NBER WORKING PAPERS SERIES

ON THE GROWTH EFFECTS OF IMPORT COMPETITION

Richard E. Baldwin

Working Paper No. 4045

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 1992

I gratefully acknowledge the helpful comments and suggestions of Harris Dellas and Thomas Gering. This paper is part of NBER's research programs in Growth and International Trade and Investment. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

NBER Working Papers #4045
April 1992

ON THE GROWTH EFFECTS OF IMPORT COMPETITION

ABSTRACT

This paper shows that the market structure of an economy's research sector is an important determinant of the aggregate growth rate, even though it has hereto been ignored in the new growth literature. To make this point in a concrete context, a simple model is used to show that import competition may stimulate growth by reducing the market power of domestic innovators. Specifically, import competition forces domestic innovators to chose between either quickening their pace of innovation or being displaced by foreign innovators. The pro-growth effect of import competition is shown to be welfare-increasing. The paper studies a number of policy implications including the growth effects of anti-trust policy, partial liberalization and trade in intellectual property rights.

Richard E. Baldwin
Chemin de la Cigale 2
1010 Lausanne SWITZERLAND
and NBER

I. Introduction

Informal analyses of trade liberalizations often argue that import competition boosts growth by disciplining domestic firms – forcing them to quicken their pace of innovation in order to match international competition. Nevertheless, the formal trade and growth theory finds that import competition *per se* has an anti–growth effect, since it reduces the profitability of innovation and thereby discourages innovation and growth.[1] This paper argues that import competition can encourage innovation and growth, despite the fact that it reduces the profitability of innovation. The economics of this pro–growth effect are simple. Import competition implies that domestic firms who do not step up their innovation activity are displaced by imports. The paper shows that this pro–growth effect raises national welfare. A number of extensions and policy implications are considered, including anti–trust policy, partial trade liberalizations and the growth effects of trade in intellectual property rights (TRIPs).

To build intuition before turning to the formal model, consider the innovation decision in a static setup. Suppose a firm has a monopoly on innovation in its industry. If it does not innovate its operating profit is π^N; if it does innovate (at a cost of F) its operating profit is greater, namely π^I. The innovation decision turns on the direct cost and benefit of innovating, as well as the opportunity cost. In this case the firm innovates only if the net direct benefit (namely, $\pi^I - F$) exceeds the opportunity cost of innovating (namely, π^N). Contrast this monopoly case with the other polar case of unrestricted entry into innovation. A limitless supply of potential

[1]See Feenstra (1990), and Grossman and Helpman (1991a). Of course in these models trade opening has other pro–growth effects due to market expansion, etc. The point is that import competition – in and of itself – leads only to an anti–growth effect in these models.

innovators' implies that their opportunity cost of innovating is zero, so $\pi^N = 0$. In this case of unrestricted entry, innovation occurs if the net direct benefit of innovating exceeds zero, namely, if $\pi^I - F > 0$.

The impact of import competition can differ substantially in these two polar cases. Assuming that increased import competition squeezes the home firm's operating profit (viz π^I), extra import competition clearly discourages innovation in the no-entry-barriers case. The extra competition reduces the net direct benefit of innovating yet does not alter the opportunity cost of doing so (since it is already zero). The impact of import competition on the monopolist's innovation decision, however, is less clear cut. Extra import competition lowers both the direct net benefit (viz $\pi^I - F$) and the opportunity cost of innovating (viz π^N). Without putting more structure on the problem, the net effect on innovation by the monopolist cannot be determined. Nevertheless, it can be said that the lowering of the opportunity cost of innovation, other things equal, constitutes a pro-growth effect in that it tends to stimulate innovation and thereby growth. Phrasing this differently, <u>import competition can alter the consequences of not innovating, as well as the consequences of innovating</u>. The former may have an impact on innovation when there are barriers to entry into research activity.

Entry into innovation activity may be constrained by any number of factors. Establishing a research capability in some industries requires large sunk set up costs, so the number of potential innovators may be quite limited (especially in small economies). Likewise, the cost of any particular innovation may depend upon industry-specific and firm-specific experience in research and development. This sort of firm-specific learning curve in innovation technology would act as a barrier to entry in the usual manner. Government sanctioned monopolies (for example telecommunication services and utilities) may also have the effect of restricting other firms from developing innovations in such industries. Lastly, a limited endowment of workers capable of performing innovative research, together with economies of scale in research, may serve to restrict competition in innovation (again especially in small countries).

Another way of looking at the growth effects of import competition is to focus on the impact that it has on domestic market structure. The innovation decision depends on at least two kinds of market structure: market structure in the product market and market structure in the innovation market. Import competition can alter both. In the output market, import competition is likely to diminish profit margins and market shares of home firms, thereby depressing the incentive to introduce new innovations. Import competition, however, may also discipline monopolistic innovators in the home country, forcing them to innovate faster and accept lower profits, or a lower return on research-specific factors.

Relation to Existing Literature

The subject of trade and growth enjoys a long intellectual history dating back at least to David Ricardo. Scholars such as Harry Johnson, Ron Findlay and Alasdair Smith made important advances in the context of Ricardian and neoclassical growth models, however the path-breaking work of Grossman and Helpman (1991a) has sparked much interest by introducing trade models in which the growth rate is endogenously determined.[2] As is true of all seminal work, the Grossman-Helpman literature raises as many interesting questions as it answers. One of the topics that has not been fully explored is the growth effects of import

---

[2]Some of the classic pieces in the exogenous growth and trade literature are Johnson (1959), Oniki and Uzawa (1965), Stiglitz (1970), Findlay (1973) chapter 7, Findlay (1974, 1981), Deardorff (1973) and Smith (1977).

competition, or foreign competition more generally. Feenstra (1990) and Grossman and Helpman (1991a) examine the effects of import competition in the polar case of completely unrestricted entry into innovation.

The basic analytic framework in this paper draws heavily on Krugman (1988) which is related to Shleifer (1986). The Krugman (1988) process-innovation growth model restricts firms to considering only one process innovation per period and assumes that innovation occurs in only a fraction of the economy's sectors. Grossman and Helpman (1991b) note that their "quality ladder" model is structurally similar to a process-innovation growth model.

The paper has six parts after the introduction. The second section presents the basic model. The third derives the steady state growth path in a closed economy. The fourth does the same for the integrated world economy. The fifth looks at the welfare implications. The sixth section discusses a number of policy implications and extensions of the basic model, and the final section presents a summary of results and some concluding remarks.

II. Basic Model

Growth in this model is driven by cost-lowering process innovations developed by research labs. Innovations receive limited-life patents permitting them to generate temporary profits which cover innovation costs. Innovations become public knowledge after their patents expire, so continual innovation is necessary to maintain an advantage in the product market. The resulting stream of innovations drives labor productivity growth and thereby output growth.

There are N symmetric sectors (N is fixed), each of which produces a distinct good. The preferences of the infinitely-lived representative consumer are given by:

$$(1) \qquad U = \sum_{t=0}^{\infty} \beta^t \ln C_t, \text{ where } C_t \equiv \prod_{i=1}^{N} (c_{it}^{1/N}).$$

Here β equals $(1+\rho)^{-1}$, ρ is the discount rate and c_i is the consumption of good i. The consumer is endowed with all of the economy's labor, L, and the shares of all manufacturing firms and research labs. Income is the sum of wage income $w_t L$ (w is the real wage measured in units of the index C) and dividend income z_t (also measured in units of C). Each period, the consumer finds it optimal to spend one Nth of total income on each of the N goods.

Innovation Technology, Imitation and Manufacturing

Labor, which is the only primary factor, is employed in manufacturing or research. Research laboratories can develop sector–specific process innovations that lower the manufacturing unit labor requirement. Specifically, the application of mF units of labor to research yields a manufacturing unit labor input coefficient, b_{it}, equal to $\gamma^m b_{it-1}$, where $0 < \gamma < 1$. There is no gestation lag and m is a continuous variable. Research laboratories are sector–specific in the sense that they can improve technology only in their sector. Imitation of innovations is costless, however innovations are protected from imitation by one–period patents. Manufacturing technology follows constant returns to scale for a given unit input coefficient.

Market Structure in Manufacturing and Research

Manufacturing firms play Bertrand in the output market with no adjustment costs or capacity constraints in production. Entry into manufacturing is unrestricted. To make the analysis more transparent, manufacturing firms and research laboratories are assumed to be unrelated. Manufacturing firms chose between buying innovations from a research laboratory and using the best un–patented technology, viz last period's patented technology. A manufacturer who buys innovations enjoys a cost advantage that her rivals do not. To maximize profits, she undercuts her rivals' lowest possible price (i.e., their marginal cost) by epsilon, thereby taking the whole market. Since this is true regardless of how small epsilon is, we say that the manufacturer charges a price equal to her rivals' marginal cost and still gets the whole market. Plainly, only the low cost manufacturers are active in equilibrium.

Market Structure in Research

Most endogenous growth models assume that there is a limitless number of potential innovators. Others require that an infinite number of innovators be continuously engaged in infinitely small research projects. These assumptions of convenience simplify the models, however they have the undesirable side effect of implying that trade cannot affect the research market structure. To allow the study of such effects, we go to the other extreme and examine a research market structure that is marked by a monopoly in each sector. To this end, we assume that in order to develop innovations, a research lab must have incurred a sunk cost G that represents the one–time cost of setting up a research facility. We assume that G is large enough so that only a single research laboratory per sector is set up in equilibrium.

The profit maximizing strategy for monopoly innovators is to auction off a package of innovations to a single manufacturer at a price that makes the manufacturer just indifferent to buying the technology.[3] Each research lab make its choice taking as given "macro" variable, i.e., consumption expenditure and the wage rate.

[3]The output price is set at the second lowest marginal cost. Selling innovations to more than one manufacturer would only lower the operating profit earned by the low cost producer. Since research labs extract all of these operating profits, they will sell to only one manufacturer.

The simplified structure of this economy permits definition of an exact manufacturing labor productivity index,

$$(2) \qquad A_t = (1/N) \prod_{i=1}^{N} (b_{it}^{-1/N}),$$

and an exact aggregate production function,

$$(3) \qquad C_t = A_t L_X.$$

Here L_X is the amount of labor devoted to manufacturing economy–wide. Lastly, given the innovation technology and the symmetry of sectors,

$$(4) \qquad A_t = A_{t-1}(1/\gamma)^m,$$

where m is the number of innovation per period developed by a typical research lab.

Definition of Steady State

The steady state is defined by a time–invariant division of labor between research and manufacturing. This division, together with the following side conditions, completely characterizes the steady–state growth path:

$$(5a) \qquad C_{t+1}/C_t = A_{t+1}/A_t = 1+g = (1/\gamma)^m$$

$$(5b) \qquad m = L_I/NF$$

$$(5c) \qquad w_t = A_{t-1}.$$

The first condition comes from (2), (3) and (4), and the second from the innovation technology and symmetry of sectors. The third condition is true since A_{t-1} is the most labor could earn working for a firm using the publicly available technology.

The steady state division of labor is found by aggregating the employment implied by private agents' optimal choices.

III. Closed Economy Steady–State Growth Path

Consider the decision of a typical research lab. Competition among potential manufacturers forces the auction price to the level of operating profit earned by the purchaser. Operating profit varies with m according to:

$$\pi(m) = (1-\gamma^{m})(C_t/N),$$

where C_t is economy–wide consumption expenditure.[4] The cost of developing m innovations is $w_t mF$, so the problem facing a typical research lab is:

(6) $\max_m V(m) = (1-\gamma^{m})(C_t/N) - mw_tF.$

Assuming that F is small enough for an interior solution, the optimal number of innovations per period, $\bar{m}$, is implicitly defined by:

(7) $\ln(1/\gamma)\, \gamma^{\bar{m}}\, (C_t/N) = w_tF.$

Figure 1 depicts the problem and its solution graphically. Clearly, $\bar{m}$ is the point where the slope of π equals w_tF. Note that $V(\bar{m})$ is strictly positive, L_I equals $\bar{m}FN$, and that $\bar{m}$ (and therefore L_I) is decreasing in w_t.

The employment choice of manufacturers is simpler. Since b_{it-1} is the unit input coefficient implied by the publicly available technology, the optimal pricing strategy implies that output in a typical sector, c_{it}, equals (C_t/Nw_tb_{it-1}). The amount of labor need to produce this output is $\gamma^{m}b_{it-1}c_{it}$, so employment of manufacturing labor in all N sectors is related to the real wage by:

(8) $L_X = \gamma^{m}C_t/w_t.$

The Steady State Allocation of Labor

Private employment choices depend on the economy–wide division of labor via consumption expenditure and the wage rate, however the economy–wide division of labor depends upon the private employment choices. Figure 2 cuts through this

---

[4]The price in a typical sector will be $b_{it-1}w_t$, while the firm's marginal cost will be $\gamma^{m}b_{it-1}w_t$. Since price times sales must equal C_t/N, due to the Cobb–Douglas preferences, we have operating profit equal to $(1-\gamma^{m})C_t/N$.

apparent circularity. The demand for manufacturing labor, given by (8), is plotted as L_X^d in Figure 2. The demand for labor in innovation as a function of the wage rate is given implicitly by (7) since m equals L_I/NF. This is plotted as L_I^d in Figure 2. The length of the x–axis in Figure 2 is the economy's labor endowment, so it is clear that there is a unique full–employment division of labor where agents are optimizing. To characterize the steady state division algebraically, note that at the intersection of the two labor demand schedules:

(9) $\bar{L}_X = NF/\ln(1/\gamma)$, and $\bar{L}_I = L - NF/\ln(1/\gamma)$.

The pure profits equal to $NV(\bar{m})$ are paid out as dividends.

With each lab developing $\bar{m} = \bar{L}_I/NF$ innovations per period, the growth rate of consumption, labor productivity, dividends and the real wage is $1+\bar{g} = \gamma^{-\bar{m}}$.

Uniqueness and Stability

It is clear from Figure 2 that there is a unique equilibrium division of labor. From condition (9), it is clear that this division is time–invariant, and so constitutes the steady–state division of labor. The division of labor is globally stable since L_I^d is below L_X^d every where to the right of $\bar{L}_I$ and the opposite is true to the left of $\bar{L}_I$. This implies that the steady–state growth path in globally stable. The economy jumps immediately to the steady–state growth path.

IV. The Open Economy Growth Path

Consider the impact of opening up free trade between the economy described above and other one that is identical in every respect. Market opening has two proximate effects: it doubles the labor force in the integrated economy and it changes the market structure for research in each sector from a monopoly to a duopoly.

To begin analysis of the duopoly innovation game, suppose that one lab developed a package with m' innovations, where m' is strictly between zero and $\tilde{m}$ where $\tilde{m}$ is such that $V(\tilde{m})$ equals zero (see Figure 1). In response the other lab would develop a package containing more than m' innovations. The reason is straightforward. The second best package (viz the package with the fewest innovations) is worthless to manufacturers, due to the Bertrand pricing in the output market. Consequently only the best package will be sold. This means that the developer of the second best package would lose all of its development cost. Of course both labs know that the other would attempt to leapfrog their package, so they would never offer a package containing a positive number of innovations less than $\tilde{m}$ innovations. It is therefore plain that there are only two equilibria in this innovation game: the foreign research lab offers a package with $\tilde{m}$ innovations and the home lab develops none, and vice versa. Appendix 1 analyses the duopoly innovation game more formally.

The outcome in any given sector is indeterminate in this simple model, however balanced trade requires that home firms gain the entire integrated market in half of the N sectors, with the other half being dominated by foreign firms.[5]

The Allocation of Labor, the Growth Rate and Pure Profits

As argued, one lab in each sector innovates up to the level where its pure profits are zero in order to avoid being displaced by the other research lab. The resulting demand for research labor in the integrated economy is implicitly related to the real wage by:

$$(10) \quad (1-\gamma^{L_I/NF})C_t/N = w_t(L_I/NF)F.$$

Figure 3 plots this demand for research labor in the open economy as $L_I^d(V=0)$. The

[5]Since consumers in the two economies have identical preferences and endowments, there will be no intertemporal trade, i.e., trade is balanced in all periods.

schedule $L_I^d(V'=0)$, which depicts what labor demand would under research monopolies, is drawn for comparison. From Figure 1 (interpreting C as world consumption expenditure), we see that this always involves a higher level of innovation than the monopoly case. As before L_X^d is given by: $L_X = \gamma^m C_t/w_t$, where all variables represent world quantities and prices. The intersection of the two labor demand schedules marks the steady state division of labor. Algebraically:

$$(11) \quad \tilde{L}_I \text{ and } \tilde{L}_X = 2L - \tilde{L}_I, \text{ s.t. } \left((1/\gamma)^{\tilde{L}_I/NF} - 1\right) = \tilde{L}_I/(2L - \tilde{L}_I)$$

With each firm innovating $\tilde{m} = \tilde{L}_I/NF$ times per period, the world and national growth rates are $(1/\gamma)^{\tilde{m}}$. Pure profits and dividends are zero. As in the closed economy case, the steady state division is globally stable and the economy jumps immediately to it.

The Growth Effects of Market Opening

In this model trade has two standard pro–growth effects: (i) Trade opening enlarges the potential market thereby raising the relative return on research labor (due to greater scale economies in research); (ii) Trade opening improves worldwide efficiency in innovation since it eliminates duplication of research effects (each country's research work force is divided among N/2 industries instead of among N). There is also a novel third pro–growth effect. Trade opening makes the market structure in research more competitive, forcing research labs to innovate faster in order avoid being displaced by the rival research lab. Additionally, trade has the standard anti–growth effect in this model. Opening to trade forces half of the domestic innovators to become inactive. Other things equal, this would tend to slow growth.

As it turns out the net effect of the three pro–growth effects outweigh the anti–growth effect, so growth is faster under free trade than under autarky. This can be seen with two comparisons. First, note that if somehow labs did retained monopoly positions in the open economy, L_I under free trade would be $\check{L}_I$ in Figure 3. Clearly $\check{L}_I$ is lower than $\tilde{L}_I$. Inspection of condition (9) shows that $\check{L}_I$ equals $\bar{L}_I$ plus L since the steady state L_X is invariant to the endowment of labor when labs act as monopolists. The clear implication of these two comparisons is that $\tilde{L}_I$ is higher than $\bar{L}_I$, so world and national growth rates are higher under free trade. In fact, since $\bar{L}_I < L$, $\check{L}_I$ is more than twice the size of $\bar{L}_I$, implying that $\tilde{L}_I$ is also more than twice $\bar{L}_I$. This tells us that despite that fact that trade leads half of the labs to become inactive, it leads to an overall increase in the aggregate amount of labor devoted to research in each nation.

V. Welfare Implications

Welfare comparisons are trivial in this model since the economy jumps immediately to the steady state. Solving (1), we have:

$$U = (\tfrac{1}{1-\beta})\ln C_0 + \beta(\tfrac{1}{1-\beta})^2 \ln(1+g).$$

Since $\ln(1+g)$ equals $(L_I/NF)\ln(1/\gamma)$ and C_0 equals $A_O(L-L_I)$ in the closed economy, the socially optimal L_X is:

$$\text{(12)} \quad L_X^* = \rho\, NF/\ln(1/\gamma).$$

Comparing this with (9), it is clear that growth is too slow in the closed economy steady state since too much labor is devoted to manufacturing. Figure 4 plots closed economy utility against the allocation of labor showing the socially optimal L_I^* as well as the closed economy $\bar{L}_I$. For comparison, the point L_I' shows what L_I would be if there were competition among domestic innovators, i.e., L_I' is the steady state allocation if labs innovated up to the point where $V(m) = 0$. It is straightforward to show that (L'_I/L'_X) equals the growth rate g'. This fact together with the expression for L^*_X can be used to demonstrate that L'_I is also sub–optimal.[6] The pro–growth effect of import competition is clearly welfare increasing.

Welfare Effects of Free Trade

The home country's utility as a function of worldwide allocation of labor (recalling that home gets half of world consumption) in the open economy case is also plotted in Figure 4. Since the marginal utility of labor employed in research is constant in this model yet the marginal utility of labor in manufacturing is declining, the optimal worldwide L_X is the same as L^*_X in (11). Using the same argumentation as in the closed economy, it can be shown that the steady state level of research labor in free trade, $\tilde{L}_I$, is sub–optimal.

VI. Policy Implications

A number of straightforward policy implications are evident even in this highly streamlined model. The first stems from the simple observation that trade liberalization forces a large number of domestic innovators to stop innovating, yet innovation activity as a whole increases. Thus evidence that import competition forces the exit of innovative firms cannot be used to argue that import competition discourages domestic innovation activity. The second stems from the fact that if factor prices are equalized in the steady state, growth in each nation depends upon the level worldwide innovative activity. Consequently, even if trade liberalization reduced the level of innovative activity in each country, it might speed growth in all

---

[6]Since $g' < (1+g')\ln(1+g')$, L^*_X/L'_X is less than the ratio of $(1+g')\ln(1/\gamma)/NF$ over $\ln(1/\gamma)/NF\rho$. This latter ratio equals $(1+g')/(1/\rho)$, so since $1+g'$ is less than $(1/\rho)$ for any reasonabls values of g and ρ, $L^*_X/L'_X < 1$, and so $L^*_I > L'_I$.

countries by eliminating redundant research efforts. Lastly, if the efficiency cost of raising government revenue is not too high, the government should subsidize R&D.

Antitrust Policy and Growth in an Open Economy

The relationship between antitrust policy and endogenous growth is far too broad a topic to be addressed by a single model. However even in this simple growth model a number of interesting points comes through. Consider a slight variant on the basic open economy model. Suppose that we allowed research labs to make takeover bids for labs in the same sector. Given that in steady state either the domestic or the foreign lab is inactive, the shareholders of the dormant lab would benefit from any positive bid. Such a takeover would eliminate the potential R&D competition thereby allowing the merged labs to innovate at the lower, more profitable, monopoly rate. Clearly the two labs have a great incentive to merge. Indeed all home and foreign labs in each sector would merge – were it permitted – resulting in the steady state division of labor marked by $\check{L}_I$ in Figure 3. This would lower growth and thereby world welfare (see Figure 4).

The obvious policy implication is that profitable and non–hostile mergers or takeovers of innovative firms may not be in the best interest of society. A number of caveats present themselves. First, if we extended the model to allow for more than two potential innovators per sector (as would be the case if we opened trade between three identical economies), then clearly there would be only one active lab per sector in steady state. Acquisitions in this world would have no impact on growth as long as at least one innovator remained independent of the others. Second, cross–sector acquisitions have no effect on growth in this model. (Although it must be said that no research lab would make a positive bid for a lab in any other sector.)

Of course this streamlined model has assumed away any possibility that mergers are socially beneficial, although in the real world many such reasons exist. The only general policy implication is one of caution: since the market structure in research can affect growth, wholesale merges and acquisitions may affect the aggregate growth rate.

Growth Effects of Trade in Intellectual Property Rights

Trade in intellectual property rights (TRIPs) is a substitute for the disciplining effect of import competition. To see this, consider two autarkic economies of the Section II type that mutually allow TRIPs but do not allow trade in goods. The impact of this market opening on the market structure in research is identical to that stemming from free trade. Domestic labs that previously enjoyed monopoly must now face competition from foreign innovations. A moment's reflection reveals that the game between domestic and foreign innovators is exactly that same as in the open economy case, except that the leading package of innovations (in each sector) will be sold to a domestic and a foreign manufacturing firm. Nevertheless the aggregate operating profit earned by these manufacturers is the same as in the single manufacturer in the free trade equilibrium, since the two manufacturers do not compete with each other. This in turn implies that the winning research lab earns the same in this equilibrium as in the integrated world economy case. As a result, the new steady state rate of innovation will be the same as in the open economy steady state. The difference between this steady state and the open economy steady state lies in the fact that one local manufacturer will be active in each sector in each country. In half of the sectors the manufacturers will be using foreign–made technology. The problem of paying foreign innovators without trading goods has a simple solution in this model. Since domestic labs export patents in half of the sectors and foreign firms export patents in the other half, payment could be arranged via a simple swap of patent rights. Domestic and foreign research labs (in different sectors) could swap patent rights and sell them locally.

In many real world industries, intellectual property often crosses borders in the form of joint ventures or direct foreign investment. Noting this, it could be argued that this sort of disciplining effect of TRIPs occurs in industries such as the US auto industry and the European electronics industry.

Research Market Structure and Growth Effects of Tariff Liberalization

To examine the impact of marginal trade liberalization on growth consider two identical economies as in Section IV. However, suppose that while trade in goods is permitted, the countries initially impose an *ad valorem* tariff on all goods. The tariff is chosen so that foreign firms using the latest technology are only as competitive as domestic manufactures using publicly available technology. In this case, imports are no more competitive than the local potential manufacturing rivals, so prices and the profit accruing to monopoly innovators are the same as in the closed economy. The steady state division of labor is therefore $\bar{L}_I$.

Consider the effects of lowering the tariff in every sector by a factor of $1/(1+\epsilon)$, where ϵ is a small positive number. This makes imports slightly more competitive than domestic producers using public technology. If the local manufacturers did not change their prices, imports could undercut local prices, thereby yielding foreign manufacturers increased operating profits. If the tariff cut is not too large, the incumbent local manufacturers will find it optimal to match the potential import price and thereby maintain their 100 percent market shares. The new first order condition of monopoly research labs becomes:

$$\ln(1/\gamma)(1+\epsilon)\gamma^{m}(C_t/N) = w_t F.$$

This is plotted as $L_I^{d}{}''$ in Figure 2. The new demand schedule is to the right of the old one, since the expanded output increases the marginal incentive to develop cost–saving innovations. The lower prices, however, also boost the demand for production labor by exactly the same proportion, i.e,:

$$L_X = \gamma^m(1+\epsilon)C_t/w_t.$$

This is plotted as L_X^{d}" in Figure 2. It is clear that the marginal tariff reduction has no impact on the steady state division of labor, so it has no impact on growth.

Note that in the case of a monopoly innovator, a prohibitive quota and tariff have the same growth effect.

The effect of the marginal liberalization, however, depends upon the market structure in research. For instance, consider a closed economy where for some historical reason, two domestic research labs exist in each sector. It is obvious that, just as in the open economy equilibrium, only one lab per sector will be active, but the active lab produces enough innovations to ensure that the operating profit from using the innovations just equals their development cost. Given this set up, consider the impact of marginally opening up trade as above. Formally, the condition determining the rate of innovation is:

$$(1-(1+\epsilon)\gamma^m)(C_t/N) = w_t mF.$$

We plot the implied L_I demand curve as L_I^{d}' in Figure 2. Clearly the reduced profit margin shifts the demand schedule to the left in this case. Manufacturers demand for labor, however, is exactly the same as in the monopoly innovators case. It is clear from Figure 2 that the net result of the marginal tariff reduction is slower innovation and growth, and therefore lower welfare.

Note that in the case of a competitive research sector, tariffs and quotas do not always have the same effect. A zero quota results in the closed economy growth rate, while a range of prohibitive tariffs leads to a lower growth rate. Furthermore, in the case of a competitive domestic innovation sector, the relationship between liberalization and growth is U–shaped. Starting from autarky, slight opening slows growth and lowers welfare, while a full liberalization raises growth and welfare.

The only robust policy implications arising from this analysis is that the impact of trade liberalization on innovation and growth depends on the market structure of the domestic innovative sector.

VII. Concluding Remarks

This paper shows that the market structure of an economy's research sector is an important determinant of the aggregate growth rate, even though it has hereto been ignored in the formal literature. To make this point in a concrete context, a simple model is used to show that import competition may stimulate growth by forcing domestic monopolistic innovators to act more competitively. In this model, import competition forces domestic innovators to chose between either quickening their pace of innovation or being displaced by foreign innovators. The resulting pro-growth effect is set against the usual anti-growth effect that stems from the manner in which import competition reduces the return on domestic innovation, thereby by driving some innovators out of business. The opening of trade – taken as a whole – boosts the domestic growth rate and domestic welfare due to two additional pro–growth effects of trade. Trade opening expands the potential market for innovations and thereby allows greater exploitation of scale economies in knowledge creation. It also improves the efficiency of research labor by eliminating redundancy in research efforts. The paper also demonstrates that the pro-growth effect of import competition tends to raise welfare while the anti-growth effect tends to lower welfare.

The normative conclusions in this paper may be quite model–dependent, so they should be interpreted cautiously. The model does not allow for important real-world capital market characteristics such as asymmetric information between lenders and borrowers, taxation, and risk. Moreover a one–period patent probably fails to adequately capture important real–world aspects of intellectual property rights and the appropriability of knowledge. The results would seem less sensitive to the polar nature of the assumed market power in research. The basic source of the pro-growth effect in the model is the manner in which increased competition among innovators raises the total output of innovations. The result that more competition in a sector leads to higher total output in the sector is common to most models of imperfect competition. In the case of the innovation sector, a higher total output of innovations means faster productivity gains and thereby faster output growth. Thus the result that import competition has a pro–growth effect would appear to be rather robust.

The theoretical model in this paper highlights the growth effects of import competition, however it does not provide any guide as to their quantitative importance. This effort is an important topic for future empirical and theoretical research. One method of getting at this roughly would be to attempt to calibrate the growth model as in Baldwin (1989, 1992).

REFERENCES

Baldwin, R. (1989) "The Growth Effects of 1992", Economic Policy, 9.

Baldwin, R. (1992) "Measurable Dynamic Gains from Trade", Journal of Political Economy, in press.

Deardorff, A. (1973) "The Gains from Trade In and Out of Steady State Growth", Oxford Economic Papers, 25:173–191.

Feenstra, R. (1990) "Trade and Uneven Growth", NBER Working Paper No. 3276, Cambridge, MA.

Findlay, R. (1973) International Trade and Development Theory, Columbia University Press, New York.

Findlay, R. (1974) "Relative Prices, Growth and Trade in a simple Ricardian System", Economica, 41:1–13.

Findlay, R. (1981) "Fundamental Determinants of the Terms of Trade", in Grassman, S. and E. Lundberg, eds., The World Economic Order: Past and Prospect, Macmillan, London.

Grossman, G. and Helpman E. (1991a) Innovation and Growth in the Global Economy, MIT Press, Cambridge MA.

Grossman, G. and Helpman E. (1991b) "Quality Ladders in the Theory of Growth", Review of Economic Studies, 58:43–61.

Johnson, H. (1959) "Economic Development and International Trade", Nationalokonomisk Tidssdrift, 5–6:253–272.

Krugman, P. (1988) "Endogenous Innovation, International Trade and Growth", Presented to SUNY–Buffalo conference; later published in Rethinking International Trade, Paul Krugman, MIT Press, Cambridge MA, 1990.

Oniki, H. and Uzawa, F. (1965), "Patterns of Trade and Investment in a Dynamic Model of International Trade", Review of Economic Studies, 32:15–38.

Shleifer, A. (1986) "Implementation Cycles" Journal of Political Economy 94:1163–1190.

Smith, A. (1977) "Capital Accumulation in the Open Two–Sector Economy", Economic Journal, 87:273–282.

Stiglitz (1970) "Factor Price Equalization in a Dynamic Economy", Journal of Political Economy, 78:456–488.

</ref_section>

APPENDIX 1: ***Formalization of Duopoly Innovation Game***

To formally demonstrate that the duopoly innovation game leads to the outcome described in the text, consider a three phase game each period. In the first phase, the two research labs play a sequential game in innovation packages. One lab, call it lab A, develops a package containing m^a innovations. Since the m^a innovations are physically created, the second lab, lab B, takes this as given. Lab B then develops a package containing m^b innovations. This sequence is repeated a number of times (one repetition is sufficient for our purposes) allowing labs to bump up the number of innovations in their package. Since the innovations are actually developed at each step, labs cannot reduce the number of innovations in their package. In phase two the packages are auctioned off one at a time to manufacturing firms with proceeds going to the innovators. The content of the packages and their sale or non–sale are public knowledge. In order to implement a purchased package, a manufacturer must incur a very small cost, ξ, of switching over to the new production technique. In order to avoid spurious indeterminacies, we assume that one lab's switch–over cost is smaller than the other's, namely $\xi^a > \xi^b$, or $\xi^b > \xi^a$. After solving the game for given ξ's, we study the impact of allowing the ξ's to go to zero. In the last phase manufacturers play Bertrand in the output market. It is useful to divide phase–one outcomes into three categories: (i) both packages contain a positive number of innovations but one contains a smaller number, (ii) the packages contain the same number of innovations, (iii) one of the packages contains zero innovations while the other contains a positive number.

Consider the auction phase when the first phase involves an outcome in the (i) category. The outcome of the third phase (Bertrand competition in the output market) is summarized as payoffs in the normal–form of the second phase (the auction phase) of the game. This is done in Figure A1. As shown in the figure, there are four possible outcomes in the auction phase depending upon whether each of the two packages is bought. Without loss of generality, suppose that $m^b < m^a$ and manufacturer #1 buys m^a. The payoffs in the figure represent the various operating profit (i.e., revenue minus production and switching costs) that manufacturers would earn in the third phase Bertrand competition. The manufacturer who buys the package with m^a innovations earns positive operating profit whether the other package is bought or not. Given this, no manufacturer would buy the package with fewer innovations – even for a zero price – since this would result in a small loss. Consequently the sub–game perfect equilibrium is that only the package with the greater number of innovations is sold.

Obviously the operating profit earned from a package is the maximum a manufacturer would bid for the package. Since there are limitless potential manufacturers, the auction price will equal operating profit, if this is non–negative. If operating profits from a particular package would be negative, the auction price would be zero.

Next consider category (ii) of phase–one outcomes where both packages have the same number of innovations. Figure A2 depicts the various outcomes when $m^a = m^b$. Here there are two Nash equilibria: one or the other package is bought and the other is not.

The last category of phase–one outcomes is that only one package contains a positive number of innovations. In this case the outcome is obvious. The package with a positive number of innovations gets sold and the purchaser earns operating profit equal to $\pi[m] - \xi^i$. The empty package is not sold.

Given all this, consider what the sub–game perfect equilibrium is in the first phase. As usual, we look at what lab B would do, taking lab A's package as given, before looking at what A would do knowing how B would react. Suppose A chose $0 \leq m^a < \tilde{m}^b$ where $\pi[\tilde{m}^b] - \xi^b = \tilde{m}^b w_t F$. Lab B's reaction to such a package would be to upstage any m^a less than $\bar{m}^b$ by choosing m^b equal to $\bar{m}^b$ (where $\bar{m}$ is the monopoly solution, i.e., $\pi_m[\bar{m}^b] - \xi^b = w_t F$). For $\bar{m}^b \leq m^a < \tilde{m}^b$, the optimal m^b is just slightly larger than m^a. Finally, for $m^a = \tilde{m}^b$ the best thing for B to do is to offer zero innovations. If lab B did not do so, it would lose money on any package containing $m^b \in (0, \tilde{m}^b)$ (since such a package would never sell), and it would lose money on any package containing more than $\tilde{m}^b$ innovations (since the sales price would exceed the development costs).

Having found B's reaction to A's offer, consider what A's choice would be in the case that $\xi^b > \xi^a$. Clearly, A would offer a package with $\tilde{m}^b$ innovations since this would force B to offer no innovations, yet would earn A positive profits, namely $\pi[\tilde{m}^b] - \xi^a - w\tilde{m}^b F > 0$. The second round of innovations allows A and B the opportunity to increase the number of innovations in their packages, however in this case there would be no change. Next consider that case of $\xi^b < \xi^a$. Here A would offer zero innovations, and B – in anticipation of A's second round reaction – would offer $\tilde{m}^a$ innovations. This would earn B positive profits and A zero profits.

Restricting our attention to sub–game perfect equilibria, there are two possible outcomes in this duopoly innovation game. In each equilibrium, the number of innovations implemented each period will be $\tilde{m}^b$ or $\tilde{m}^a$. Taking the limit as the ξ's get arbitrarily small, we see that the equilibrium number of innovations each period limits to $\tilde{m}$ satisfying $\pi[\tilde{m}] = \tilde{m} w_t F$. Of course, lab A may be the foreign or domestic research lab, so the nationality of the equilibrium innovation is not determined in this simple model.

Figure A1

Manufacturer #1\Manufacturer #2

$m^a \backslash m^b$	Bought	Not Bought
Bought	$A-\xi^a, -\xi^b$	$\pi[m^a]-\xi^a$, 0
Not Bought	0, $\pi[m^b]-\xi^b$	0, 0

NB: $A \equiv (1-\gamma^{m^a-m^b})C_t/N$, so that if m^a-m^b is positive then there exists an ξ^a small enough so that $A-\xi^a$ is positive. Also as in the text $\pi[m] = (1-\gamma^m)C_t/N$.

Figure A2

Manufacturer #1\Manufacturer #2

$m^a \backslash m^b$	Bought	Not Bought
Bought	$0-\xi^a, 0-\xi^b$	$\pi[m^a]-\xi^a$, 0
Not Bought	0, $\pi[m^b]-\xi^b$	0, 0

Figure 1
Optimal Innovation Package

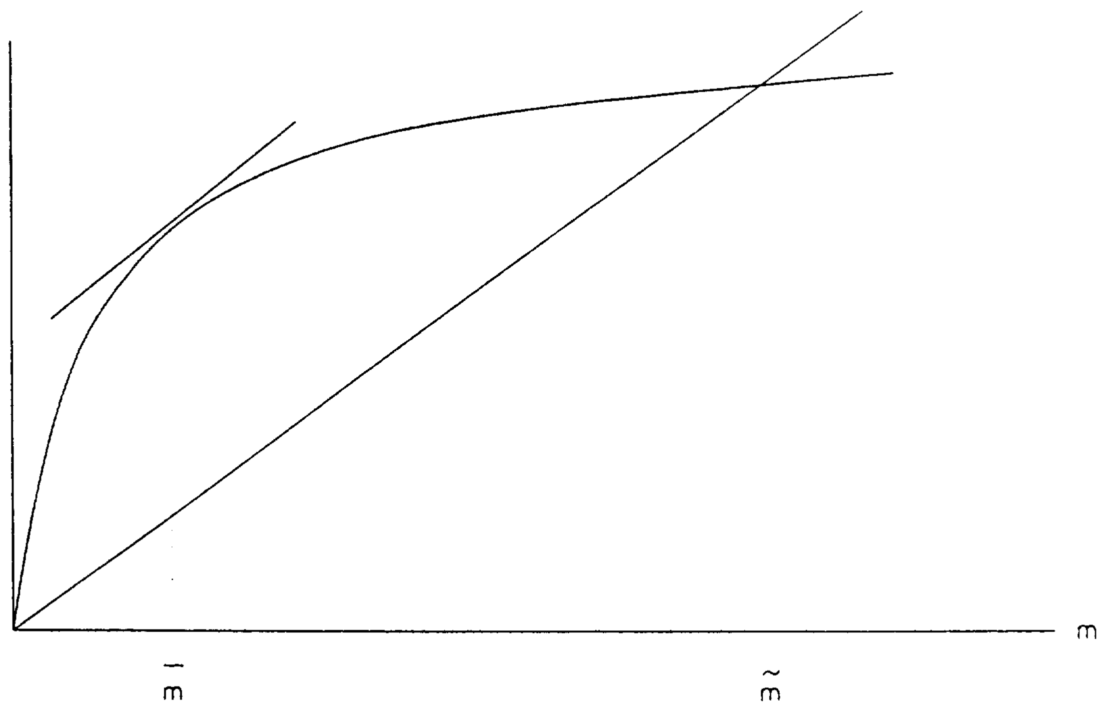


Figure 2
Closed Economy Division of Labor

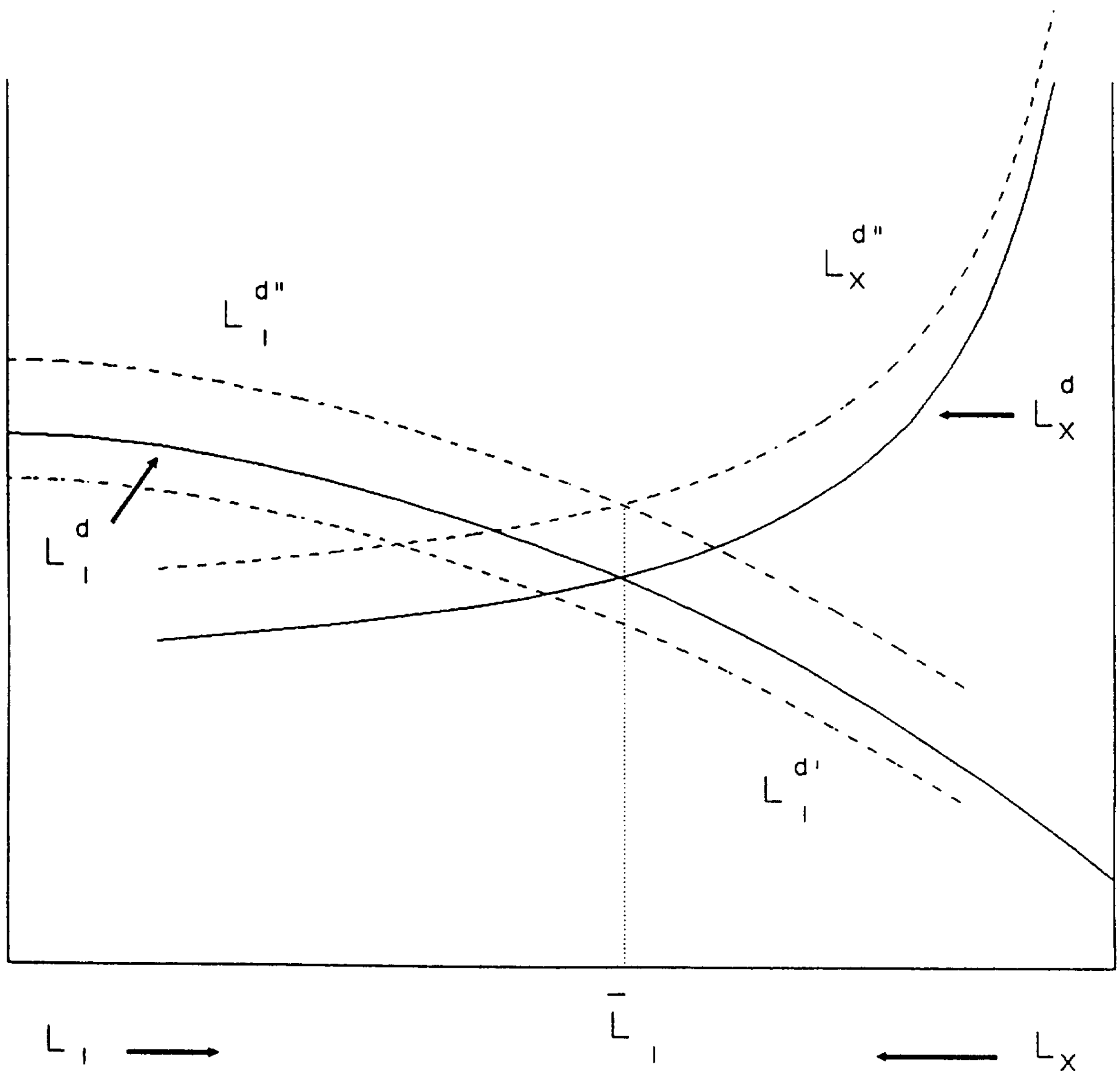


Figure 3
Open Economy Division of Labor

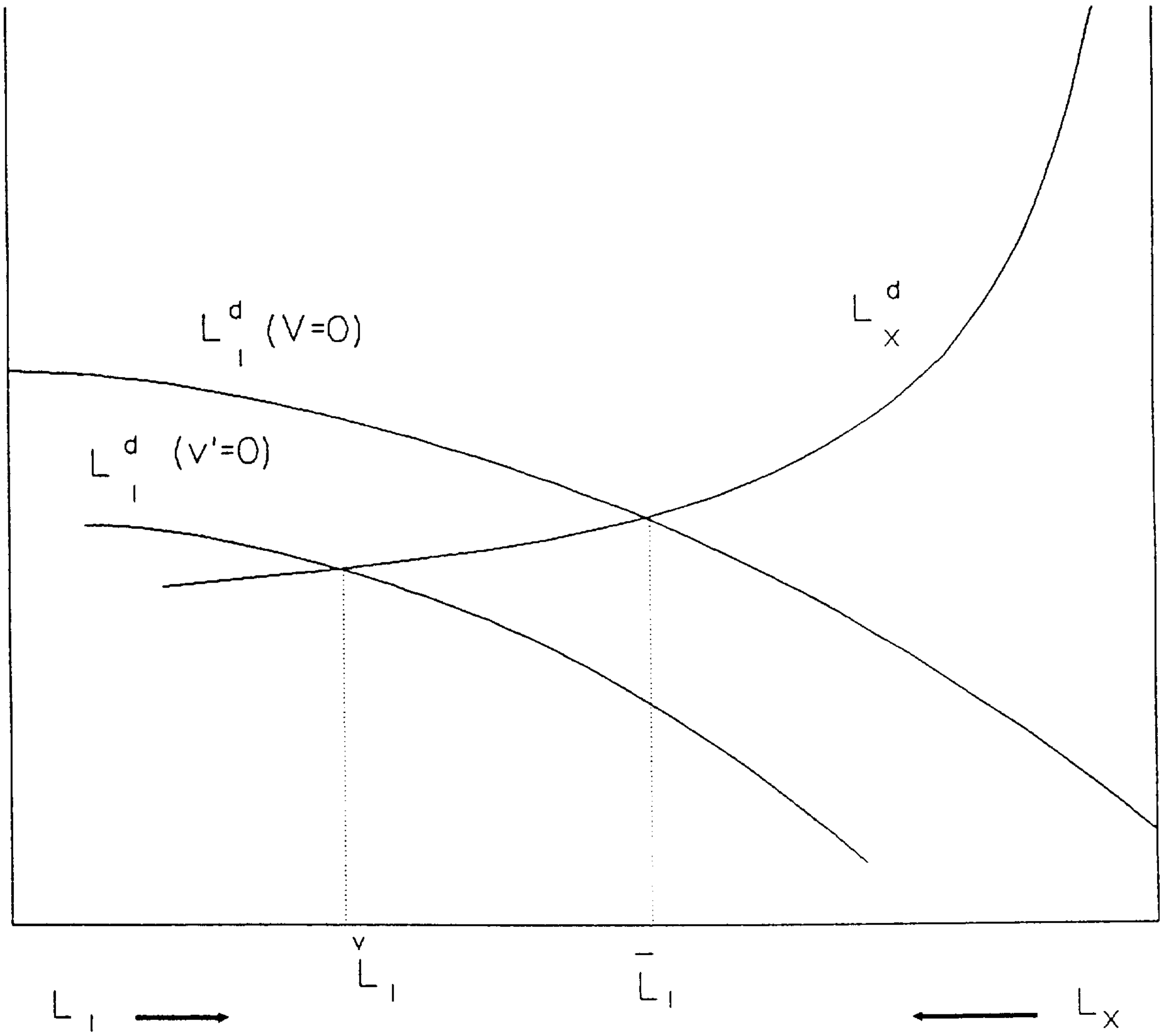
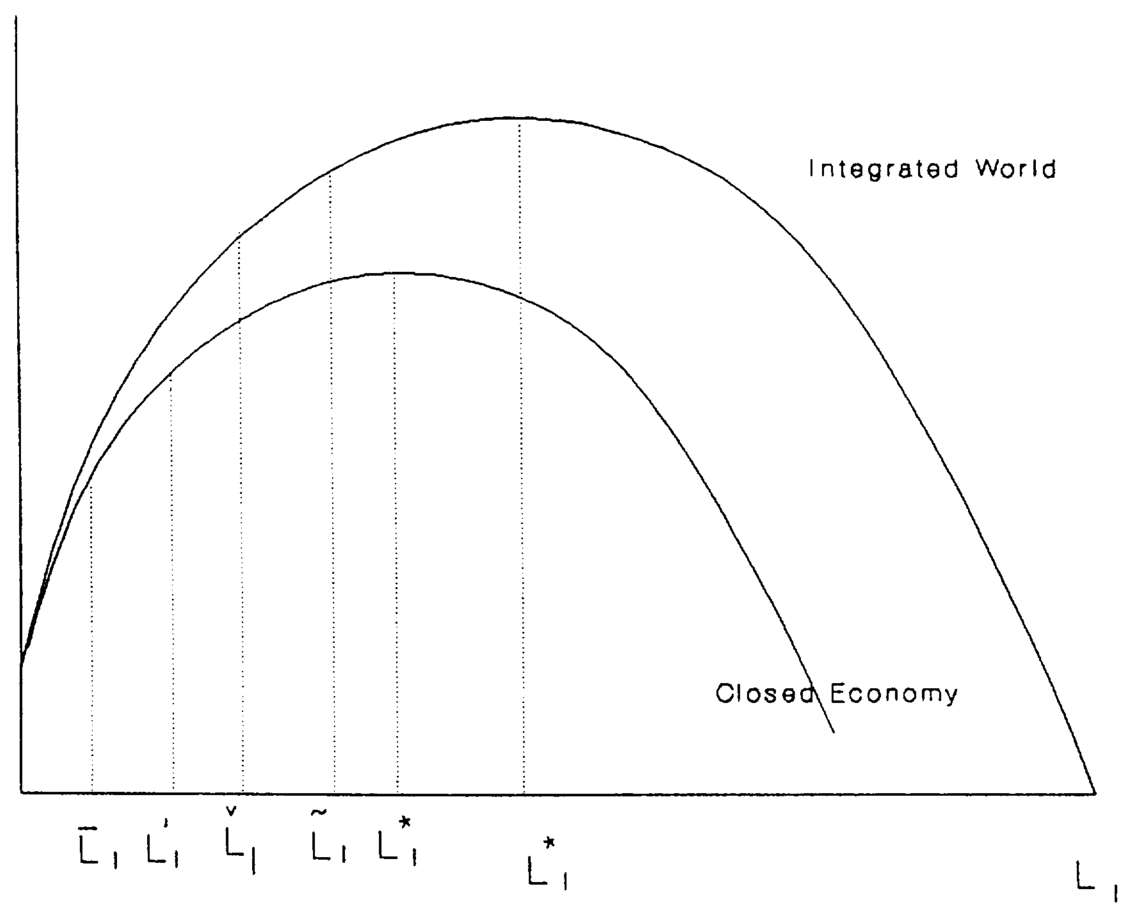


Figure 4
Welfare Effects



L