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LARGE FOREIGN MARKETS AND EXPORT-LED GROWTH IN DEVELOPING COUNTRIES

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Abstract

Many economists and policymakers believe that international trade played an important role in the economic growth miracles of East Asia, but there is no consensus on the precise way trade helped. However, narrative accounts give the impression that an eminent feature of the growth miracles was a move toward producing goods that higher-income countries produced, adopting the better technologies and methods used in those countries. Those goods were not always demanded much in the domestic markets of the newly industrializing East Asian countries, because of lower aggregate income and smaller share of those goods in domestic demand. International trade gave those countries access to larger markets, which enabled their producers to adopt the better technologies even if domestic demand did not justify fixed costs. This paper presents a dynamic general equilibrium model of this role of trade. The key assumption, as in Murphy et al. (1989), is that sectoral production functions are subject to a minimum efficient scale (beyond which they exhibit constant returns). To highlight the proposed gain from trade, the model rules out all other types of gains—such as those arising from access to a larger variety of goods or from comparative advantage.

Overview

Section 1 presents the background and motivation for the paper, and lays out an explanation for the importance of trade in development. Section 2 discusses some of the other explanations and relates this paper to other works in the literature. Section 3 provides an intuitive description for the model. Section 4 presents the formal model and results. Section 5 presents the summary and conclusions.

1 Introduction

The rapid development experiences in the second half of the 20th century of some East Asian countries, such as South Korea and Taiwan, were so extraordinary that they are sometimes referred to as growth miracles. Those miracles have been researched extensively, and the literature concludes that some factors were important, such as openness to trade, a stable macroeconomic environment, high levels of education, and the successful provision of infrastructure and various public services. Debate remains on the effectiveness of the industrial policies adopted by those countries.

A remaining issue is the role international trade played in those growth miracles. As a World Bank policy research study on the East Asian Miracle reports, "while the link between international trade and economic growth is widely accepted, the precise nature of the relationship is not clear".[1]

Several potential mechanisms have been identified for the role of trade. Because developing countries tend to specialize first in textiles and other labor-intensive sectors, the traditional static gains from trade are first on the list. These gains, however, are considered too small to account for development miracles. Another way trade can be conducive to development is that exporters in developing countries may ben-

[1] World Bank (1993), page 292.

efit from knowledge spillovers while they deal with buyers from developed countries, and thereby international trade may help improve productivity. However, this explanation is not supported by evidence, as demonstrated by Clerides et al. (1998) and others. A third alternative is the ability to import better capital equipment. Although this hypothesis has some empirical support, it has not been established that improvements in available capital explain East Asian growth miracles, and recent studies provide evidence that questions this explanation.

Rapid development involves the acquisition of better methods of production already in use in developed economies. The World Bank (1993, page 50) reports that "both theory and empirical evidence lead us to conclude that total factor productivity growth in . . . low- and middle-income economies" is because of "movements toward the international best practice." This process of catching up raises the returns to factors of production in a developing country to levels that are closer to those in developed economies. Wacziarg (2001, page 397) describes that pattern as a "broad transformation in the product composition of output and exports from agriculture to heavy industry and finally to high-tech goods, through the imitation of technology originating in industrial countries."

Acquiring better methods of production may not be an easy task. Developing countries usually do not have access to the best technologies. Even if they are able to acquire new and better techniques, they need time to master them, to achieve an acceptable level of efficiency. And, in most cases, some or many of the necessary public services and institutions may not be well established in developing economies; this can make adopting the international best practices employed in developed countries more difficult or useless. In the context of East Asian growth, improvements in the provisions of public services might have been attempts to address this problem.

But even if a developing country overcomes those barriers to adopting better techniques, there may be another problem it has to face: The size of the domestic market can be a limiting factor for production. Krueger (1998) explains this in the following way:

> "Because people have such low per capita incomes, most developing countries' markets are relatively small, outside of food and housing. Protection of production activities in these small markets results in a dilemma: either the number of firms producing a given good must be very small, or the size of individual plants may well be below minimum efficient size. . . . By contrast, a liberalised trade regime permits low-cost producers to expand their output well beyond that demanded in the domestic market. Whereas industrialisation based on protection of domestic industries thus results in ever-higher capital intensity of production . . . the open trade regime permits enjoyment of constant returns to scale over a much wider range."

This paper pursues the idea that this was the crucial role of trade in the East Asian development miracles. Foreign markets can provide an outlet for the goods of a developing economy, and this can enable firms to operate at sufficiently large scales. As firms that operate at high productivity levels are established, income rises and the size of the domestic market increases.

Given that developing countries start their industrialization with products that are not usually characterized by high degrees of increasing returns to scale (such as textiles and apparel), this argument may at first appear irrelevant.

But it is not that the developing country does not have the capacity to accumulate a sufficient amount of capital to establish a single factory that produces a certain type of luxury apparel. It is rather that the industry would not be able to sell *enough* in the domestic market. For example, a particular apparel item that might typically be demanded at higher levels of income may not be in much demand in the domestic market of a developing country. Firms would not enter that line of business because sales prospects would be too low to justify fixed costs. This points to the difference of the mechanism emphasized in this paper from other models based on increasing returns even at high levels of production. In those models, trade benefits a country simply because it allows a country to specialize in a certain sector, as in Devereux (1997).

This paper formalizes its argument by use of a dynamic general equilibrium model. To emphasize and distinguish the importance of large foreign markets, the argument rules out other benefits from trade. These benefits include the gains from trade based on differences in factor proportions, Ricardian differences in relative techological efficiencies, and other sources of comparative advantage. Also ruled out is the benefit from trade that it makes more varieties available; in the model, all varieties are produced in all countries, both before and after trade liberalization. The paper assumes that domestic capital goods are not inferior to foreign ones, thus also ruling out the advantage of importing better foreign capital equipment. In the model, the technology exhibits constant returns to scale after the minimum efficient scale is reached. This ensures there would be no advantage from specialization in a single product. Finally, the paper also rules out international capital flows, although that is not crucial—capital inflows would make no difference in the model other than accelerating the industrialization of the developing country.

The paper bypasses the issue that some factors may prevent a developing country from utilizing foreign technologies. These factors include the costs associated with transferring technology, and the need for a period of learning by doing to reach the long-run minimum average cost level. The paper simply assumes that better technologies can be copied at no cost from more developed countries. It also assumes that the government has provided a stable environment with well-defined property rights, as well as other needed initial conditions for development, so that a firm in the developing country is not impaired by a lack of infrastructure or other public services.[2] Finally, the developing country is not at a disadvantage due to the lack of cost linkages—the lack of a well-developed supplier network and other local producer services. This is another potential obstacle to industrialization that has been emphasized in the literature, but is left out of the model for the sake of simplicity.[3]

Although more productive techniques can be copied at no cost, they cannot be adopted profitably because of the minimum efficient scale requirement when the size of the domestic market is small and the foreign markets are not open to trade. This is a vicious cycle: Because the country cannot adopt better technologies, it cannot increase its income level. However, when the country opens to international trade, the access to large foreign markets enables firms to use better technologies. Industrialization starts immediately upon opening to foreign markets, and, by the end, fully transforms the country into a high-income one.

As Krueger (1998) mentions, there are at least two reasons for inadequate demand: the low level of aggregate income, and high income elasticity of demand for more sophisticated country products. For simplicity, the model of this paper does not include the income elasticity effect, and the lack of demand arises solely from low national income. However, the precise source of the demand insufficiency does not make a substantive difference; the lack of demand is the reason modern firms are not established, regardless of the source of that insufficiency. Engel's Law is not incorporated here, because it would complicate the model without providing additional insights. The model assumes that the same goods are produced and consumed in the developed and developing countries, and that the difference between the old and new technologies is only in the amount (rather than in the composition or quality) of output they generate for given levels of factor inputs.

[2] Allowing for insufficient public services would not make a substantive difference for the conclusions of this paper, unless different sectors are affected differently.

[3] In the model, the developing country is assumed to have such "backward linkages" already in place before trade liberalization—it produces all goods even in autarky.

The traditional development literature, going back at least to Rosenstein-Rodan (1943), observes that the size of the domestic market may be a reason that developing countries remain in their state of lesser development. Several decades later, Murphy, Shleifer, and Vishny (1989) formalized the idea. This paper shares the insight of Rosenstein-Rodan and borrows elements from the well-known model of Murphy et al.

2 Literature on the Role of Trade in Development

This section discusses some other explanations offered in the literature for the role of trade in growth miracles, although it is not meant to be comprehensive. As mentioned in the introduction, the one that may come to mind first is the traditional gains from trade. International trade enables a developing country to specialize in labor-intensive products, such as textiles and apparel, and income rises as a result of utilization of this comparative advantage. Although the typical pattern of specialization in rapidly developed countries in the early stages of development is consistent with that argument, the behavior of factor prices in those countries is not consistent with what factor proportions theory would predict. The theory suggests that specialization in labor-intensive products should result in a decline in the relative price of capital. But the observed pattern is an increase in the returns to both labor and capital. Furthermore, the traditional gains from trade (sometimes called static gains) are not estimated to be large enough to explain major transformations such as those achieved by the East Asian countries.[4]

Another argument is the "knowledge spillovers" view (e.g., Grossman and Helpman 1991, pages 165-171). A central theme in that literature is that firms of developing countries learn from their dealings with buyers or sellers from developed

[4]See Baldwin (1992) and Krueger (1998), as well as Deardorff and Stern (1995) on the size of static gains from trade.

countries, and hence improve their productivity. However, empirical studies suggest that exporting does not improve the productivity of firms (Clerides et.al. 1998).

The literature also investigates the implications of increasing returns to scale. International trade allows a country to specialize in a range of products and utilize increasing returns to scale, thereby improving the level of income (e.g., Devereux 1997). The pattern of development in East Asian countries appears to differ from this. What we see instead is gradual industrialization in a wide range of sectors rather than specialization in a narrow set of products.

Models of monopolistic competition also have implications for the relationship of trade and development. International trade allows access to a larger range of intermediate goods, and this results in an increase in output (Ethier 1982a), although the increase is a sudden one. On the other hand, international trade also allows access to a larger range of capital goods (Romer 1991). A liberalizing country obtains access to different varieties of capital goods, and this effectively reduces the price of capital. A given amount of nominal investment therefore translates into a higher real level of investment after trade liberalization. The decline in the price of capital goods is also emphasized by Bhagwati (1996), who points out the ability to import new and/or more productive capital equipment from developed countries.

On the empirical side, Lee (1995) and Mazumdar (1996) show that when one controls for the share of imported capital in total imports, other measures of openness have no significant predictive power, although Mazumdar notes that the results are not as strong with more recent data.[5] Jones (1994) and, in a series of papers, DeLong and Summers argue that there is a strong empirical relationship between equipment investment and growth.[6] Furthermore, machinery and equipment are the components of investment for which prices are most sensitive to openness. However,

[5]Personal communication.

[6]See DeLong and Summers (1991) for a review.

DeLong and Summers (1991, page 487) acknowledge that subsequent investigation showed that "aggregate production functions suggest much smaller effects of equipment investment on growth" than that suggested by the partial correlations in the data. In other words, further research proved the relationship not to be robust.

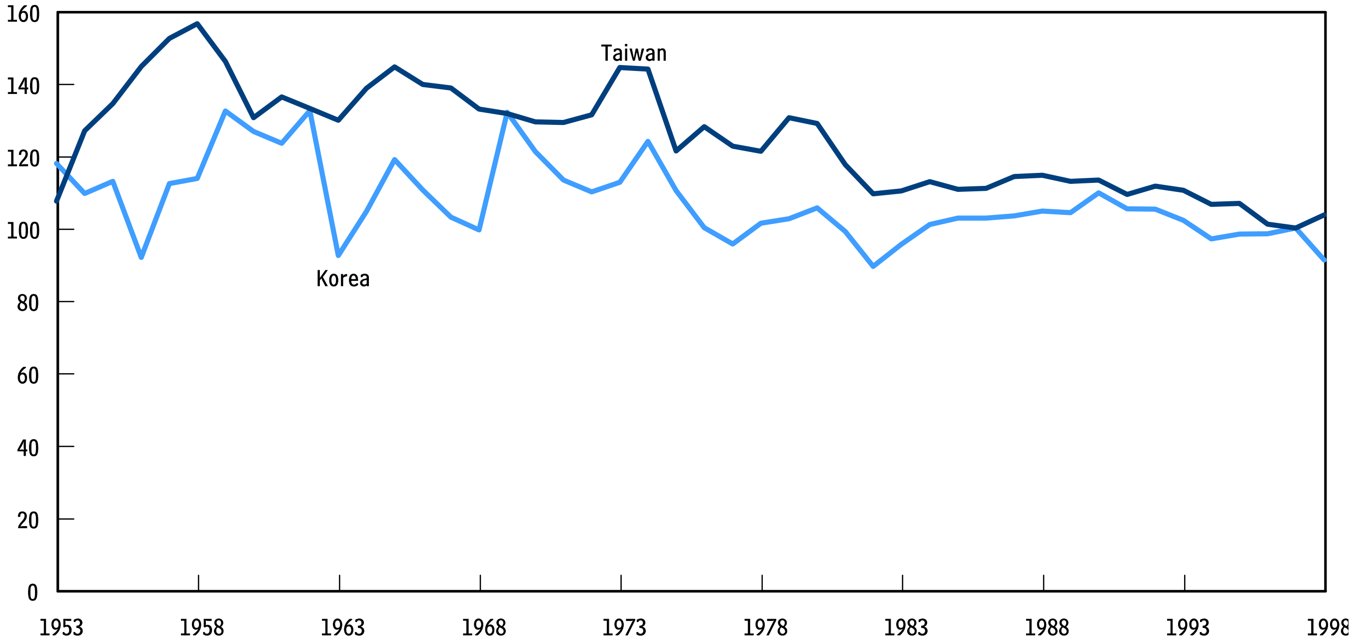
The improvement in the price index for investment in Korea and Taiwan does not appear substantial enough to explain the large changes in income in those countries. Figure 1 shows the fall in investment prices in Korea and Taiwan relative to the consumption price index according to the Penn World Tables. Figure 2 shows the expansion in imports and investment in Korea in the same time period, for comparison to Figure 1. (A similar pattern prevailed also in Taiwan.) From peak to the lowest level, the drop in price of investment relative to consumption is less than 40 percent for both countries—apparently closer to 25 percent in Korea and 30 percent in Taiwan. In both countries the decline is gradual. We do not see a sharp reduction at the beginning, and the decline in Taiwan starts only in the mid 1970s, when investment, growth and trade were already at high levels. A reduction of 40 percent in the price of capital leads to about 29 percent increase in steady state per capita output according to neoclassical models with a capital share of 0.3.[7] With a larger capital share such as 2/3, the increase in the steady state level of output implied by a 40 percent reduction in the price of capital is 176 percent. While that would be a substantial increase, it is far below the observed changes in income in these two countries. Gross Domestic Product (GDP) per worker in Korea relative to the United States has increased 617 percent from 1953 to 1990 (Penn World Tables). Although this mismatch in the magnitude of these numbers may arise from the inaccuracies of the price indices provided in the Penn World Tables, there does not yet appear to be conclusive empirical evidence supporting the capital goods view.

[7] A 40 percent reduction in the investment price level means that a given amount of sacrificed consumption results in 66 percent more capital than before (as $\frac{1}{1-0.4} = 1.66$), and $1.66^{\frac{\alpha}{1-\alpha}} = 1.29$.

Figure 1.

Price of Investment Relative to Consumption

(1997 = 0)

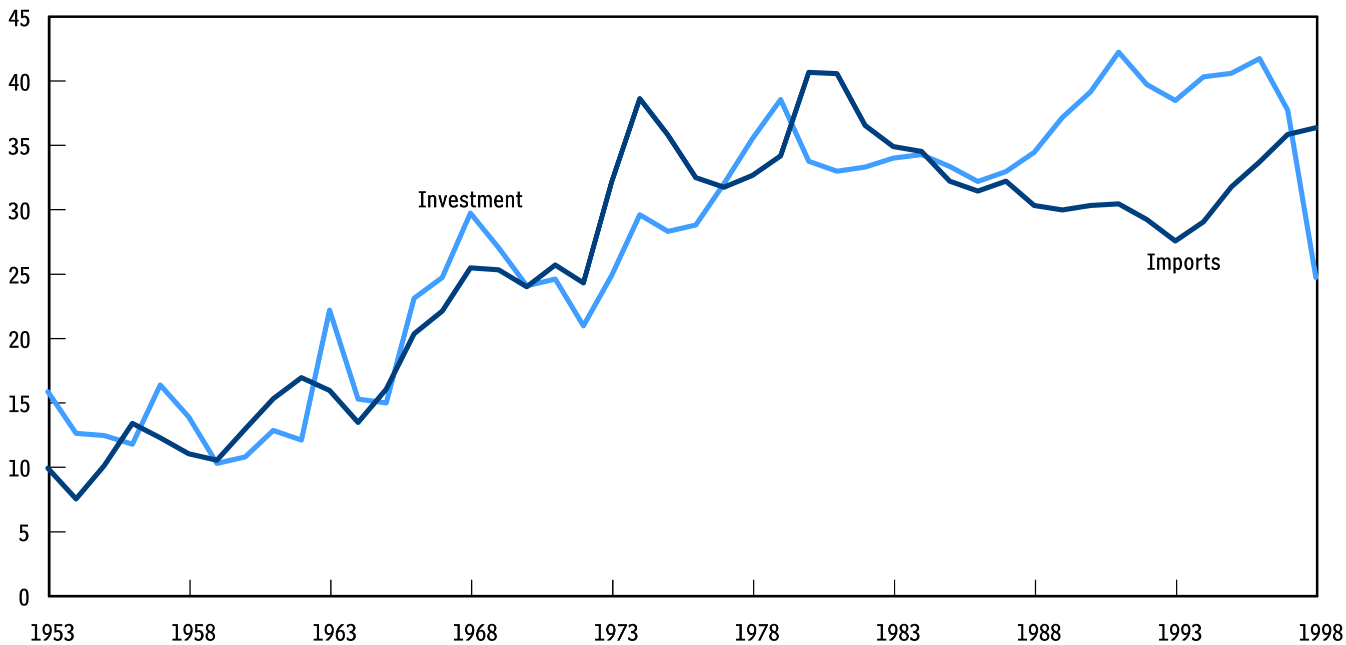


Source: Penn World Tables 6.1.

Figure 2.

Imports and Investment in Korea

(Percentage of GDP)



Source: Penn World Tables 6.1.

3 The Basic Story

There is an infinite variety of intermediate goods in the economy indexed by the points in the unit interval [0,1]. Aggregate output consists of a homogeneous final good, produced by combining intermediates using the production function:

$$Y_t = \exp \int_0^1 \ln y_z dz,$$

which then is used either for consumption or investment. This, of course, generates constant returns to scale with unit elasticity of substitution between products.[8] Each variety $z \in [0,1]$ can be produced either by traditional methods or by copying, wihtout cost, modern and more productive techniques used in developed countries

$$F^0(k_z, l_z) = l_z,$$

or

$$F^1(k_z, l_z) = Ak_z^{\alpha} l_z^{(1-\alpha)} \quad \text{subject to } k_z \geq \bar{K},$$

i.e., either by a constant returns to scale technology that uses only labor, or a Cobb Douglas technology that employs both labor and capital. A is chosen sufficiently high to ensure that the latter technology would be more attractive if it were not for the minimum capital stock requirement $k_z \geq \bar{K}$. Note that sectors are infinitesimally small; the requirement $k_z \geq \bar{K}$ essentially means that, to start using the new technology in a sector of size dz, capital of at least the amount $\bar{K}dz$ is required. Other than that constraint, the production function has constant returns to scale. Thus, the capital requirement imposes a minimum efficient scale on the technology. The market for the composite final good is perfectly competitive.

[8] This parallels the exposition in Murphy, Vishny, and Shleifer (1989). An alternative specification would be to use a Dixit-Stiglitz type function.

The closed economy can have two steady state equilibria. In one, only the traditional and less productive technology is used and income is low. Because income is low, only a small amount of each product is demanded, making it unprofitable to undertake the minimum investment $\bar{K}$ required to start using the highly productive technology. This in turn becomes the reason why income stays low, constituting a *poverty trap.* It may seem counterintuitive that the country is not able to undertake investment of $\bar{K}dz$, an infinitesimal amount. The restriction does not come from an inability to generate this small amount of capital stock. Rather, because the demand for the product is low, a firm that undertakes the investment $\bar{K}dz$ will not be able to recover the interest payment on that capital, and no firm will therefore make the investment to adopt the new technology.

The model considers the effect of trade liberalization in a developing country trapped in the low-income steady state. Because large foreign markets provide unlimited demand for each variety (at international prices), firms can start to operate with the new technology at efficient scale without concern about ability to sell output. Because the new technology is more productive, it is also more profitable (in the absence of the demand limitation), and many firms will want to undertake the minimum investment $\bar{K}$ and start to operate using the modern methods. This in turn increases the demand for capital goods, which raises the interest rate, as long as capital is not perfectly mobile internationally. To keep the analysis simple, the model rules out capital flows altogether.[9]

[9]With perfect capital mobility, the interest rates in the home and foreign country have to be the same. For this to be possible, the developing country has to receive a sudden lump sum capital injection of an amount equal to its steady state level of capital immediately after liberalization, transforming the developing country into a developed economy at once. In practice, what we have is between these two extremes—capital flows do exist, but they are not perfect. If capital movements were allowed in the model, capital would flow into the developing country (where labor is cheap) and would make the industrialization process faster depending on the extent of the assumed mobility of capital. Given that new investments are assumed to have no adjustment costs, with perfect capital mobility the developed country would turn into a developed economy instantly. The qualitative features of the outcome would be the same as in the case where capital flows are not allowed.

The lifetime utility is given by

$$U_t = \int_t^{\infty} e^{-\rho(s-t)} \ln C_s ds.$$

In response to the increase in the interest rate, consumption falls and saving rises. The interest rate rises to a level where the new technology is no longer profitable—it rises so that the advantage of cheap labor input is countered by high rental cost of capital. At that point, the rates of saving and investment are high, and capital accumulation drives industrialization. As capital stock builds up, capital needed to use the new technology is installed in additional sectors. In the other equilibrium, the country is fully industrialized (i.e., only the more productive technology is used) and income is high. The high level of income, in turn, creates high demand for individual varieties, which justifies the investment $\bar{K}$ required by the more productive technology.

Note that the capital requirement constitutes a resource constraint that prevents a sudden and full transformation as long as unlimited foreign borrowing is unavailable. The country therefore has to accumulate capital slowly, with sectors switching to new technologies gradually.

After all sectors industrialize, the economy behaves according to the familiar Ramsey Model. This is because $\bar{K}$ is no longer a constraint and the production function for the final good takes the usual Cobb Douglas form.

The model assumes the markets for varieties are contestable, ensuring no profits at any point in time. The purpose of this is to rule out (to abstract from) the benefit of trade that may arise from increased competition and lower markups.[10]

[10]For models of contestable markets with equilibria in which the incumbent firm engages in average cost pricing, see Maskin and Tirole (1984); or Tirole (1990, pages 340-341) for an illustrative example. The main feature of these models is that the capacity commitment has a short duration, so that a firm that challenges the incumbent has to fight only for a limited time period. In the model, capital is perfectly mobile between sectors and there are no sunk costs.

4 The Model

The economy produces Y_t units of a final good, which is either consumed or used in capital formation. Capital does not depreciate. These are expressed by:

$$Y_t = C_t + I_t \quad \text{and} \quad I_t = \dot{K}_t.$$

Households supply L units of labor inelastically. Their maximization problem is given by

$$\max \quad U_t = \int_t^\infty e^{-\rho(s-t)} \ln C_s ds, \tag{1}$$

$$\text{subject to} \quad \int_t^\infty e^{-(R_s - R_t)} C_s ds \leq \int_t^\infty e^{-(R_s-R_t)}(r_s K_s + w_s L) ds \tag{2}$$

where ρ is the subjective discount rate, r_t is the real interest rate, $R_t = \int_0^t r_s ds$ is the cumulative interest factor, and w_s is the real wage rate. The solution to this maximization problem is characterized by the Euler Equation

$$\frac{\dot{C}_t}{C_t} = r_t - \rho \tag{3}$$

as well as the budget constraint (2).

The final good is chosen as the numeraire. It is produced by combining intermediate inputs (products) $z \in [0,1]$ using the production function

$$Y_t = \exp \int_0^1 \ln y_z dz,$$

where y_z is output of intermediate good z at time t. (The time subscripts are omitted below from variables that are also indexed by z.) This specification implies that the demand curve for each product is unit elastic:

$$q_z^D = Y_t/p_z, \tag{4}$$

where p_z is the price of a unit of product z. Note that the production function for the final good exhibits constant returns to scale and that final goods markets are competitive. The price of the final good, P_t, is therefore equal to its average cost, which can be shown to equal $\exp \int_0^1 \ln p_z dz$. These are summarized in

$$P_t = \exp \int_0^1 \ln p_z dz \ = \ 1. \tag{5}$$

Intermediate products are supplied by monopolistically competitive firms—i.e., there is free entry and firms are not price takers. Each intermediate good z is produced by using either of the following two technologies,

$$F^0(k_z, l_z) = l_z, \qquad \text{or} \tag{6}$$

$$F^1(k_z, l_z) = Ak_z^{\alpha} l_z^{(1-\alpha)} \quad \text{subject to } k_z \geq \bar{K}. \tag{7}$$

Sectors that use the latter technology (indexed by 1) will be called industrialized or modern, and the former technology (technology 0) will be called old or cottage technology. The constraint $k_z \geq \bar{K}$ means that the modern technology has a minimum efficient scale to operate. The parameter A in the expression for the modern technology is chosen sufficiently large to ensure that the modern technology is preferable to the old one. However, the minimum capital stock requirement $k_z \geq \bar{K}$ may prevent adoption of that more productive technology if the market is not large enough.

The next subsection shows that the model has two steady state closed economy equilibria, one of which is a poverty trap. In that equilibrium, $w = 1$ and $r = \rho$. A is chosen in the model such that the unit cost of producing product z in that steady state, $c^1(w=1, r=\rho)$, equals a number a less than 1 if the requirement $k_z \geq \bar{K}$ is not binding. Note that, with $w=1$ and $r=\rho$, the unit cost of producing variety z with the old technology is 1. Thus, the parameter a indicates the unit cost with the new technology relative to the unit cost in the traditional sector. The technology in (7) implies that, if the requirement $k_z \geq \bar{K}$ is not binding:

$$c^1(w,r) = \frac{r^{\alpha} w^{(1-\alpha)}}{A\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}}. \tag{8}$$

In order to have $c^1(1,\rho) = a$, we need

$$A = \frac{\rho^{\alpha}}{a\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}}, \tag{9}$$

where, as described above, a is chosen so that:

$$a \equiv c^1(1,\rho) < 1.$$

This assumption ensures that the modern sector provides cost savings, and is preferable to (that is, more productive than) the old technology, provided that the minimum efficient scale requirement is not binding.

Equations for factor market clearing are:

$$L = \int_0^1 l_z dz, \quad \text{and} \quad K = \int_0^1 k_z dz.$$

Each sector is infinitesimally small, and factor employment in a sector is negligible compared to the national factor supply. (The capital stock and employment in sector z are infinitesimal.) The producers of varieties therefore take factor prices as given.

4.1 Steady-State Equilibria of the Closed Economy

In this section I show that this economy can have two non-trivial steady-state equilibria, one good and the other bad. In the poverty-trap equilibrium, only the cottage technology is used and output (in all products) is low. Low output, in turn, means low income and low demand. As a result of the small market size, a firm that undertakes the minimal required investment $\bar{K}$ suffers a loss in the poverty-trap steady state. On the other hand, in the industrialized equilibrium, only the modern technology is used and output is high.

The model has no exogenous productivity growth, and, therefore, all the variables are constant in the steady state. The time subscripts are usually dropped for clarity, because this section analyzes only the steady state.

Poverty Trap

This subsection investigates the conditions under which there exists a steady state equilibrium with only the cottage technology in use. Since the old technology involves constant returns to scale, free entry ensures that profits are driven down to zero. Since the production function is $q_z = l_z$, price of each product is equal to wage in the equilibrium, and, using equation (5), the aggregate price level is $P = w = 1$.

For the poverty trap to be an equilibrium, establishing a firm with the modern technology must be unprofitable. The model considers a firm that undertakes the minimal required investment $\bar{K}$, and investigate whether this firm experiences a profit or loss. The firm can not charge a price higher than unity, because of competition from the cottage technology. In the steady state, $\dot{C}_t = 0$, and from equation (3):

$$r_t = \rho.$$

For any price less than one, the firm will be a monopoly facing the demand curve given in equation (4). Note that $Y = wL + rK = L$, since $K = 0$ and $w = 1$. Thus the demand curve becomes:

$$q_z^D = L/p_z.$$

Given this unit elastic demand, the monopolist will charge the price $p_z = 1$ (as stated above, prices above unity bring in no revenue, because of competition from the old technology) and, at that price, $q_z = L$.

The choices that the firm faces are shown in Figure 3. The isoquants are for $F^0(k_z, l_z) = L$ and $F^1(k_z, l_z) = L$, and the straight line indicates the combinations of factor inputs that cost L at the steady state factor prices $w = 1$ and $r = \rho$. Without the requirement $k_z \geq \bar{K}$, the optimal production would be at point D and would involve positive profits. The point labeled $\bar{K}_{\min}$ on the vertical axis is the minimum value of $\bar{K}$ for which entry does not involve positive profits at the prevailing factor prices. If $\bar{K} = \bar{K}_{\min}$, production could be at point B and revenue would equal cost, making entry a break-even decision. If, however, $\bar{K}$ is larger than $\bar{K}_{\min}$, as shown in the figure, point C would be the best choice if the modern technology were adopted, but that entails a loss to the firm.

In order to produce the amount $q_z = L$, the firm needs to employ l_z such that $F^1(k_z, l_z) = A\bar{K}^\alpha l_z^{(1-\alpha)} = L$. This can be solved to yield:

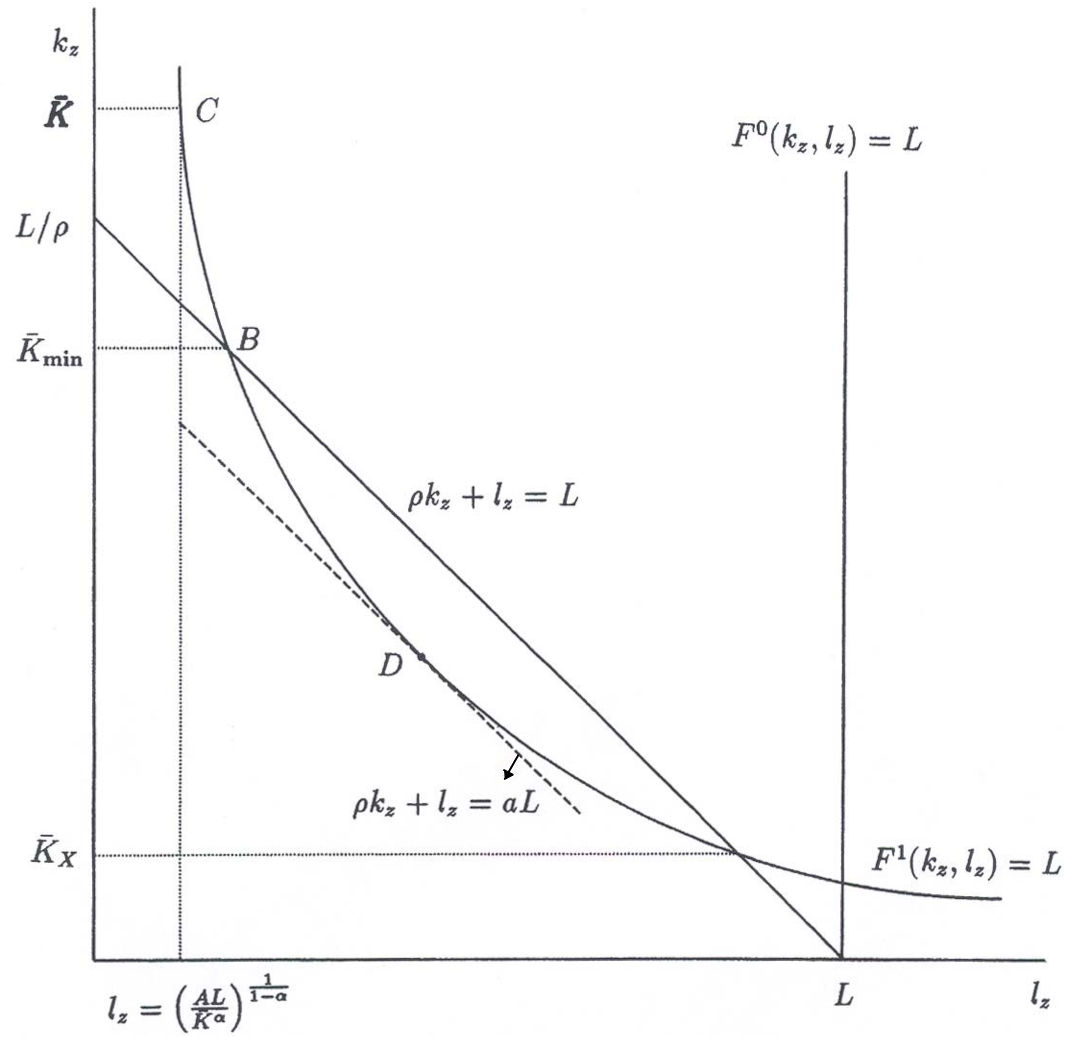
$$l_z = \left(\frac{L}{A\bar{K}^\alpha}\right)^{\frac{1}{(1-\alpha)}}.$$

The profits of the firm are:

$$\begin{aligned}\pi_z &= p_z q_z - (rk_z + wl_z)\\ &= L - \rho\bar{K} - l_z\\ &= L - \rho\bar{K} - \left(\frac{L}{A\bar{K}^\alpha}\right)^{\frac{1}{(1-\alpha)}}.\end{aligned}$$

Figure 3.

The Isoquants for Both Old and Modern Technologies



Note: The isoquants show, for a given variety z, the factor input combinations needed to produce L units of z. The variables l_z and k_z are labor and capital employed in sector z. If $\bar{K}$ is greater than $\bar{K}_{\min}$ (as shown), the new technology is too expensive to be profitably adopted by the developing country in autarky.

Profits are negative if:

$$L - \rho \bar{K} - \left(\frac{L}{A\bar{K}^{\alpha}} \right)^{\frac{1}{(1-\alpha)}} < 0.$$

There are two values of $\bar{K}$ that satisfy the equality $L = \rho\bar{K} + \left(\frac{L}{A\bar{K}^{\alpha}}\right)^{\frac{1}{(1-\alpha)}}$, and these are $\bar{K}_{\min}$ and $\bar{K}_X$, as shown in Figure 3. Inequality (10) is satisfied for $\bar{K} > \bar{K}_{\min}$ and $\bar{K} < \bar{K}_X$. It can be seen from the figure that only $\bar{K} > \bar{K}_{\min}$ is relevant, and the condition we have is

$$\bar{K} > \bar{K}_{\min}, \tag{10}$$

where $\bar{K}_{\min}$ is the larger of the two solutions ($\bar{K}_{\min}$ and $\bar{K}_X$) mentioned above. Inequality (10) is satisfied for sufficiently large values of $\bar{K}$—e.g., for $\bar{K} \geq L/\rho$.[11]

Good Equilibrium (Developed Country Steady State) This subsection investigates the conditions under which the economy can have a steady state with full industrialization (i.e., $k_z \geq \bar{K}\ \forall z \in [0,1]$). The necessary and sufficient condition turns out to be:

$$F_K^1(\bar{K}, L) \geq \rho. \tag{11}$$

If $F_K^1(\bar{K}, L) < \rho$, a fully industrialized steady state is not possible, because the optimizing household will find it more attractive to consume some of the existing capital if the capital stock is equal to or above $\bar{K}$. So the condition is necessary.

The condition is also sufficient. When the condition holds, there exists some $K^* \geq \bar{K}$ such that $F(K^*, L) = \rho$, and a steady state equilibrium with $K = K^*$ exists. Using the definition of the new technology in equation (7), condition (11) can be rewritten as $L \geq \bar{K}\left(\frac{\rho}{\alpha A}\right)^{\frac{1}{(1-\alpha)}}$. Defining L_c by:

$$L_c \equiv \bar{K}\left(\frac{\rho}{\alpha A}\right)^{\frac{1}{(1-\alpha)}}, \tag{12}$$

[11] $\bar{K}_{\min}$ is a function of A, α, ρ and L, and is proportional to L.

condition (11) becomes

$$L \geq L_c. \tag{13}$$

Here L_c indicates the minimum size of the labor force for a developing country to achieve full industrialization. If this condition fails, the country will not be able to fully industrialize in all sectors, as the country's population is too small to achieve minimum efficient scales of production in all sectors. Instead, it will fully specialize in some sectors and import in other sectors. An example of this might be Hong Kong, possibly too small a country to establish the most efficient levels of production in all products, and an opposite example might be Japan, with a population large enough to achieve modern production in most industries. (These are not empirical claims but are merely examples to clarify a point.) I call countries with L less than L_c *small*, and those for which condition (13) is satisfied *large*. Note that trade liberalization triggers a process of industrialization, and that trade liberalization takes a developing country in poverty trap out of that trap regardless of the country's size.

Condition (13) can also be written as

$$A > \frac{\rho}{\alpha}\left(\frac{\bar{K}}{L}\right)^{(1-\alpha)}.$$

The condition in this form can be reinterpreted as follows. The parameter A describes how productive the modern technology is: The larger A is, the higher the level of income is in the fully industrialized equilibrium (if it is achieved). The condition ensures that A is high enough to support a large market where investing $\bar{K}$ to start to use the new technology is justified.

It is possible to find parameter values that satisfy both conditions, (10) and (13): E.g., set $\bar{K} \geq L/\rho$ for condition (10) and set $A = 2\frac{\rho}{\alpha}\left(\frac{\bar{K}}{L}\right)^{(1-\alpha)}$ for condition (13).

4.2 The Open Economy

This section assumes that there two countries, home and foreign. All goods (intermediate or final) are tradable. Labor is not mobile between countries. Furthermore, countries cannot borrow externally, hence trade is instantaneously balanced.[12]

Both countries have access to the same technologies described above. The foreign country is industrialized, and is large enough to absorb or provide any given quantities at fixed (and identical) relative prices. (As analyzed above, all products are priced identically in that equilibrium.) The model starts with the home country in autarky and in the poverty-trap equilibrium, and analyzes the dynamic process that starts upon opening up to trade and that ultimately results in full industrialization. Finally, trade liberalization is assumed to be unanticipated.

Dynamics

The prices of products are identical in the world market, and, from equation (5), $p_z = 1 \; \forall z \in [0, 1]$. Income is therefore given by $Y = \int_0^1 q_z dz$. The large foreign market assumption ensures that home country producers face horizontal demand curves. Together with free entry and exit of firms, this ensures that profits are zero at any moment in time. The firms are established gradually, because a sudden increase in the capital stock would require infinite investment. (Note again that international capital flows are ruled out.) Capital and labor are paid their marginal

[12]This assumption is not crucial. As long as capital is not perfectly mobile, outcomes of the model with capital mobility are not very different qualitatively. The difference capital mobility would make in the model is that the high interest rates in a liberalized developing country would attract capital flows, and capital would accumulate faster. As a result, industrialization would be quicker—as well as everything else in the model—compared to the case with no capital flows. Other than the speed of the evolution of the variables, however, variables would exhibit similar patterns over time. At the other extreme, with perfect capital mobility (which equalizes the foreign and domestic interest rates), a liberalized developing country would import its steady state capital at once, and industrialization would take place instantaneously. The developing country would instantaneously become developed in the absence of adjustment costs to investment. If adjustment costs are taken into account, such instantaneous development would be prevented, and other variables would display similar patterns as those in the paper: The interest rate would rise, investment would go up, capital would accumulate gradually, and foreign trade would still show its hump-shaped pattern.

revenue product:

$$F_K^1 = r_t, \qquad \text{and} \qquad F_L^1 = w_t.$$

Initially (at $t = 0$), the economy is assumed to produce in all sectors using the old technology, i.e., it is in the poverty-trap equilibrium. After opening up, it becomes feasible to establish plants that make use of the modern technology, because it is possible to sell in the large foreign markets. However, all sectors cannot switch to the new technology simultaneously; that would require a jump in the capital stock.

As long as there are sectors in which the old technology is used,

$$w_t = 1. \tag{14}$$

Because profits are zero also in the modern sector, from equation (8) and from the fact that $p_z = 1$,

$$c^1(w, r) = a\frac{r^\alpha w^{(1-\alpha)}}{\rho^\alpha} = 1,$$

which implies (together with equation 14) that $r = a^{-1/\alpha}\rho$. Because $a < 1$, $a^{-1/\alpha} > 1$, which means that the interest rate jumps up immediately upon opening up to foreign markets. Define the shorthand:

$$\tilde{r} = a^{-1/\alpha}\rho.$$

As long as there is production with the old technology, factor prices stay at

$$r_t = \tilde{r} \qquad \text{and} \qquad w_t = 1. \tag{15}$$

The model assumes that there are slight transportation costs that cause firms to give priority to domestic markets, although these costs are negligible and are not taken into account in the equations. The usefulness of this assumption is that, when there are multiple equilibria, it eliminates those with redundant trade and chooses the one with the least amount of international trade. The implication of the assumption is that the level of the capital stock in sectors that adopt the modern technology is not higher than $\bar{K}$ until all sectors are converted. That is, $k_z = \bar{K}$ in all the newly modernized sectors until modernization is implemented in all sectors. (After all sectors adopt the new technology, sectoral capital stocks increase at the same rate in all sectors. This is, again, due to the negligible trade cost assumption.) Let s_t be the share of industrialized sectors at any moment. Without loss of generality, it is assumed that all sectors in the interval $[0, s_t]$ are industrialized and that the rest continue to use only the old technology.

The liberalized economy will now be analyzed in the interval that precedes full industrialization. The total capital stock is $K_t = s_t \bar{K}$, and:

$$I_t = \dot{K}_t = \bar{K} \dot{s}_t.$$

The labor market clearing condition becomes:

$$L = s_t l_1^t + (1 - s_t) l_0^t, \tag{16}$$

where l_0^t and l_1^t are labor employed in individual firms in the traditional and modern sectors, respectively. Note that l_0^t, the labor employed in a given traditional sector, differs from the total employment in the traditional sectors, $(1 - s_t) l_0^t$. Define b as:

$$b \equiv \left[A(1-\alpha)^{(1-\alpha)} \right]^{1/\alpha}. \tag{17}$$

It can be verified that $b = \frac{\rho}{\alpha a^{1/\alpha}}$, and, therefore (from equation 15), $r_t = \alpha b$. In sectors that have adopted the modern technology, cost minimization requires that:

$$\frac{r_t k_z}{w_t l_z} = \frac{\alpha}{(1-\alpha)} \; \forall z \in [0, s_t],$$

i.e., that:

$$\frac{r_t \bar{K}}{w_t l_1^t} = \frac{\alpha}{(1-\alpha)}. \tag{18}$$

When there are still some sectors that use the old technology, using equations (15) and (16), equation (18) becomes:

$$l_1^t = \frac{\rho a^{-1/\alpha} \bar{K}(1-\alpha)}{\alpha} \equiv l_1, \tag{19}$$

i.e., labor employment in the new firms is constant during the industrialization period. It can easily be seen that $l_1 > L_c$ by comparing this expression for l_1 above to the definition of L_c in (12). Output in each modernized sector is $y_1 = A\bar{K}^\alpha l_1^{(1-\alpha)}$. Using this and equations (9), (17) and (19), it can be shown that $y_1 = b\bar{K}$. Note that $wl_1 = l_1 = (1-\alpha)y_1$, implying that $l_1 = (1-\alpha)b\bar{K}$.

The Euler Equation becomes $\frac{\dot{C}_t}{C_t} = \tilde{r} - \rho$, and this can be solved for C_t:

$$C_t = C_0 e^{(\tilde{r}-\rho)t}. \tag{20}$$

Since $\dot{K}_t = I_t = Y_t - C_t$, and $\dot{K}_t = \dot{s}_t \bar{K}$, we can obtain the differential equation

$$\dot{s}_t = \frac{L}{\bar{K}} + \tilde{r} s_t - \frac{C_0 e^{(\tilde{r}-\rho)t}}{\bar{K}}, \tag{21}$$

with the initial condition $s_0 = 0$.

Note that l_1 can be larger or smaller than L (see equation 19), depending on the parameter values. (E.g., if α is close to 1, l_1 is small; if α is close to 0, l_1 is large, etc.) If $l_1 < L$, it is straightforward to verify from equation (16) that $l_0^t > L$. On the other hand, if $l_1 > L$, it can be seen (again from equation 16) that $l_0^t < L$ and and that l_0^t decreases as s_t increases. Indeed, l_0 becomes 0 when s_t reaches $\frac{L}{l_1}$. We will see below that the outcomes are qualitatively similar in many ways whether l_1 is equal to, greater than, or less than L, although the analyses for these cases may appear different.

The rest of this section analyzes the cases of large and small developing countries, respectively. It is assumed that condition (10) holds throughout and that the economy is in the poverty-trap steady state at the time of liberalization.

***Large Developing Country* ($L \geq L_c$):**

As discussed above, when the condition $L \geq L_c$ holds, all sectors are gradually industrialized after trade liberalization. Let T denote the time when s_t becomes 1—i.e., when all sectors become modernized.

Case 1: $l_1 = L$

This is a knife-edge case obtained when the profit maximizing level of sectoral employment in the newly modernized sectors is the same as it was before the new technology was adopted. The level of employment in each sector therefore stays at L, although the level of output in the modernized sectors ($q_z = F^1(\bar{K}, L)$) is higher than that in the traditional sectors ($q_z = L$). Before full industrialization, production in the remaining traditional sectors continues as before, without a change in its level, and therefore equations (20) and (21) characterize the behavior of the economy. (Remember that those equations (20) and (21) characterize the liberalized economy as long as there are some sectors that use the old technology.)

After full industrialization at T, the economy becomes the same as the standard Ramsey growth model. In each sector, $k_z = K_t$ and $l_z = L$, and, by equation (4),

$Y_t = F^1(K_t, L)$. The equations of motion are

$$\dot{C}_t = C_t[F^1_K(K_t, L) - \rho], \quad \text{and} \tag{22}$$

$$\dot{K}_t = F^1(K_t, L) - C_t. \tag{23}$$

Equation (22) comes from equation (3) and equation (23) comes from equation (4). The phase diagram for this system is shown in Figure 4. After K_t reaches $\bar{K}$ (i.e., for $t \geq T$), the economy behaves according to this diagram. We define C_T as the level of consumption on the stable arm when $K_T = \bar{K}$, as shown in the figure. The differential equation (21), which governs the behavior of the economy during $t \in [0, T]$, is first order linear and can be solved to yield the general solution:

$$s_t = \frac{C_0 e^{(\tilde{r}-\rho)t}}{\rho \bar{K}} - \frac{L}{\tilde{r}\bar{K}} + \delta e^{-\tilde{r}t}.$$

From the boundary condition $s_0 = 0$, δ can be determined to be $\delta = \frac{L}{r\bar{K}} + \frac{C_0}{\rho\bar{K}}$. Given C_T, the unknowns C_0 and T can be determined by the following two equations:

$$C_0 = C_T e^{-(\tilde{r}-\rho)T} \tag{24}$$

$$s_T = \frac{C_T}{\rho\bar{K}} - \frac{L}{\tilde{r}\bar{K}} - \delta e^{-\tilde{r}T}. \tag{25}$$

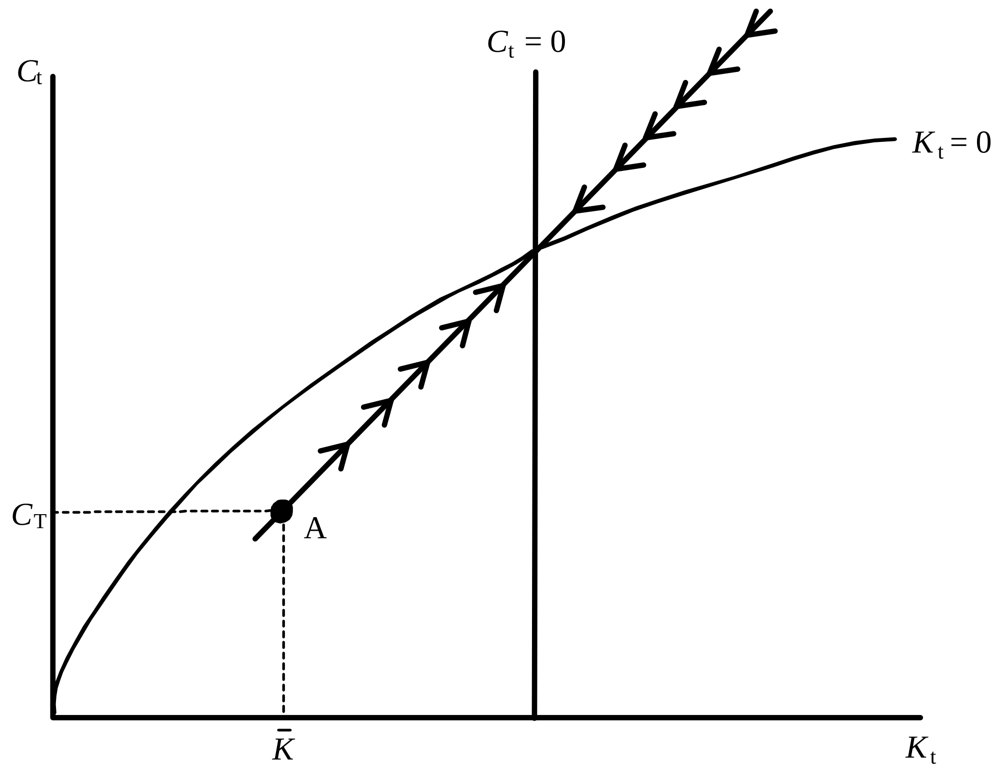
The time paths of variables of interest are shown in Figure 5. Although the figure is obtained by simulation using a particular set of parameters, these are representative of the general shapes that result in this case.[13,14]

[13]In all the simulations, $L = 1$ and $\rho = 0.03$. $\alpha = 2/3$ and $a = 0.7$ in Figures 5 and 6, and $\alpha = 1/3$ and $a = 0.5$ in Figures 7 and 8. $\bar{K}$ is 33, 30 and 50 in Figures 6,7 and 8, respectively. In Figure 5, $\bar{K}$ is 29.04, a value chosen so that $l_1 = L$.

[14]The behavior of the economy during $t \leq T$ is obtained analytically above. The simulation is needed for the part after T, when the economy turns into a standard Ramsey model.

Figure 4.

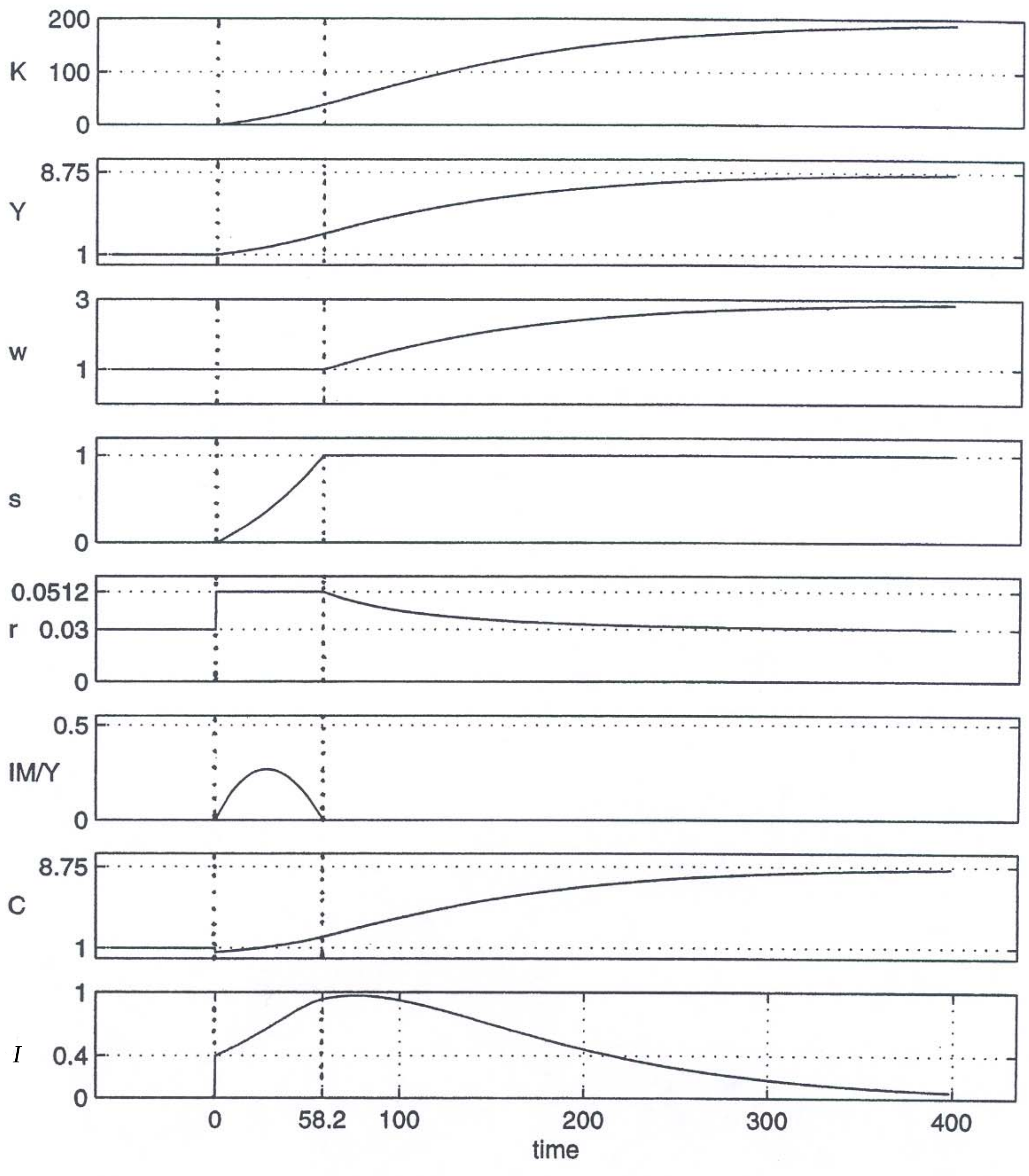
The Phase Diagram for the Dynamics of the Economy After the Industrialization Period



Note: The economy is at point *A* at time *T*, at the end of the industrialization period. The line with arrows shows the path of convergence to the steady state. *C* is consumption; *K* is the capital stock.

Figure 5.

Simulation Results for the Time Paths of Variables of the Model in Response to Unanticipated Trade Liberalization at Time t = 0: the Case of Large Developing Country with $L = l_1 > L_c$



Note: *w* is the wage rate, *s* is the share of sectors that have adopted the new and better technologies, *IM/Y* is ratio of imports to GDP, *Y* is GDP, *r* is the interest rate, *C* is consumption, *I* is investment, *L* is the labor force, and *K* is the capital stock of the developing country.

Case 2: $l_1 < L$

In this case, industrialization in a sector releases labor from that sector, and, as more and more sectors are industrialized, employment in the remaining traditional sectors l_0^t increases. This continues until the level of output in the traditional sectors ($q_0^t = l_0^t$) reaches the level of production in the modernized sectors ($q_1^t = F^1(\bar{K}, l_1)$). International trade becomes zero at that point, and stays at zero afterward. This is because additional capital accumulation is accompanied by the movement of traditionally employed labor among sectors to equalize the level of output of different goods in order to minimize the costs of trade. Thus, in the modernized sectors some amount of cottage production takes place along with high-tech production using l_1 units of labor and $\bar{K}$ units of capital. Intuitively, the labor intensity of the new technology is too low under this case to offer $w = 1$ to the whole labor force even when all sectors are endowed with capital $\bar{K}$, and those that are not employed in the modern plants are employed by traditional methods.

After industrialization is achieved in all the sectors, capital continues to accumulate, while traditional production shrinks gradually, as more and more labor is needed to work with the ever-increasing capital in the new technology plants. When the capital stock reaches a critical level (when $F_L^1(K_t, L)$ reaches 1), employment in the traditional sector disappears and the economy behaves like the Ramsey Model thereafter.

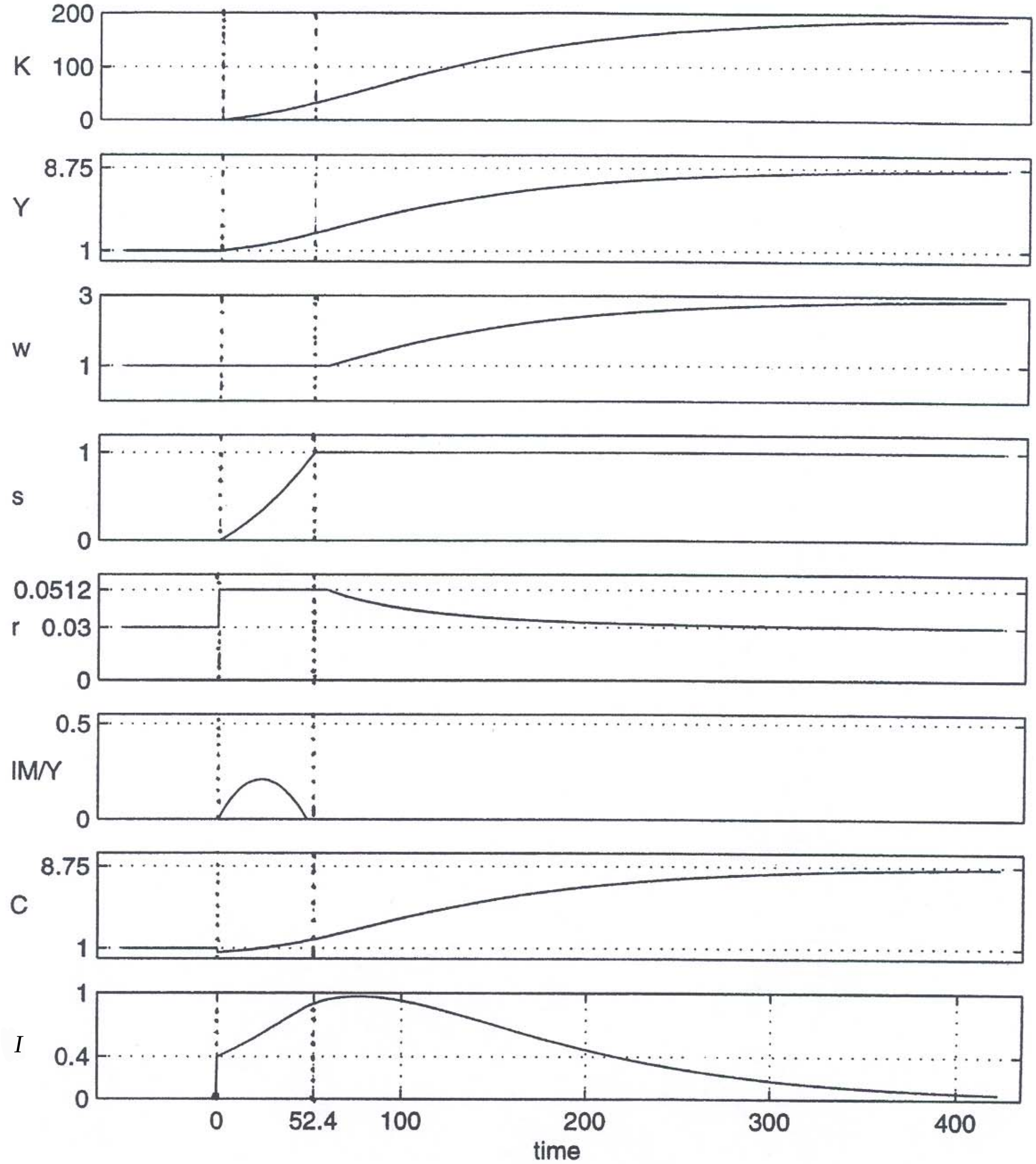
Figure 6 presents the simulation results for this case. In general, the time paths of variables in Figure 6 resemble those in Figure 5. But in Figure 6, w stays at 1 and r stays at $\tilde{r}$ for a period of time after T (third and fifth rows of the graph). In addition, imports become zero *before* full industrialization takes place (sixth row).

Case 3: $l_1 > L$

The inequality $l_1 > L$ means that industrialized sectors draw labor from sectors that continue to use traditional technology, and that l_0^t gradually decreases. As

Figure 6.

Simulation Results for the Time Paths of Variables of the Model in Response to Unanticipated Trade Liberalization at Time t = 0: the Case of Large Developing Country with $L > l_1 > L_c$



Note: *w* is the wage rate, *s* is the share of sectors that have adopted the new and better technologies, *IM/Y* is ratio of imports to GDP, *Y* is GDP, *r* is the interest rate, *C* is consumption, *I* is investment, *L* is the labor force, and *K* is the capital stock of the developing country.

argued above, there is a critical value of s_t at which l_0^t becomes zero, and that value is $\frac{L}{l_1}$. Let $s_c \equiv \frac{L}{l_1}$, and let t_c denote the moment s_t reaches s_c. The differential equation (21) is still valid during $t \in [0, t_c]$. Let T be, as before, the time when industrialization is achieved in all sectors. The behavior of the economy in the period $t \in [t_c, T]$ is governed by the equations:

$$\dot{C}_t = C_t[F_K^1(\bar{K}, L/s_t) - \rho], \text{ and} \tag{26}$$

$$\dot{s}_t = \frac{1}{\bar{K}}[s_t F^1(\bar{K}, L/s_t) - C_t]. \tag{27}$$

Equation (26) follows from the Euler Equation (equation 3), noting that $r_t = F_K^1(k_1, l_1) = F_K^1(\bar{K}, L/s)$. Equation (27) follows from $\dot{K}_t = \dot{s}_t \bar{K}$ and equation (4), and noting that, because there is no production in the fraction $(1 - s_t)$ of the sectors, $Y_t = s_t F^1(k_1, l_1) = s_t F^1(\bar{K}, L/s_t)$.

In the period $t \in [0, t_c]$, there are still some sectors that operate with the old technology; the equations of motion are:

$$\dot{C}_t = C_t[F_K^1(\bar{K}, l_1) - \rho], \text{ and} \tag{28}$$

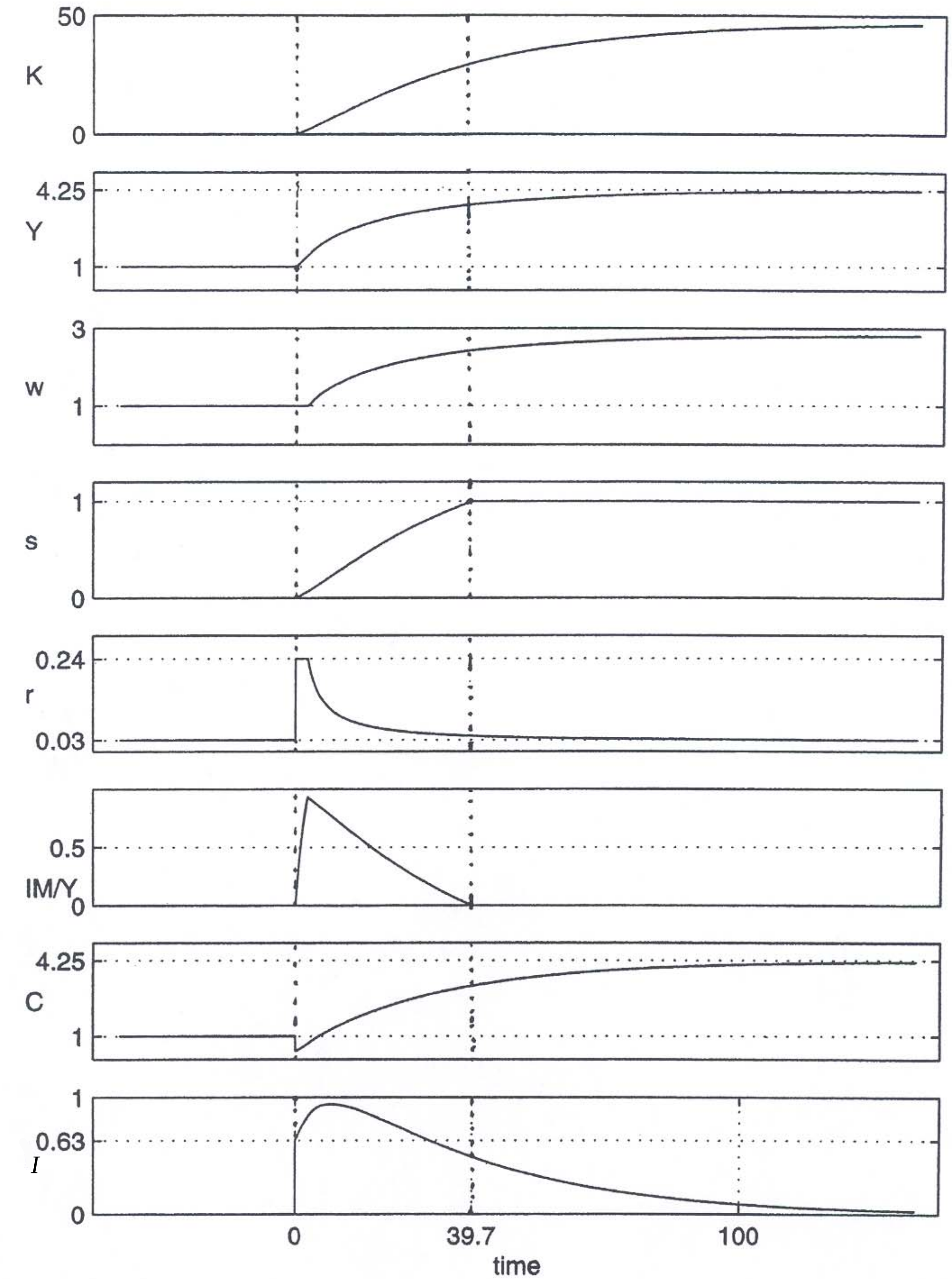
$$\dot{s}_t = \frac{1}{\bar{K}}[s_t F^1(\bar{K}, l_1) - C_t], \tag{29}$$

which yield the analytically solvable equations (20) and (21) above.

As in Case 1, the model becomes the standard Ramsey model after T, and the economy behaves according to equations (22) and (23). The simulation results are shown in Figure 7. Comparing Figures 7 and 5, we see that in Figure 7 the wage rate (w in the third row) starts to rise before the economy becomes fully industrialized. With the chosen parameters, it is profitable to employ a large amount of available cheap labor with $\bar{K}$. Even a small fraction of sectors is enough to absorb all the available labor at the pre-industrial wage rate $w = 1$, and, as a result, industrialized sectors use up all the labor supply of the country long before

Figure 7.

Simulation Results for the Time Paths of Variables of the Model in Response to Unanticipated Trade Liberalization at Time t = 0: the Case of Large Developing Country with $l_1 > L > L_c$



Note: *w* is the wage rate, *s* is the share of sectors that have adopted the new and better technologies, *IM/Y* is ratio of imports to GDP, *Y* is GDP, *r* is the interest rate, *C* is consumption, *I* is investment, *L* is the labor force, and *K* is the capital stock of the developing country.

the modernization process reaches all the sectors. Afterward, the wage rate starts to increase as more labor is needed to work with the continuously accumulating capital, and employment in each modernized sector is reduced to equate the marginal product of labor to the increasing wage rate. This process continues until T—until all sectors are industrialized. After T, the economy follows the Ramsey growth path, as in the earlier cases.

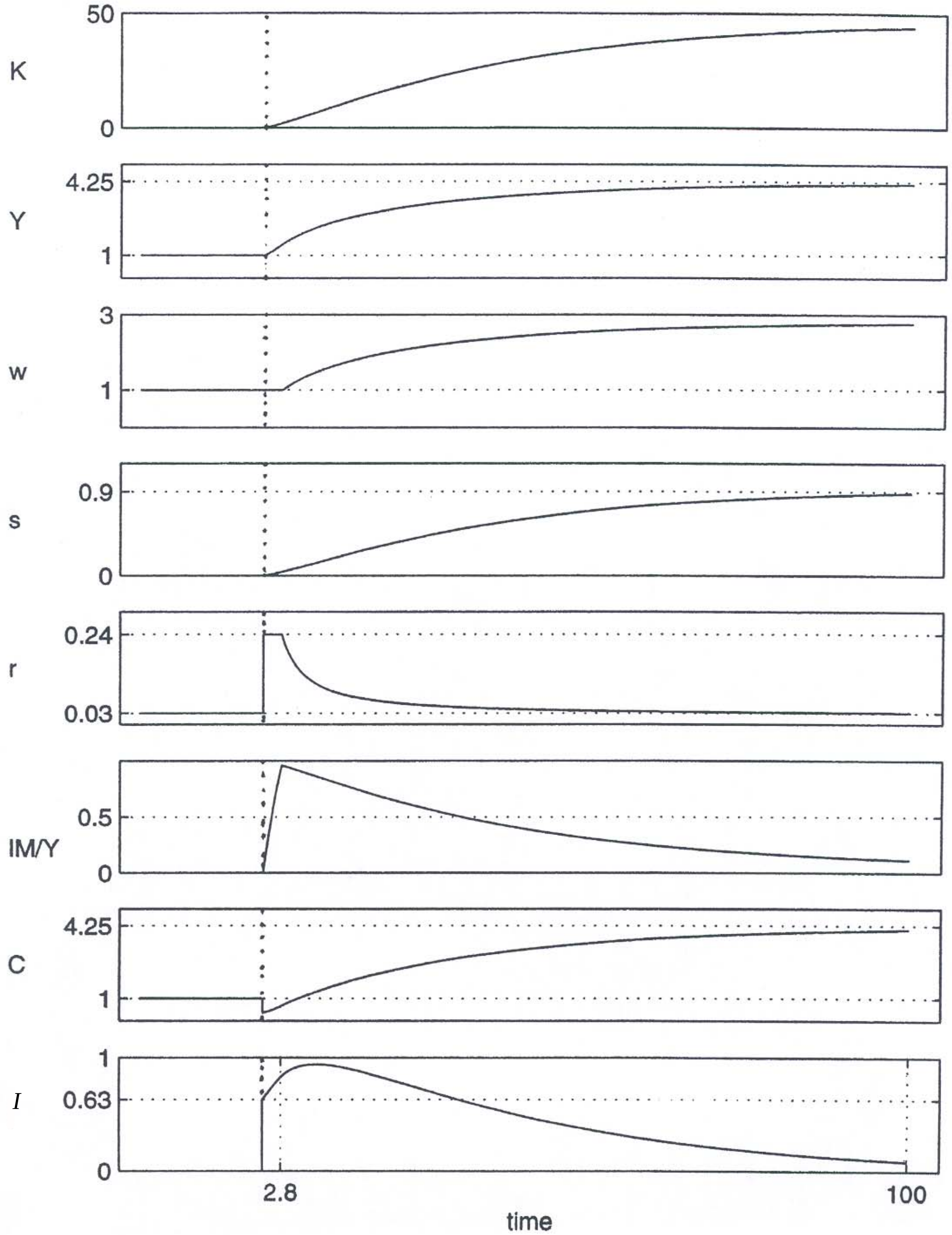
In Figure 7, the hump in IM/Y has a sharp corner and reaches a higher level than in Figures 5 and 6. The peak corresponds to the time when traditional sector employment disappears. The high level of IM/Y is a result of the particular choice of parameters as well as the smaller size of the developing country (a smaller $L/\bar{K}$) compared with the previous cases.

Small Developing Country ($L < L_c$): In this case the economy does not industrialize in the full range of sectors because it is not possible for the small country to operate in all the sectors at efficient scales. Since $l_1 > L_c$, we automatically have $l_1 > L$ and we do not have three different cases, as we had for a large developing country. However, the outcome is similar to Case 3. The labor supply of the country is used up early, when the wage rate is $w = 1$, and after that the wage rate rises as capital accumulates, lowering employment in each industrialized sector. However, unlike Case 3, some sectors are not industrialized, although the whole labor force is fully employed with modern techniques and traditional production ceases to exist. The steady state share of sectors that operate in the economy, s^*, can be found by $F_K^1(\bar{K}, L/s^*) = \rho$, and the result is $s^* = L/L_c$.

The simulation results for that case are shown in Figure 8. They are very similar to those in Figure 7, except that s does not reach 1 in Figure 8.

Figure 8.

Simulation Results for the Time Paths of Variables of the Model in Response to Unanticipated Trade Liberalization at Time t = 0: the Case of Large Developing Country with $l_1 > L_c > L$



Note: *w* is the wage rate, *s* is the share of sectors that have adopted the new and better technologies, *IM/Y* is ratio of imports to GDP, *Y* is GDP, *r* is the interest rate, *C* is consumption, *I* is investment, *L* is the labor force, and *K* is the capital stock of the developing country.

4.3 Implications of the Model, and Comparison with Patterns Observed in Rapidly Developing Economies

This section compares the dynamic behavior of key variables in the model with patterns observed in some East Asian countries. The simulation results in Figures 5-8 show that the interest rate rises and stays high in the industrialization period. Hsieh (1998) presents data that show interest rates were indeed high in the newly industrialized countries of East Asia in the period 1966-1992. In both Korea and Taiwan, the rates were substantially above those in developed countries, in spite of substantial restrictions that aimed to control interest rates from rising too high.

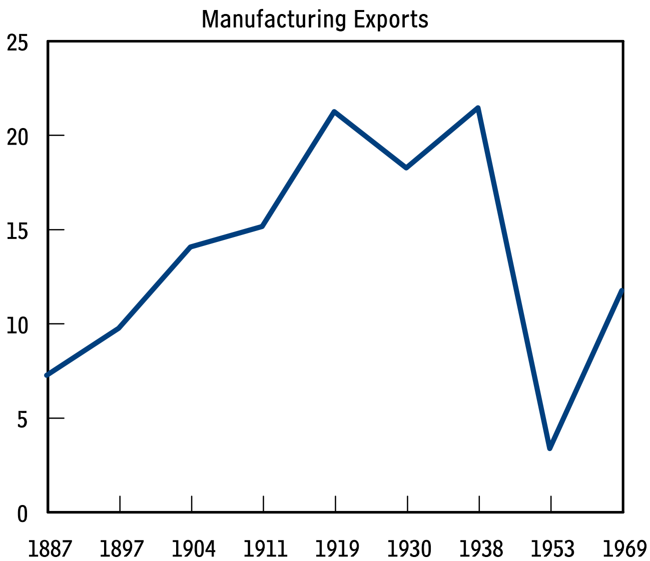
The gradual increase in the wage rate (w) in the simulations (Figures 5-8) is consistent with the well-known increases in payments to labor in well-performing East Asian countries (wage data are not provided here). The increases in saving and investment are familiar patterns from newly industrialized countries (NICs), and these variables increase in the simulations as well. However, some patterns differ somewhat in the simulations from those observed in Taiwan and Korea. Investment rose only gradually both in Korea and Taiwan (see Figure 2); in the model, these variables jump as soon as trade is liberalized. The reason that investment and savings go up in the model is that the higher level of productivity in the modern sector and cheap labor make investment very profitable, thereby raising investment. This profitability increases the demand for capital, which raises the interest rate, which in turn induces households to forgo present consumption and save. The data show that the interest rates were indeed high (Hsieh, 1998), but saving and investment appear to have risen after a delay in actual experience. The reason for a delay in the response of consumption could be a delay in intertemporal consumption decisions. Different (and perhaps more plausible) specifications of the preferences, such as habit formation or subsistence level of income, could also generate such delays. The delay in investment may result from the restrictions in the loan markets and from lack of an increase in national saving coupled with limited access to foreign capital. Finally, the policy changes in real life took place gradually and the future outcomes were not certain, unlike the responses in a deterministic model to a sudden policy change from autarky to free trade.

The volume of trade shows a hump-shaped pattern in the simulations. Especially in the case for a large developing country, after international trade has accomplished its role in the industrialization process, trade disappears. This is because all types of traditional gains from trade are explicitly ruled out from the model. When the economy of a developing country evolves into a developed economy, it becomes identical to the developed foreign country. After full industrialization, the developing country ceases to need the large foreign market, because its own domestic market is now sufficiently large. Since there is also no comparative advantage, we are left with a situation where there are no gains to be made from trade, and therefore no incentive to engage in trade. Although this implication of the model may seem at first in conflict with real-life experience, Japan provides an interesting example demonstrating that this may not be the case. Japan, which has gone beyond its early industrialization, is now a relatively closed economy. Among the 138 countries in the Penn World Tables 6.1, Japan had the lowest $\frac{\text{Exports+Imports}}{\text{GDP}}$ ratio in 2000. Figure 9 presents the share of exports in GDP over time for Japan, starting from the 1880s, shortly after Japan started its export-led growth process. (Japan implemented substantial changes in economic policies in 1868.) The hump shape in the first panel is similar to that in Figures 5-8, in the sense that foreign trade as a share of GDP first increases and then decreases. The trough around 1950 can be attributed to World War II, but the ratio does not recover even by 1970 to its levels in the first half of the twentieth century. The second panel in Figure 9 shows that the decline in the exports/GDP ratio is not an artificial result from the secular decline in manufacturing share in output. It should also be noted that a model of

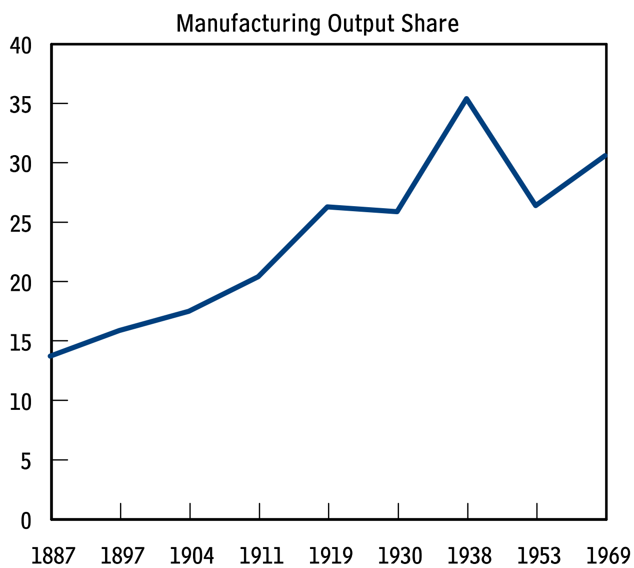
Figure 9.

Japanese Manufacturing Exports and Output

(Percentage of net domestic product)



(Percent)



Source: Ohkawa and Shimomura (1979), pp. 18, 35, and 135.

intra-industry trade with transportation costs could generate a similar picture, and therefore the evidence cited is not conclusive support for the mechanism outlined in the model. But the evidence shows that a particular implication of the model—that the economy of a developing country may become self-sufficient after a period of intense international trade—may not be in conflict with facts.

On the other hand, Singapore and Hong Kong may never be able to reach such a degree of closedness, just as developed small open economies of Europe have not. In the model, this is meant to be represented by the case of the small developing country, which never becomes independent of international trade because of its size. Similarly, there is no substantial decline in the exports/GDP ratio for Korea and Taiwan so far. Continued increase in exports/GDP could be an indication that those countries are not finished with their export-led industrialization. Or the reason could simply be that those two countries, unlike Japan, are too small to attain a high degree of self sufficiency in terms of market size even in the steady state. (In terms of the parameters of the model, that would mean that condition (13) is violated.) Thus, the fact that trade has not declined in these two countries does not refute the model.

4.4 Dynamic Gains from Trade

As discussed earlier, the static gains from trade are not considered likely to account for a major part of the development in East Asian. That is likely to be the reason that policymakers are interested in identifying benefits from trade beyond the static gains.[15]

This paper measures the gains from trade in the simulations by the change in the

[15]Baldwin's (1992) estimates of dynamic gains from trade in response to a trade liberalization are 15 to 90 percent of the static gains. These arise from external returns to capital. Given the size of static gains, however, doubling their size does not bring the overall gains to levels that can account for East Asian growth.

level of lifetime utility (in the present discounted-value sense) that results from the switch from autarky to free trade. This paper proposes to call the gains that arise from a reallocation of existing resources *static*, and the other gains–which involve accumulation of resources–dynamic.[16]

With this distinction, it is easy to see that all gains from trade are dynamic in the model of this paper. The present value of the change in income can be computed, and this indicates the size of the dynamic gains. The model illustrates that dynamic gains can be completely independent of any static gains that trade may provide. Indeed, static gains are not present in the model.[17] Furthermore, these dynamic gains can be very large. An example is the simulation in Figure 5, where the level of steady state income and consumption increases by a factor of 8.85. However, that increase is obtained by sacrificing present consumption. To find the overall utility gain, this section uses a monotonic transformation of the lifetime utility function given in (1) that exhibits homogeneity of degree 1. The expression is:

$$\tilde{U} = \exp\left(\rho \int_0^\infty e^{-\rho t} \ln C_t dt\right),$$

which is obtained by exponentiating (1). $\tilde{U}$ increases by a factor of 1.46. The 785 percent increase in steady state income and consumption and the 46 percent increase in utility are dynamic gains from trade, based on the definition above.

[16] Although they do not exist in this model, if a country had comparative advantage in certain industries and specialized in them, these gains would be static according to this definition, regardless of whether the reallocation of resources mentioned takes place instantly or requires an adjustment period that is spread over time. The latter may be considered a dynamic gain elsewhere.

[17] "Static gain" here means a recognized gain in trade theory, such as those due to Ricardian technological differences, Heckscher-Ohlin type factor proportion differences, gains from increased number of varieties, or gains due to increased competition. In the model, there is a movement of labor in the transition period into capital-intensive high-technology sectors, but this is clearly not a shift as in the Rybczynski theorem, because in this case the shift in the labor-abundant country is toward exporting capital-intensive goods.

4.5 An Alternative Strategy to Break the Poverty Trap: Coordinated Investment

Rosenstein-Rodan (1943) proposes that it is possible to break the poverty trap by following policies that coordinate investment in many sectors. Investment in an individual sector is not profitable alone, but, if industrialization is achieved in many sectors at once, individual investments also become profitable. Such coordinated investment is dubbed the term "big push." Murphy et al. (1989a) show, in a two-period extension of their basic model, how a big push can take a developing country out of its poverty trap.

This paper investigates the importance of international trade for development. Therefore, the possibility of coordinated investment in an autarkic developing country to break the poverty trap is not a main issue for this paper. Nevertheless, this subsection examines how big push compares with export-led growth in the model.

The main obstacle for industrialization in many sectors is the resource constraint, as Matsuyama (1991) points out. If foreign capital is not available (the likely scenario for a closed developing country), capital needs to be raised domestically by sacrificing current consumption. As a result, capital can accumulate only gradually, and the sectors that industrialize early in the process will not be profitable.[18]

Consider first the strategy of coordinated investment in a closed economy, where each sector is constrained to the domestic market. If a central planner forces the establishment of modern plants, these investments are not profitable, because the domestic market is small initially.[19] Later, as capital is forced to accumulate, income rises and therefore the domestic market expands, and finally profit flows from

[18] Entrepreneurs evaluate investment decisions on the basis of current profit flow, regardless of whether the investment will be profitable later. The reason is that capital decision is perfectly reversible.

[19] The level of output in the modern plants will be high and the price (or marginal utility) of their goods will be low.

modern plants turn positive. The central planner then needs to compare the losses associated with reduced consumption in the early periods to the gains that arise because of increased income (and increased consumption) in the future. Although such industrialization is always possible by enforcement of central planning, it does not always result in an increase in the discounted present value of the utility flow. Whether the big push increases lifetime utility depends upon the parameter values. A low discount rate and a large population are among factors that favor the big push.

In the case of the export-led industrialization strategy, industrialization is always profitable. It is achieved by market forces, and this removes the need for large-scale coordination in the early years of industrialization.[20]

5 Discussion and Conclusion

This paper formalizes the idea that the major benefit of trade in the process of rapid development came from the outlet large foreign markets provided to firms in developing countries. Using a dynamic general equilibrium model, the paper demonstrates that this feature of trade alone has the potential to explain the rapid development observed in East Asia, even when all other mechanisms that result in gains from trade are explicitly ruled out.

Factors of production of the developing country earn higher returns if they are employed with the same techniques of production used in developed countries. The better techniques of production used in the developed world are assumed to be

[20]Why is export-led industrialization always welfare-improving in the model? It is a result of the assumptions of the model. In particular, the model assumes that modern technology is sufficiently productive that, if not for the scale requirement $\bar{K}$, it would be more profitable to operate with the modern technology at factor prices that prevail in the poverty-trap steady state. This means that the productivity of the modern technology is assumed to be large enough to overcome the resistance to postpone consumption due to the discount factor. This can also be seen from equation (9). A is related to ρ, and, the higher the discount rate is, the higher A needs to be.

accessible to a developing country, but the lack of adequate demand prevents the developing country from adopting these methods of production. In practice, there are at least two reasons that demand may be inadequate: low level of aggregate income (upon which the model of this paper is based), and high income elasticity for developed country products, as mentioned in Krueger (1998). To keep the model simpler, the model does not include this latter effect. However, the insufficiency of demand is still is the main driver of the results, regardless of the source of that insufficiency.

One empirical pattern observed in rapidly developing countries is the movement from less capital-intensive to more capital-intensive products. This is precisely what the factor proportions theory predicts for a country that starts from a low level of wealth and accumulates capital rapidly. However, the gains from utilizing factor proportion differences are not considered large enough to account for most of the benefits from trade. And the evolution of factor prices observed in East Asia do not fit well with what would be expected from this theory. Furthermore, the pattern of gradual climb up the ladder of capital intensity or product sophistication is not inconsistent with the logic of this model. For example, consider the case where all sectors require the same $\bar{K}$, but have different capital intensities—characterized by different values of α's in the notation of the model. Upon trade liberalization, the sectors that have a low capital intensity would be chosen first by entrepreneurs to start industrialization, because these sectors would have a higher marginal product of labor.

The story that is modeled (and summarized in Figure 5) is intended for a developing country that is large enough to attain industrialization in all sectors and reach a self-sufficient steady state. The story for a small country would be quite similar, except that a small country would not industrialize in all sectors.

The model also gives justification to the view that there are large dynamic gains from trade that are not well identified by the traditionally emphasized static gains. Indeed, there are no static gains in the model, and yet trade has important benefits.

Although the model assumes that there is no foreign borrowing, removing this restriction would not change the model's qualitative features as long as capital is not perfectly mobile. Capital inflows would increase the rate of capital accumulation and thus speed up the industrialization process in the developing country, but the qualitative features of the equilibrium would be the same. The higher the capital flows are, the faster industrialization would be, in the limit approaching to a sudden transformation into a developed economy. To stress the fact that capital flows are not central to the mechanics of the model, note that liberalizing capital markets would have no benefit (even with perfect capital mobility) if the developing country did not liberalize trade.

In practice, of course, capital flows have not been unlimited, as indicated by the high levels of interest rates that prevailed in the East Asian growth miracles, and as would be expected from sovereign debt and risk considerations.

Also neglected in the model are forward linkages—i.e., the cost advantages that arise from having local suppliers. The importance of forward linkages is an empirical question. On one extreme is an economy in which all other varieties must be immediately accessible to a producer within its local economy. The other extreme is an economy in which each firm can start up without a need for any intermediate inputs. This paper's model is closer to the latter.[21] Alternatively, there may be groups of industries (possibly small subsets compared with the rest of the economy) that need to start together for economic feasibility. Yet another possibility is that there may be key industries, such as chemical manufacturing or heavy manufactur-

[21] However, in the model capital input comes from the final composite, which is produced by using all varieties. However, these varieties do not have to be produced in the local economy. The need for intermediate inputs in production could be completely eliminated by postulating that capital is produced by using only labor.

ing, that serve as inputs to most other industries. It is possible to think of a firm in the model as a conglomerate—such as a *chaebul*—operating in a group of sectors. If there are key industries needed by other industries, these must be thought of as already established (possibly by the encouragement and interventions of the government) before trade is liberalized, so that newly established firms have immediate access to needed local inputs. The model focuses on the process after those steps are taken.

Learning by doing, obviously an important factor in practice, is also ruled out in the model. The infant industry argument is based solely on the idea that there needs to be a period of protection that allows industries to mature. Indeed, a major characteristic of export oriented growth has been governments' encouragement and protection of sectors that are expected to be future exporters. This type of intervention is ubiquitous in policies adopted by some of the rapidly developing East Asian countries (see, e.g., Pack and Westphal, 1986). Again, the paper ignores those issues and considers the situation that would arise after the difficulties associated with infancy are overcome.

Finally, although no systematic empirical work is done in this paper, the implications of the model appear consistent with the patterns observed in Korea, Taiwan, and Japan. High returns to capital and a high level of investment are among the implications of the model, consistent with the experiences in the growth-miracles.

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