac{a_f}{a} \left(\frac{n}{n_{NS}} \right)} \right) . \quad (26)$$

This essentially gives us an equation for the relative *profitable* sales of Northern and MNC firms, which must hold in order for the profit rates of the two types of firms to be equal. Recall that *profitable* sales of firms which locate production in the North include sales to all consumers (x^N), whereas *profitable* sales of firms which have transferred production to the South include sales to only Northern consumers (c_N^S). Another point worth noticing is that with costly technology transfer ($a_f \neq 0$), if the share of Southern products (c^S) rises, the productivity of technology transfer rises. Then, because the cost of transfer determines the difference between v_{NS} and v_N —refer to equation(16)—the value of a MNC firm relative to that of a Northern firm can fall. The lower ($\frac{v_{NS}}{v_N}$) means that the relative profits of a MNC firm ($\frac{\pi_{NS}}{\pi_N}$) can also be lower.

¹⁷This can be shown quite easily by differentiating the condition for no excess returns from technology transfer (16) and noting that $\frac{\dot{n}}{n} = \frac{\dot{n}_{NS}}{n_{NS}}$ in steady-state.

¹⁸Note that costless technology transfer does not lead to factor price equalization between the two regions because Northern firms still lose profits from sales to Southern consumers when they transfer their production to the South.

The profitable sales of each type of firm will obviously depend on demand. We can manipulate the demand functions (9)-(12) to obtain the following ratio of demands¹⁹:

$$\frac{x^N}{c_N^S} = \alpha \left(\frac{n_{NS}}{n_N} \right) \left(\frac{w^S}{w^N} \right) + \left(\frac{w^S}{w^N} \right)^\varepsilon \quad (27)$$

So, the *profitable* sales of a firm producing in a particular region rise as the relative wage of that region falls. Indeed, relative *profits* of a firm producing in a particular region rise as the relative wage of that region falls. This is the expected result of *cost reduction*, although it is nontrivial here because the MNC firm receives profits from sales to only Northern consumers. In addition, as the share of Southern products rises, the profitable sales and profits of an N firm rise relative to that of an MNC firm. This is easy to understand: recall that when a Northern firm converts itself into an MNC firm, it loses profits from sales to Southern consumers. As ζ^S rises, the relative purchasing power of Southern consumers rises.²⁰ Then, as ζ^S rises, the profit loss for MNC firms is greater. Combining this relative demand expression (27) with (26), it follows that

$$\frac{w^S}{w^N} = \left(\frac{1}{1 + \frac{a_f}{a} \left(\frac{1}{\zeta^S} \right)} - \alpha \frac{\zeta^S}{1 - \zeta^S} \right)^{\frac{1}{\varepsilon-1}}. \quad (28)$$

We therefore have an expression for the relative wage in terms of ζ^S , which must hold so that the profit rates of the two types of firms are equal. The relative wage responds to a rise in ζ^S for two separate reasons:

- First, as ζ^S rises, the relative profits of MNC firms fall because, as explained above, the *Southern market loss* from transferring to the South is higher. As a result, the relative wage of the South must fall in order to raise the relative profits of MNC firms back up, so that the profit rates are once again equal. Through this channel, therefore, $\frac{w^S}{w^N}$ falls in response to a rise in ζ^S .

¹⁹Refer to the appendix to see how we obtain this expression for relative demands. Essentially, $\frac{x^N}{c_N^S} = \frac{x^N}{c_N^N} * \frac{c_N^N}{c_N^S}$, where $\frac{c_N^N}{c_N^S}$ is relative demands of Northern and Southern products *by same type of consumers* and hence depends only on relative prices. On the other hand, $\frac{x^N}{c_N^N} = 1 + \frac{c_N^S}{c_N^N}$ compares the part of the Northern good consumed by Southern consumers to that consumed by Northern consumers. This rises with the size of the Southern market, which in turn rises with $\frac{n_{NS}}{n_N}$.

²⁰This is because, as ζ^S rises, the price index of products falls more for Southern consumers than for Northern consumers, since the difference between N and NS prices is greater for Southern consumers than for Northern consumers. Thus, Southern consumers become richer relative to Northern consumers as ζ^S rises.

- Second, as ζ^S rises, the productivity of technology transfer rises and hence results in the value of an MNC firm falling relative to the value of an N firm. This implies that the relative profits of an MNC firm must also fall in order for the profit rates to remain equal. In order for the relative profits of an MNC firm to fall, the relative wage in the South must rise. Through this channel, therefore, $\frac{w^S}{w^N}$ rises in response to a rise in ζ^S .

Next, we write down an expression for the relative demand of a good produced in the South in terms of relative wages and the share of products in the South:

$$\frac{x^S}{x^N} = \left[\alpha^{\varepsilon-1} \left(\frac{n_N}{n_{NS}} \right) \left(\frac{w^S}{w^N} \right)^{\varepsilon-1} + 1 \right] \left(\frac{w^S}{w^N} \right)^{-\varepsilon} \left[\frac{1}{\alpha^{\varepsilon-1} \left(\frac{n_N}{n_{NS}} \right) \left(\frac{w^S}{w^N} \right)^{\varepsilon-1} + \alpha^\varepsilon} \right]. \quad (29)$$

Substituting in for relative wages using (28), we obtain the following expression for relative demand only in terms of the share of products in the South:

$$\frac{x^S}{x^N} = \left[1 + \frac{(\zeta^S + \frac{a_f}{a}) (\alpha^{1-\varepsilon} - \alpha)}{1 - \zeta^S} \right] \left[\frac{1}{1 + \frac{a_f}{a} \left(\frac{1}{\zeta^S} \right)} - \alpha \frac{\zeta^S}{1 - \zeta^S} \right]^{-\frac{\varepsilon}{\varepsilon-1}}. \quad (30)$$

Equating this to the relative supply of a good produced in the South—from the labor constraints of the two regions—to obtain our second steady-state relation g and ζ^S :

$$\frac{L_S}{L_N - (a_f + a)g} = \frac{\zeta^S}{1 - \zeta^S} \left[1 + \frac{(\zeta^S + \frac{a_f}{a}) (\alpha^{1-\varepsilon} - \alpha)}{1 - \zeta^S} \right] \left[\frac{1}{1 + \frac{a_f}{a} \left(\frac{1}{\zeta^S} \right)} - \alpha \frac{\zeta^S}{1 - \zeta^S} \right]^{-\frac{\varepsilon}{\varepsilon-1}}. \quad (31)$$

Equations (24) and (31) together give us our steady-state solution for g and ζ^S . It is not possible to obtain explicit solutions for g and ζ^S for general parameter values.²¹ We can, however, diagrammatically represent the steady-state relations and the implicit steady-state solution. Figure 1 does exactly this, with curve AA depicting equation (24) and curve LL representing equation (31).²²

²¹Note that equation (31) contains terms raised to the power of a general parameter.

²²In order for the two curves to intersect in the positive quadrant, we essentially need L_S large relative to L_N or a_f small relative to a .

The shape of the AA curve (equation 24) has been explained previously. The shape of LL can be explained as follows: as ζ^S rises, the relative demand for Southern labor surely rises. This creates an excess supply of Northern labor, which allows more resources in the North to be devoted to product development. As a result, g rises. However, the extent of the response of g to a rise in ζ^S depends on the extent of the increase in relative demand for Southern labor, which in turn depends on how the relative demand for a typical Southern product $\left(\frac{x^S}{x^N}\right)$ responds to the rise in ζ^S . If there is no explicit cost of transfer (i.e. $a_f = 0$), a rise in ζ^S will surely be associated with a drop in the relative wage of the South (see equation 28). This will then lead to an increase in $\left(\frac{x^S}{x^N}\right)$, which means that the increase in relative demand for Southern labor will be greater. It follows that the response of the rate of innovation will be greater. On the other hand, if there exists an explicit cost of transfer (i.e. $a_f \neq 0$), the relative wage of the South may rise as ζ^S rises. This would lead to a decline in $\left(\frac{x^S}{x^N}\right)$ and hence dampen the increase in the relative demand for Southern labor. It follows that the response of the rate of innovation would be smaller.

Isolation vs. an integrated world.

Let us now examine how the rate of product development g with technology transfer compares with the rate which would have been obtained if the North were in isolation. Inspecting our steady-state solution, we see that the intersection of the AA curve with the vertical axis is given by

$$g^{AA}(\zeta^S = 0) = \frac{a}{(1-\alpha)a_f + a} \left((1-\alpha) \frac{L_N}{a} - \alpha\rho \right) = \frac{a}{(1-\alpha)a_f + a} (g^{ISOL}) < g^{ISOL}$$

where g^{ISOL} is the rate of innovation in the North under isolation. Note that the intersection of the AA curve with the vertical axis is a lower bound on the possible rate of innovation in an integrated world. While the steady-state innovation rate with technology transfer is indeed to the right and greater than the value of g at the intersection, we are not guaranteed that the steady state g is greater than g^{ISOL} , because $g^{AA}(\zeta^S = 0) < g^{ISOL}$. However, if the explicit cost of technology transfer (a_f) is small compared to the cost of innovation (a), the rate of innovation with technology transfer is likely to be greater than g^{ISOL} . Indeed, if technology transfer is costless ($a_f = 0$), the rate of innovation with technology transfer is certain to be greater than g^{ISOL} .

Table 1 presents some comparisons of the rates of product development under the two regimes, using a variety of parameter values. In most cases, the rate of product development is greater in an integrated world. This is a scale result: in an integrated world, the transfer of product lines to the South frees up resources in the North which can be devoted to product development. This brings about a faster rate of innovation.²³

Only when the cost of technology transfer is considerable does the rate of innovation under isolation exceed that in an integrated world in table 1. If a_f is substantially high, this perverse result follows because the share of products in the South (ς^S) is very low as a result. With a low ς^S , the resources freed up from moving product lines to the South is less than the substantial resources that the North spends (since a_f is high) on transferring products to the South in an integrated world. As a result, less resources are available for product development in an integrated world. While this outcome is a possibility, it is unlikely because the costs of transfer are not likely to be so perversely high. Thus, we conclude that for reasonably low costs of technology transfer, the potential to shift products to the South increases the rate of product development.

A reduction in the costs of technology transfer.

Let us now look at the effects of an exogenous decline in the explicit costs of transfer (a_f). A lower cost of transfer can result from, for example, an improvement in Southern infrastructure, a reduction in bureaucratic red-tape associated with setting up new production units in the South, or greater access to information about conditions in the South. In our model a decline in a_f shifts the AA curve up and the LL curve to the right. As a result, both the rate of innovation and the share of products in the South rise. Table 2 demonstrates the effects of a decline in transfer costs for a variety of parameter values. Note that the relative wage of the South also rises in response to the decline in transfer costs.

The increase in the rate of innovation g in response to the decline in the costs of technology

²³Moreover, the faster rate of decline of the value of Northern firms accompanying higher g is compensated for by higher (sales and) profits for each Northern firm when product lines migrate to the South.

transfer a_f works through two channels. First, a decline in a_f means that fewer resources in the North need to be devoted to technology transfer, so that more resources are available for product development. As a result, the AA curve shifts up (i.e. g increases for a *given* ζ^S). Second, the increase in ζ^S means that more resources are freed up from manufacturing in the North, so that even more can be devoted to product development. This is represented by movement to the right along the AA curve, again producing an increase in g .

On the other hand, the increase in ζ^S resulting from the rightward shift of the LL curve can be explained as follows: a decline in the costs of transfer a_f means that in equilibrium, the value of an MNC firm (v_{NS}) will fall relative to the value of an N firm (v_N). This means that relative profits of an MNC firm ($\frac{\pi_{NS}}{\pi_N}$) will also fall in steady-state. This can occur through either a higher share of products in the South (a higher ζ^S) or a rise in the relative wage of the South ($\frac{w^S}{w^N}$). In fact, both must take place. This is because a rise in ζ^S alone would raise the relative demand for Southern labor above relative supply and hence lead to an increase in relative wage of the South. On the other hand, a rise in $\frac{w^S}{w^N}$ alone would lower the relative demand for Southern labor below relative supply (by lowering the relative demand for a typical Southern product $\frac{x^S}{x^N}$) and hence lead to a rise in ζ^S . Thus, in response to a decline in the costs of transfer, we get both a higher share of products in the South and a rise in the relative wage of the South.

These results point to the crucial importance of reducing the costs of technology transfer in developing countries where indigenous firms are unable to recover the costs of imitation and adaptation. By improving infrastructure, cutting bureaucratic red-tape associated with setting up new production units, or providing greater access to information about local conditions, developing countries can *both* increase the share of products in the South (i.e. increase the rate of technology transfer) and also raise their relative wage in the steady-state equilibrium. This happens even though a higher share of products in the South is associated with a *larger Southern market loss* for Northern firms and even though a higher Southern relative wage implies *less cost reduction* for Northern firms. The fact that the South is able to raise both ζ^S and $\frac{w^S}{w^N}$ under such circumstances suggests that lowering the costs of technology transfer should be treated as a key policy objective for developing countries faced with such an environment.

A closer look at the numbers in table 2 suggests that countries with a higher cost of technology transfer stand to gain much more by cutting their transfer costs by the certain percentage. For example, with $\alpha = 0.55$, cutting the transfer costs in half from $a_f = 2$ to $a_f = 1$ reduces the gap between $\frac{w^S}{w^N}$ and unity by $\frac{0.540-0.444}{1-0.444} = 17.3\%$. On the other hand, reducing the transfer costs from $a_f = 1$ to $a_f = 0.5$ reduces the gap between $\frac{w^S}{w^N}$ and unity by $\frac{0.584-0.540}{1-0.540} = 9.6\%$.

Relative wages

For a given cost of transfer, the steady-state relative wages in this model are determined fully by the steady-state share of products in the South. Equation (28) tells us how the relative wage varies with the steady-state ζ^S : this depends crucially on whether or not there exists an explicit cost of transfer in the model. Figure 2 presents a number of plots of the relative wage of the South against the steady-state share of products in the South. Note that these plots involve two variables which are both endogenously determined in steady-state. So, they should be interpreted as the locus of (relative wage, ζ^S) combinations that we trace out as we move between different steady-states (for a given cost of transfer a_f). We can move across steady-states by varying some parameter in our model—in the next section, we will examine the effects of changing region size.

Turning to figure 2, consider first the case of costless technology transfer ($a_f = 0$). In this case, a higher steady-state share of products in the South must be associated with a lower relative wage for the South. As previously explained, this is because a higher ζ^S means that the *Southern market loss* effect is greater for firms transferring their production to the South. Then, the Southern relative wage must be low enough to induce firms to transfer: a lower Southern relative wage allows transferring firms to experience a greater *cost reduction* effect. This negative relation between the Southern relative wage and the steady-state share of products in the South can be attributed to poor (in our case completely absent) Southern intellectual property rights protection. Since firms are choosing between two locations of production, they will choose to locate in the region with poor IPR protection only if that region offers a sufficient degree of cost reduction.

Now, consider the case where there exists an explicit cost of technology transfer. Figure 2 shows that with $a_f \neq 0$, the Southern relative wage can rise over some range of values of ζ^S . Moreover, the higher the cost of transfer, the larger the range over which the Southern relative wage rises with ζ^S . This can be explained as follows: as ζ^S rises, the productivity of technology transfer rises so that profits from production in the South need not be all that much higher than those from production in the North. The decline in relative profits of NS firms is brought about by a rise in the relative wage of the South. Thus, with an explicit cost of technology transfer, higher steady-state values of ζ^S (i.e. higher rates of transfer) can also be associated with higher Southern relative wages because a higher ζ^S improves the productivity of the transfer process. To think about what this means in practice, suppose that a Northern firm can choose between one of two Southern locations (S1 and S2). The wages in S1 are slightly lower than S2, but there are many more products being produced in S2. Then, the Northern firm may choose to produce in S2 even though its wages are higher, because the costs of transferring to S2 will be lower. On the other hand, if technology transfer were costless, the Northern firm would choose to produce in S1.

Accumulating Resources in the South: the effects of scale.

One of the predominant themes in models of endogenous growth is that scale matters for growth rates.²⁴ In models with technology transfer, the effect of scale on the world distribution of income (i.e. on relative wages) is also an important concern. Let us examine here the effects of scale in our model.

Tables 3 and 4 demonstrate the effects of increasing the size of the South and North respectively. An increase in the size of any region raises the rate of product development and the share of products being produced in that region. An increase in the size of the South shifts the LL curve to the right and leaves the AA curve unaffected. Thus, g and ζ^S both increase unambiguously. An increase in the size of the North shifts both the LL and AA curves up. While this does not unambiguously tell us that g and ζ^N will rise, in all the

²⁴The effect of scale on the growth rate has been questioned by Jones (1995). As a result, subsequent work, such as Young (1998) and Jones (1999) has attempted to construct models of endogenous technological change without scale effects.

numerical examples that we have examined, this turns out to be the case.

The effect of an increase in region size on relative wages of that region depends on whether or not there exists an explicit cost of transfer. With costless transfer ($a_f = 0$), as the size of a region rises, the relative wage of that region falls unambiguously. Suppose that the size of the South (L_S) becomes larger. In the new steady state, ζ^S will be higher, which means that the Southern market loss (as a result of transferring to the South and becoming an MNC) is larger. In the new steady-state, therefore, relative wages in the South ($\frac{w^S}{w^N}$) must be lower to induce firms to still transfer their technology. So, in response to an increase in the size of the South, we get an increase in the share of Southern products at the expense of lower wages in the South.

With costly transfer ($a_f \neq 0$), the relative wage of the South can rise with its size over some range. This is because the induced increase in ζ^S raises the productivity of the transfer process and hence allows Southern profits to fall relative to Northern profits. As a result, the relative wage of the South ($\frac{w^S}{w^N}$) can rise as ζ^S increases. In the case of costly transfer, therefore, in response to an increase in the size of the South, we can get an increase in the share of Southern products as well as an increase in Southern wages. However, as the size of the South continues to expand, the relative wage of the South eventually declines. (The shaded portions of table 3 indicate regions over which an increase in the size of the South can be associated with a higher relative wage in the South. Everywhere else, an increase in the size of the South is associated with a lower Southern relative wage.)

The effects of scale in this model are different from those in previous models of technology transfer. Table 5 presents a comparison with Krugman (1979) and Grossman and Helpman (1991). In Krugman (1979), the share of products in the South is determined from exogenous rates of innovation and transfer. An increase in the size of the South has no effect on the share of products in the South. The increase in supply of resources in the South must, therefore, be accompanied by a fall in ($\frac{w^S}{w^N}$)—a simple supply, price response. In the Grossman and Helpman (1991) model of transfer based on imitation, the rates of innovation and the share of products in the South *are* endogenously determined. An increase in the size of the South induces a more-than-proportional rise in the share of Southern products (ζ^S),

which raises relative demand for Southern labor more than relative supply. As a result, the relative wage of the South ($\frac{w^S}{w^N}$) rises. In our model, an increase in the size of the South induces a rise in ζ^S as well. However, the rise in ζ^S must be accompanied by a fall in ($\frac{w^S}{w^N}$) in steady-state. The fall in ($\frac{w^S}{w^N}$) itself raises the demand for Southern labor, so that the increase in ζ^S here is less-than-proportional, in contrast to Grossman and Helpman (1991).

It is interesting to use these results to consider the implications of an improvement in the productivity of workers in the South. Suppose that all workers in the South were to become twice as productive—in our model, this is equivalent to a doubling in the size of the South. Our results above indicate that while the increase in Southern worker productivity will attract a larger share of products to the South, it will lead to a decline in the relative wage of an effective worker in the South. In other words, an increase in productivity of workers in the South will lead to a less than proportional increase in the relative wages of physical units of Southern workers.

It is enlightening to compare this to the effect of an increase in worker productivity in the Grossman and Helpman (1991, chapter 11) model, where technology transfer is achieved through indigenous imitation activity. In that case, an increase in the productivity of Southern workers would lead to a more than proportional increase in the relative wages of Southern workers. This comparison suggests that if a developing country relies on technology transfer initiated by Northern firms instead of also fostering indigenous imitation activity, then the relative wages of its workers will fail to keep up with productivity improvements.

5 Concluding thoughts

This paper has studied the transfer of technology in an environment where firms in developing countries are unable to appropriate the benefits of their imitation or adaptation activity, because markets in developing countries are very competitive, intellectual property rights are weak, and an adapted production process, once successful, spreads rapidly to other entrepreneurs. We have provided examples to show that such an environment is empirically important for large numbers of developing countries.

Given this particular nonappropriability problem in developing countries, the question naturally arises about what policymakers should do to respond to this impediment. Our analysis suggests that a key policy objective for developing countries faced with such an environment should be to aggressively cut the costs of technology transfer for foreign firms. Cutting the transfer costs not only raises the rate of technology transfer, but also raises the relative wage of the developing country. This is no small accomplishment, because a higher rate of transfer (i.e. a higher share of products in the South) in steady state implies a *larger Southern market loss* for foreign firms and because a higher Southern relative wage implies *less cost reduction* for foreign firms. Thus, policy effort directed toward improving infrastructure, cutting bureaucratic hassles faced by foreign firms in setting up new production units, and disseminating information about local conditions should yield rich dividends for developing countries.

This paper does *not* claim that the described environment of competitive markets in the South is the only environment in which technology transfer takes place. In fact, a comparison with indigenous imitation-based models of technology transfer demonstrates why the inability of indigenous firms to recover the costs of adaptation serves as an impediment even when foreign firms are transferring their technology.

What then (other than reducing the transfer costs for foreign firms) can developing countries do to deal with this impediment? Should they make their markets more anticompetitive in an attempt to eliminate the spillovers or the rapid diffusion of successfully adapted processes throughout the economy? Should they provide rents through trade protection?²⁵ Anecdotal evidence from the trade experiences of most developing countries suggests that such responses are *unlikely* to result in successful outcomes. On the other hand, since the particular problem being addressed is the lack of a sufficient reward for *successful* adaptation activity, a more sensible policy would likely take the form of a one-time reward to entrepreneurs demonstrating success in exporting *new* product lines. Since we have not explicitly performed the associated welfare analysis, this policy recommendation must be considered tentative.

²⁵Amsden (1989), Wade (1990), and Evans (1995), for example, have argued that such policies have been successfully employed in South Korea and Taiwan.

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Table A. Price Comparisons for 'On-Patent' Drugs

Drug Name	Dosage	Price (in Rupees) in:		
		India	UK	USA
Ranitidine	300 tabs/ 10 pack	18.5	483.6	1050.7
Famotidine	40 tabs/ 10 pack	18.6	504.3	1004.9
Ciprofloxacin	500 mg/ 4 pack	28.4	292.5	437.4
Norfloxacin	400 mg/ 10 pack	39.0	253.5	904.8

Source: Lanjouw (1998); data from 1995, various sources.

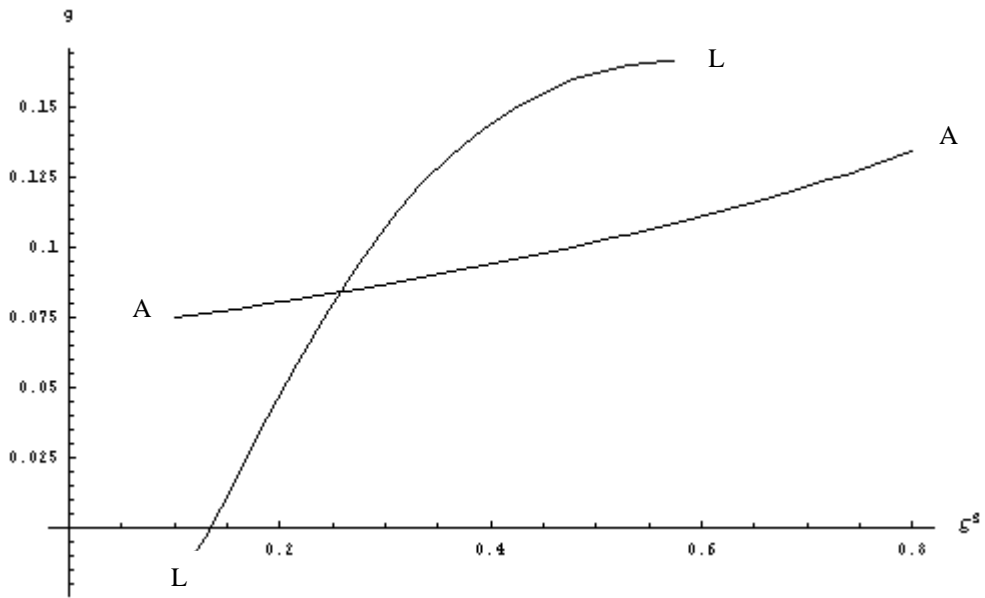
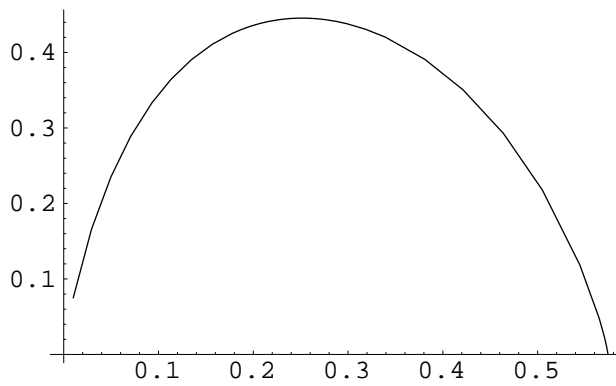


Figure 1. The Steady-State Relations

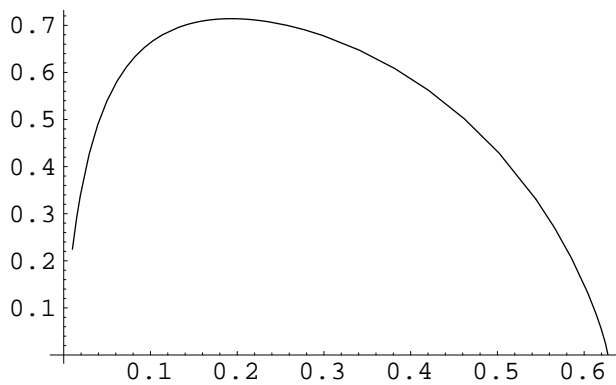
Note: Vertical axis is g
 Horizontal axis is ζ^S .

■ **FIGURE 2. (Plot Relative Wage of South against ζ_S).**
Note: Vertical Axis is (w_S/w_N) ; Horizontal Axis is ζ_S .

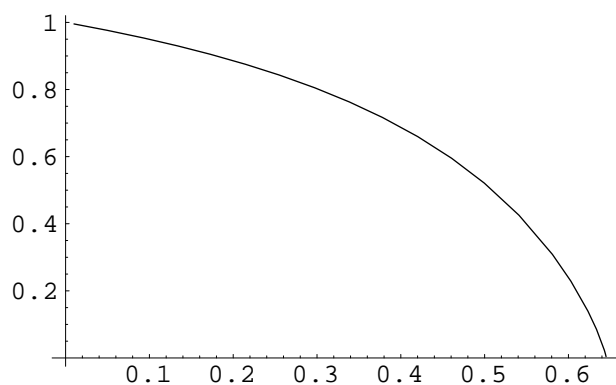
■ $\alpha=0.55$; $af=2$



■ $\alpha=0.55$; $af=0.5$



■ $\alpha=0.55$; $af=0$



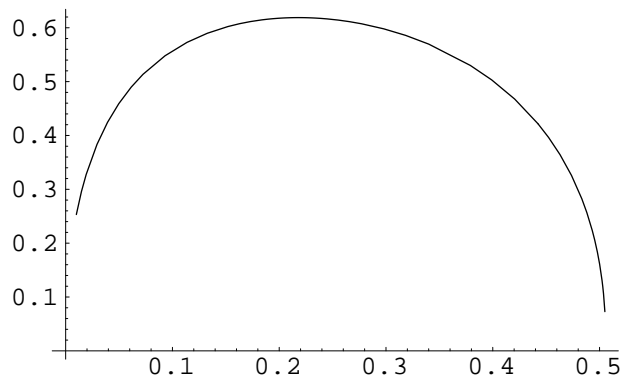
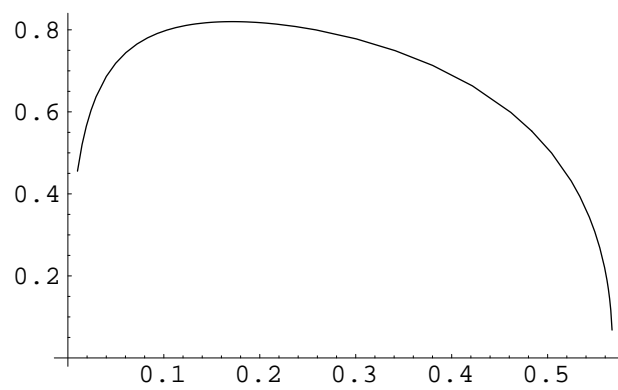
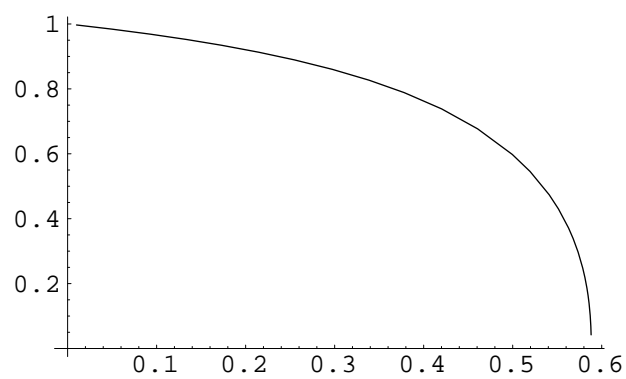
■ FIGURE 2 (Contd)... (Plot Relative Wage of South against ζ_S).**■ $\alpha=0.7$; $af=2$** **■ $\alpha=0.7$; $af=0.5$** **■ $\alpha=0.7$; $af=0$** 

Table 1.

	Isolation	Integrated world
* $L_N=2, L_S=5, \rho=.05, a=10$		
$\alpha=0.40, a_f = 2$	0.100	0.105
$\alpha=0.55, a_f = 2$	0.063	0.074
$\alpha=0.70, a_f = 2$	0.025	0.038
* $L_N=2, L_S=5, \rho=.05, a=10$		
$\alpha=0.40, a_f = 0$	0.100	0.137
$\alpha=0.55, a_f = 0$	0.063	0.099
$\alpha=0.70, a_f = 0$	0.025	0.054
* $L_N=2, L_S=10, \rho=.025, a=10$		
$\alpha=0.70, a_f = 5$	0.043	0.041

Table 2. The Effect of a Reduction in the Costs of Technology Transfer

	g	ζ^S	w^S/w^N
$\alpha=0.7$			
$a_f = 2$	0.038	0.248	0.616
$a_f = 1$	0.046	0.328	0.693
$a_f = 0.5$	0.050	0.365	0.728
$a_f = 0$	0.054	0.401	0.762
$\alpha=0.55$			
$a_f = 2$	0.074	0.272	0.444
$a_f = 1$	0.086	0.363	0.540
$a_f = 0.5$	0.092	0.403	0.584
$a_f = 0$	0.099	0.442	0.627
$\alpha=0.4$			
$a_f = 2$	0.105	0.290	0.280
$a_f = 1$	0.120	0.405	0.386
$a_f = 0.5$	0.128	0.450	0.433
$a_f = 0$	0.137	0.492	0.479

* $L_N=2, L_S=5, \rho=0.05, a=10$

Table 3. The Effect of an Increase in the Size of the South

	g	ζ^S	w^S/w^N
COSTLY TRANSFER			
$\alpha=0.70, a_f = 2$			
$L_S = 2$	0.046	0.126	0.585
$L_S = 3$	0.050	0.193	0.617
$L_S = 4$	0.052	0.235	0.618
$L_S = 5$	0.054	0.264	0.612
$L_S = 6$	0.055	0.286	0.603
$L_S = 8$	0.057	0.318	0.586
$\alpha=0.55, a_f = 2$			
$L_S = 2$	0.075	0.109	0.358
$L_S = 3$	0.081	0.207	0.439
$L_S = 4$	0.084	0.256	0.445
$L_S = 5$	0.086	0.290	0.441
$L_S = 6$	0.088	0.315	0.432
$L_S = 8$	0.090	0.350	0.414
COSTLESS TRANSFER			
$\alpha=0.70, a_f = 0$			
$L_S = 2$	0.062	0.319	0.843
$L_S = 3$	0.065	0.362	0.805
$L_S = 4$	0.068	0.390	0.775
$L_S = 5$	0.070	0.411	0.750
$L_S = 6$	0.071	0.427	0.730
$L_S = 8$	0.074	0.450	0.695
$\alpha=0.55, a_f = 0$			
$L_S = 2$	0.101	0.359	0.740
$L_S = 3$	0.105	0.402	0.685
$L_S = 4$	0.108	0.430	0.644
$L_S = 5$	0.110	0.451	0.611
$L_S = 6$	0.111	0.467	0.584
$L_S = 8$	0.114	0.490	0.541

* $L_N=2, \rho=.025, a=10$

Table 4. The Effect of an Increase in the Size of the North

	g	ζ^N	w^N/w^S
COSTLY TRANSFER			
$\alpha=0.70, a_f = 2$			
$L_N = 1$	0.022	0.672	1.726
$L_N = 2$	0.054	0.736	1.634
$L_N = 3$	0.084	0.785	1.616
$L_N = 4$	0.113	0.824	1.633
$L_N = 5$	0.140	0.859	1.679
$L_N = 6$	0.167	0.891	1.762
$\alpha=0.55, a_f = 2$			
$L_N = 1$	0.041	0.639	2.460
$L_N = 2$	0.086	0.710	2.270
$L_N = 3$	0.129	0.766	2.250
$L_N = 4$	0.170	0.815	2.330
$L_N = 5$	0.210	0.864	2.549
$L_N = 6$			
COSTLESS TRANSFER			
$\alpha=0.70, a_f = 0$			
$L_N = 1$	0.030	0.542	1.469
$L_N = 2$	0.070	0.589	1.330
$L_N = 3$	0.107	0.624	1.265
$L_N = 4$	0.144	0.651	1.223
$L_N = 5$	0.179	0.673	1.195
$L_N = 6$	0.214	0.692	1.173
$\alpha=0.55, a_f = 0$			
$L_N = 1$	0.052	0.501	1.909
$L_N = 2$	0.110	0.549	1.636
$L_N = 3$	0.165	0.583	1.504
$L_N = 4$	0.218	0.611	1.423
$L_N = 5$	0.271	0.634	1.368
$L_N = 6$	0.323	0.653	1.327

* $L_S=5, \rho=.025, a=10$

Table 5. The Effects of an Increase in the Size of the South in Alternative Models

	g	ζ^S	w^S/w^N
Krugman (1979)	No Effect	No Effect	Decrease
Grossman and Helpman (1991)	Increase	Increase	Increase
This paper (with costless transfer)	Increase	Increase	Decrease
This paper (with cost of transfer)	Increase	Increase	Increase / Decrease