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TRADE, DEVELOPMENT, AND GROWTH

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TRADE, DEVELOPMENT, AND GROWTH

1 Introduction

Gene Grossman and Elhanan Helpman begin their classic paper on comparative advantage and long-run growth with the question: "What role do the external trading environment and commercial policy play in the determination of long-run economic performance" (1990, p. 796). Their assertion that "this central question of international economics has received surprisingly little attention in the theoretical literature over the years" is a somewhat, though not entirely, curious statement. After all, Adam Smith's *Inquiry into the Causes of the Wealth of Nations* (1784) maintained that openness to international trade and competition promote the accumulation of wealth, and, as Jeffrey Sachs and Andrew Warner (1995, p. 3) remark,

> Smith's followers have stressed for generations [that] trade promotes growth through a myriad of channels [including] increased specialization, efficient resources allocation according to comparative advantage, diffusion of international knowledge through trade, and heightened domestic competition as a result of international cooperation.

In 1919, Maynard Keynes (1971) eloquently extolled the virtues of globalization during its golden period before the outbreak of World War I:

> What an extraordinary episode in the economic progress of man that age was which came to an end in August 1914! . . . The inhabitant of London could order by telephone . . . the various products of the whole earth . . . and reasonably expect their early delivery upon his doorstep; he could . . . by the same means adventure his wealth in the natural resources and new enterprises of any quarter of the world, and share, without exertion or even trouble, in their prospective fruits and advantages. . . . He could secure forthwith, . . . transit to any country or climate without passport or other formality, could despatch his servant to the neighbouring office of a bank for such supply of the precious metals as might seem convenient, and could then proceed abroad to foreign quarters, . . . bearing coined wealth upon his person, and would consider himself greatly aggrieved and much surprised at the least interference. But, most important of all, he regarded this state of affairs as normal, certain, and permanent, except in the direction of further improvement,

> and any deviation from it as aberrant, scandalous, and avoidable (Sachs and Warner, 1995, p. 9).[1]

Keynes reversed himself during the Great Depression, but he returned to his earlier position, at least implicitly, when he played a key role at the Bretton Woods conference establishing the World Bank and the International Monetary Fund. The question whether trade was an "engine of growth," as Dennis Robertson (1940) claimed, or was merely a "handmaiden of growth," as Irving Kravis ([1970] 1996) argued—or, to put it in econometric terms, whether trade was an exogenous forcing variable or an endogenous responding variable in the growth process—is still being debated.

From the time of Adam Smith, therefore, until it emerged as a distinct subfield in the 1940s, economic development was the central theme of economic inquiry. During the 1940s, the role that openness to trade has in promoting development began to attract research and policy debate. A pessimistic assessment of the prospects for export expansion and access to international capital flows (based on the disastrous interwar experience with beggar-thy-neighbor commercial policies and the collapse of international capital markets) led to the widespread adoption of import substitution (IS) as a strategy for development.

Recently, the interaction among trade, trade policy, and growth has received considerable attention.[2] However, the distinctions between the once-and-for-all "level" effect of trade liberalization on the level of output and the "growth" effect on growth of output, and between transitional effects and permanent or steady-state effects, have been blurred in the literature. Openness to trade generates its effects through several mechanisms. Traditional theory, although not ignoring the spillover effects on one nation of the activities of its trading partners, has mostly emphasized the virtues of unilateral exploitation of comparative advantage in production through trade.

By placing innovation at the center of the growth process, explicitly modeling comparative advantage in innovation as well as production, and allowing for technological spillovers and possible imitation of innovators by others, Grossman and Helpman have gone far beyond the earlier literature.

[1] There is substance to the argument that the era of the gold standard, from roughly 1870 to 1913, represented a high watermark in globalization. It has taken more than eighty years for the pre-World War I trend in globalization to resume. Although Keynes was speaking of an Englishman during the peak of British imperial power, his description is not exaggerated.

[2] Long and Wong (1997) have surveyed the literature on endogenous growth and international trade. Ben-David, Nordström, and Winters (1999) focus on the linkages among trade, economic growth, income inequality, and poverty. Dollar and Kraay (2001) concentrate on changes in trade policy and growth within (and among a cross-section of) countries.

Their book, *Innovation and Growth in the Global Economy* (1991), has become the *locus classicus* for recent research on trade and growth.

Translating the implications of simple models into testable propositions, with data that rarely correspond to their theoretical counterparts, is neither simple nor uncontroversial. This fact is well illustrated by contributions that test standard trade theories (Trefler 1993; Davis et. al., 1997). Empirical analysis of trade policy runs into several problems, not the least of which is the endogeneity of trade-policy choices. In addition, countries rarely change trade policies while keeping all other policies in place. The effects of simultaneous changes in several policies, therefore, have to be evaluated using a "calibrated" general-equilibrium model, rather than an econometrically estimated model, or by using an econometric model that "controls" for other policies. The data requirements of applied general-equilibrium models are large, and assumptions underlying calibration procedures are strong. Apart from the Lucas ([1988] 1999) critique that parameters representing the response to a policy change depend on the policy regime itself, other problems arise in econometric estimations of the effects of trade policy, because when several policy distortions are present, the effect of changing a subset of policy distortions arising from trade is ambiguous, even in theory.

Section 2 sorts out the level, growth, and transitional effects of opening to trade in neoclassical growth models and in some of the development-planning models. It shows that it is possible, in these models, to derive both level and growth effects of trade policy. Section 3 comments on a recent revisionist critique of the earlier consensus on the virtues of openness to trade from the perspective of economic development. It highlights the contributions of Rodrik (1999) and Rodriguez and Rodrik (1999), because they thoroughly cover the possible bases (economic theory, econometric methodology and techniques, and data used) on which the consensus can be questioned. It argues that although the critique makes valid points against some of the less careful analyses, it does not seriously challenge, let alone invalidate, the consensus.

2 Trade in Growth Models

The Neoclassical Model

International trade can be easily added to the Cass-Koopmans model of optimal growth in a closed economy (Cass, [1965] 1991; Koopmans, [1965] 1998). Assume that this economy produces a single *intermediate* good using a constant-returns-to-scale neoclassical technology with capital and labor as inputs. In the absence of trade, each unit of this intermediate good can be costlessly transformed into a unit of consumption or a unit of investment. The social planner's problem under autarky is described below, where c denotes consumption per worker, k is the capital-labor ratio, ρ is the pure rate of time preference, n is the exponential rate of growth of labor force, and δ is the instantaneous rate of depreciation of capital. The instantaneous felicity function $u(c)$ is assumed to be strictly concave. The average product of labor function $f(k)$ is concave. For the moment, the Inada (1963) conditions that

$$\lim_{k\to 0} f'(k) = \infty \quad \text{and} \quad \lim_{k\to\infty} f'(k) = 0$$

will be assumed as well.

Let us start with autarky. The social planner's problem is to

$$\text{maximize } \int_0^\infty e^{-\rho t} u[c(t)]dt \ , \tag{1}$$

subject to $\dot{k}(t) = f[k(t)] - (n+\delta)k(t) - c(t)$, with $k(0)$ given. As is well known, the solution to this optimal-control problem, with $k(t)$ as the state variable and $c(t)$ as the control variable, is characterized by

$$u'[c(t)] = \lambda(t) \ , \tag{2}$$

$$\dot{\lambda}(t) = -\lambda(t)\{f'[k(t)] - (n+\delta+\rho)\} \ , \tag{3}$$

and the transversality condition

$$\lim_{t\to\infty} e^{-\rho t}\lambda(t)k(t) = 0 \ , \tag{4}$$

where $\lambda(t)$ is the co-state variable. Under the assumptions made, a solution $[c(t), \lambda(t), k(t)]$ exists for (2) through (4), with the initial $k(0)$ given. The solution converges to unique steady-state values of k^{*A}, c^{*A} given by

$$f'(k^{*A}) = (n+\delta+\rho) \ , \tag{5}$$

$$c^{*A} = f(k^{*A}) - (n+\delta)k^{*A} \ . \tag{6}$$

Along the steady-state growth path, consumption, capital, and output grow at the same *exogenous* rate as the labor force. There is, thus, *no* growth in output or consumption per worker along the steady-state path. This strong implication of no long-run growth in output or consumption per worker follows from the Inada condition that the marginal product to the only accumulable factor—namely, capital—declines to zero, because capital increases indefinitely relative to labor.

Let me add trade to this model. Suppose that in international markets, each unit of investment can be exchanged for p^I units of consumption goods. For simplicity, it is assumed that p^I is constant over time. Thus, as compared to a one–for–one exchange through domestic transformation, using international trade, the economy can exchange one unit of investment for p^I units of consumption. This means that if $p^I > 1$ (respectively, $p^I < 1$), the economy will transform domestically its output of intermediates into investment goods (resp., consumption goods) and exchange part of it for consumption goods (resp., investment goods) in international markets. The remaining part is invested (resp., consumed) in the domestic economy. Let me illustrate the case of $p^I > 1$ (the other case is analogous).

Domestic output, $f[k(t)]$, of intermediates is first transformed costlessly into an equal amount of investment goods. Gross investment per worker in the economy is $\dot{k}(t) + (n+\delta)\dot{k}(t)$. Thus, $f(k) - \dot{k} - (n+\delta)k(t)$ of investment goods is exchanged for $p^I\{f[k(t)] - (n+\delta) - \dot{k}(t)\}$ units of consumption in international markets. The social planner's problem is to

$$\text{maximize } \int_0^\infty e^{-\rho t} u[c(t)]dt \tag{7}$$

$$\text{subject to} \quad c(t) = p^I\{f[k(t)] - (n+\delta)k(t) - \dot{k}(t)\} \ , \tag{8}$$

with $k(0)$ given.

It is easy to show that the optimal path under trade converges to a steady state in which consumption, capital, and output once again all grow at the same rate as the labor force, and there is no growth in per worker output or consumption. The steady-state values k^{*T}, c^{*T} are given by

$$f'(k^{*T}) = (n+\delta+\rho) \ , \tag{9}$$

$$c^{*T} = p^I\{f(k^{*T}) - (n+\delta)k^{*T}\} \ . \tag{10}$$

A comparison of (6) and (10) suggests that $k^{*A} = k^{*T}$. Thus, from (6) and (10), it is clear that $c^{*T} = p^I c^{*A} > c^{*A}$. Opening to trade, therefore, has a level effect, that is, the level of consumption under free-trade steady state is higher than under autarky steady state. But because in both steady states, there is no growth in per worker values of capital and consumption, there is no growth effect.

In the special case in which marginal felicity is a constant elasticity function of consumption, that is, $u(c) = c^{1-\sigma} - 1/1 - \sigma$, it can be shown that the optimal path of capital-labor ratio $k(t)$ is the same under both autarky and free trade. However, consumption per worker under free trade at each t is p^I times its value under autarky. This being the case, there is only a level effect, and no growth effect, even along the transition to steady state.

Growth in per worker consumption along the steady state can be generated in this model in several ways. One way is to abandon one of the Inada conditions and assume that the technology exhibits a positive floor to the marginal product of capital, because capital increases indefinitely with respect to labor.[3]

For example, consider the function $f(k) = g(k) + \beta k$ with $0 < \alpha < 1, \beta > 0$. Let $\lim_{k\to\infty} g'(k) = 0$. Then, $\lim_{k\to\infty} f'(k) = \beta > 0$. With this production function, and the above utility function, it can be shown that the steady-state growth rate of per capita consumption under both autarky and free trade with $p^I > 1$ is 0 if $\beta \leq (n + \delta + \rho)$, so that trade has a level effect but no growth effect. If $\beta > (n+\delta+\rho)$, the growth rate of per capita consumption under trade is $\beta-(n+\delta+\rho) > 0$. Thus, trade has both a level and growth effect. If, however, $p^I < 1$ and $\beta > p^I(n+\delta+\rho)$, the growth rate of per capita consumption under trade is $\frac{1}{\sigma}\left[\frac{\beta}{p^I} - (n + \delta + \rho)\right] > 0$. Thus, there is in this case, also, both a level effect and a growth effect of free trade. If $\beta > (n + \delta + \rho)p^I$, the steady-state rate of growth of consumption per worker is positive in both autarky and free trade, whatever the value of p^I.

Two points from this analysis are noteworthy. First, once there is a sufficiently high floor on the marginal product of the accumulable factor—that is, capital—growth in the steady-state per worker consumption becomes feasible under autarky. Second, given a positive floor on the marginal product of capital, if the terms of trade are sufficiently favorable, the economy can achieve a positive steady-state growth in consumption per worker, even if such growth is not possible under autarky. If $p^I < 1$, comparative advantage of the economy is in the *consumption* good, so that more units of *investment* good can be obtained through trade for each unit of consumption relinquished. Engaging in free trade enables the economy to accumulate more capital relative to autarky.

Another approach to generating sustained growth in output per worker in the long run is to introduce a third factor of production the accumulation of which does not yield inexorably diminishing returns.[4] Paul Romer ([1986]

[3] Given constant returns to scale, this assumption implies that labor is not essential to production, that is, output can be produced with capital as input and no labor. This is seen as follows:

Let

$$\frac{\partial F}{\partial K} > \beta \text{ for all } (K, L).$$

Then,

$$F(K, 0) \geqq K\frac{\partial F}{\partial K} > \beta K > 0.$$

[4] Stokey (1996) also uses a three-factor model in which physical capital and unskilled labor are good substitutes and skilled labor is complementary to the aggregate. However, her focus is not growth, but a comparison of factor returns in a closed economy with two types of economic integration, one in which a small economy experiences capital inflows from abroad and one in which the economy freely integrates with a larger and more developed neighbor and factor price equalization holds.

1997) and Robert Lucas ([1988] 1999), whose seminal contributions initiated the literature on endogenous growth, do just that. In Lucas's model, the third factor is human capital, which, because its accumulation does not yield diminishing returns, enables Lucas to obtain sustained growth in per worker output in the steady state, even in the absence of positive externalities associated with human capital. In Romer's model (1986, p. 1003), the third factor is knowledge capital. Although the production of new knowledge is through a technology that exhibits diminishing returns,

> the creation of new knowledge by one firm is assumed to have a positive external effect on the production possibilities of other firms . . . [so that] production of consumption goods as a function of stock of knowledge exhibits increasing returns; more precisely, knowledge may have an increasing marginal product.[5]

Yet another approach, which dates back to Robert Solow's ([1956] 1991) celebrated paper, is to assume labor-augmenting technical progress. In such a model, effective labor grows faster than raw labor and, so, even though output per unit of effective labor does not grow in the steady state, output per unit of raw labor grows at the same rate of labor-augmenting technical progress. In Solow's model, the rate of labor-augmenting technical progress was exogenous. By emphasizing innovation as an endogenous engine of growth, modeling the incentives to innovate in an appropriate way, recognizing the possible spillovers of innovation from innovating firms or countries to other firms and countries through imitation or otherwise, and analyzing the impact of such spillovers and imitation on the overall rate of growth, recent contributions to growth theory, primarily by Grossman, Helpman, Aghion, and Howitt have vastly advanced our knowledge of the growth process. Certainly, these innovation-based models, with their imperfectly competitive market structure, are relevant to development, particularly of those developing countries that are able to imitate and reverse-engineer products innovated by rich countries. The models are not, however, relevant to most countries. Less than a tenth of global expenditure on research and development (R&D) is made by developing countries, and this amount is concentrated in fifteen of those countries (Coe, Helpman, and Hoffmaister, 1997, p. 145, n. 3). In most developing countries, therefore, trade is less apt to promote domestic innovation than to enable those countries to

[5] Eicher (1999) considers a model with two goods-producing sectors (producing a "low-tech" and a "high-tech" consumption good) and an education sector that teaches skills to unskilled labor as teachers. The education sector produces as a byproduct a nonrival technology the use of which in production requires skilled workers. This model has features of the Lucas and Romer models. In a two-country world, trade in goods alone is sufficient to reduce differences in rates of growth and technological change between a leader and laggard economy.

access the fruits of R&D expenditures in rich countries by importing equipment embodying technology that the rich countries have innovated (Coe, Helpman, and Hoffmaister, 1997).

Development-Planning Models

In a production technology with a positive floor to the marginal product of capital, asymptotically, labor is inessential to production. Thus, a model with such a technology reduces, in the limit, to the old Harrod-Domar model, in which capital is the only factor of production. This model was fashionable in the 1950s among development planners. In fact, India's first five-year plan for the 1951–56 period explicitly used it. Contemporary endogenous-growth theorists insufficiently familiar with the earlier literature have christened it the "AK model"!

A two-sector version of the Harrod-Domar model is associated with the names of Grigorii Fel'dman (1928) of the Soviet Union, who formulated it in the late 1920s, and Prasanta Mahalanobis (1955) of India, who independently arrived at it and used it as an analytical foundation for India's second five-year plan. It is a model of a closed economy in which there are two sectors, one of which produces a consumption good, the other, a capital good. Capital is the only factor of production, and the output of each sector is the product of the stock of capital in existence in that sector and its output-capital ratio.[6] Although the *flow* of output of the investment-goods sector can be allocated in any fashion to augment the *stock* of capital in either sector, once installed in a sector, capital cannot be shifted to the other sector.

Fel'dman and Mahalanobis show that the long-run growth rate of output in both sectors is a monotone-increasing function of the proportion of the investment-goods output that is invested in the capital-goods sector. Mahalanobis used this result to argue that India should invest in heavy industries to achieve rapid long-run growth of both consumption and investment.

Just as in the one-sector Harrod-Domar model, opening the economy to trade in the two-sector Fel'dman-Mahalanobis model can produce both level and growth effects. An expanded version of the model, however, illustrates that the growth implications of opening the consumption-goods sector to trade are different from those of opening the capital-goods sector to trade.

[6] Fisher (1995) analyzes a two-sector model in which consumption goods are produced with a constant-returns-to-scale technology using labor and capital, and investment goods are produced with a fixed input of capital per unit of output using capital as the only factor of production (thus avoiding diminishing returns). In a two-country world, transferring wealth from low-saving to high-saving countries promotes growth in this model.

Let us assume two consumer goods as well as two investment goods (instead of one each), with the marginal product of capital being constant in the production of each good. Let the utility function, and the aggregation function that transforms the output of the two investment goods into aggregate investment, be Cobb-Douglas, and let capital stock be freely shiftable within each sector, but not between sectors. Let us assume, for simplicity only, that the share of investment devoted to the accumulation of capital stock in the capital-goods sector is exogenously fixed, rather than endogenously determined through intertemporal welfare maximization.

Appendix A shows that in an economy under autarky, all four goods will be produced in positive amounts. Suppose, now, that this economy is opened to free trade in consumer goods and that the relative price of the two consumer goods is fixed in world markets. The economy will then specialize in producing one of the two consumer goods (the one in which it has a comparative advantage) and will trade some of it for the other. As long as the share of investment devoted to the capital-goods sector is unchanged, however, and that sector is closed to foreign trade, the long-run growth rate of the economy will be unchanged, even though the welfare of the economy will rise relative to autarky. If, however, the capital-goods sector is opened to free trade (again at fixed world relative prices), but the consumer-goods sector is kept closed, there will be a positive long-run growth effect and a welfare effect relative to autarky. The implication is that keeping the growth-inducing sector (which is the capital-goods sector in this model) closed to international competition is costlier than closing the consumer-goods sector, because the capital stock in both sectors will be lower at each point of time in the former case than in the latter. But keeping neither closed would be even better, because for this small economy, there is no market power to be exploited through a tariff policy nor any dynamic externalities from learning effects to be internalized in the model.

Theoretical analyses of the effects of opening an economy to trade with the rest of the world can be classified into two broad categories. The first is concerned with gains from trade and extends to an open economy the results of neoclassical welfare economics of general competitive equilibrium of a closed economy. In a world of open economies, therefore, production, consumption, and market exchange occur among agents located in different nations. The simplest model of this world is a static one without uncertainty, in which production and consumption occur within each nation, only goods (and not factor services) are traded across national boundaries, and any transfers of income or redistribution of initial endowments are restricted to agents located within each nation. It has been shown (Grandmont and McFadden, 1972) that the two fundamental theorems of neoclassical welfare economics for closed economies also hold for open economies under the same assumptions about technology and taste (Koopmans, 1957). Thus, first, a competitive equilibrium of the international economy is Pareto optimal—that is, relative to the equilibrium, no consumer in any nation can be made better off without some other consumer in some other nation being made worse off. Second, a feasible allocation of production, consumption, and trade among agents in all nations that is Pareto optimal can be sustained as an international competitive equilibrium, provided there is a lump-sum redistribution of incomes (or initial endowment) among agents *located within each nation*. An important corollary is that an international competitive equilibrium can always be found that Pareto dominates the autarky competitive equilibrium of each nation.

The simple static model has been extended (as it was for a closed economy) to allow for trades across time and uncertain states of nature under the assumption of the existence of complete markets for contingent commodities. Two equivalent versions of the extension exist. In one, markets for sales and purchases of contingent claims open and clear at time zero, and agents make and accept deliveries during other periods to which they have committed themselves in their trades at time zero. In the second version, asset markets and spot markets operate in each period. Assets are promises to deliver specified amounts of different commodities contingent on the date of deliveries and the state of nature that is realized. Equilibrium in spot markets and asset markets equate the supply and demand for each commodity and asset. The basic message of the general static model and its extensions is simply that there are gains to be realized from international trade. But this model is far too general to infer much about aggregate growth or patterns of trade (that is, which nations would export and import each commodity). Propositions about comparative advantage and the resulting patterns of trade have been derived from particular and simpler versions of the general model.

The second category of models consists of an extension to an open economy of closed-economy aggregate-growth models of both the neoclassical kind, in which the rate of growth in the steady state is exogenous, and those models in which the rate is endogenous. The focus of analysis is the impact that opening to free trade with the rest of the world will have on the growth path of an autarkic economy, it being assumed that the economy is a price taker in world markets.

It is almost banal, but nonetheless true, that the sources of growth (ignoring, for the moment, the distinction between short-run and long-run, or steady-state, growth) are essentially three: factor accumulation, improvements in efficiency of resource use (that is, growth in total-factor productivity [TFP]), and innovation. Broadly speaking, being open to trade and investment can enhance the growth prospects of a small open economy by influencing each of these three sources of growth through the following mechanisms.

First, it can exert influence through the static gains from trade, which amount to an increase in TFP. By reallocating resources in response to world market prices (different from domestic autarky prices), the economy produces more value at world prices from the same total resources than under the autarky allocation. Another mechanism through which openness increases TFP is by making available a large number of differentiated inputs in circumstances in which scale economies place limits on the number of inputs an economy can produce in autarky. These gains from trade expand the options available for consumption and factor accumulation. Thus the economy can, for instance, invest all the gains in factor accumulation and thereby increase growth, at least in the short run.

Second, it can exert influence through factor inflows and outflows. An open economy can, in contrast to an autarkic economy, more cheaply obtain factors (or their services) with which it is less well endowed, and earn more for factors with which it is better endowed, relative to the rest of the world. Once again, these gains can be used partly to accumulate factors and enhance growth.

Last, it can exert influence through technological progress. Openness enables an economy to enjoy the fruits of innovation anywhere in the world. The access to foreign technology can be through (but not limited to) the imports of goods embodying such technology. Except for innovation, all the mechanisms affect growth through factor accumulation.

Of course, dysfunctional and inappropriate policies can eliminate the gains from openness. And, as second-best theory teaches us, partly redressing some of the dysfunctional policies need not result in gains from openness. But second-best considerations constitute only a case for eliminating dysfunctional policies, not a theoretical case against openness.

Turning again to the effects of factor accumulation, we note that the standard results of aggregate growth theory for a closed economy have their analogs for small open economies. Given constant-returns-to-scale production functions with capital and labor as the only inputs, the steady-state growth rate of output per worker equals the exogenous growth rate of the labor force in both closed and open economies. Thus, output per worker is constant in the steady state so long as the marginal product of capital diminishes to zero as the capital-to-labor ratio increases indefinitely. In both economies, positive growth in steady-state output per worker is possible only if the marginal product of capital has a sufficiently high lower bound.

In the absence of such a lower bound, any increase in the investment rate yields only a transitional increase in the growth rate of output per worker, although it raises its steady-state level. Opening to trade raises output as well as savings and investment along the growth path relative to autarky. In the absence of a sufficiently high positive lower bound on the marginal product of capital, therefore, it has only a transitional effect on the growth rate of output per worker. As noted above, in a technology with a positive lower bound to the marginal product of capital, labor is not essential to production, and so its exogenous growth rate cannot bound the steady-state growth ratio of aggregate output. Thus, the growth rate of capital becomes the limiting factor for asymptotic growth, or put another way, capital is the growth-inducing factor. This, in turn, means that an increase in the investment rate in a closed economy (and the induced increase in investment through the output-raising effect of trade opening) raises the steady-state growth of aggregate output.

Endogenous-growth models focus on growth-inducing factors other than physical capital. Human-capital accumulation, as in Lucas ([1988] 1999), can generate steady-state growth in output per head as long as its accumulation does not run into marginal returns diminishing to zero. Another factor, knowledge capital, also escapes the curse of diminishing returns (Romer, [1986] 1997). To the extent that human capital is accumulated through learning, and learning effects peter out in the production of any single product, steady-state growth can be obtained only through the process of introducing new products (as in Stokey, 1996). Again, being open to trade increases the probability that new products will be introduced. Last, but not least, being open not only enables an economy to access the knowledge capital accumulated elsewhere, it can also improve the efficiency of its own knowledge-accumulation process.

It is clear, in theory, that there are several mechanisms through which openness enhances growth. Whether or not these mechanisms operate in practice is an issue for empirical analysis. As we shall see in the next section, identifying the growth effects of trade empirically is a challenging task.

3 Robustness of the Consensus on Openness

Criticisms of the Consensus

Francisco Rodriguez and Dani Rodrik (1999), have reviewed recent empirical studies that strongly support the consensus on the virtues of openness.[7] They claim to have identified several weaknesses endemic to the literature

[7] Recent contributions on growth, trade, and technology spillovers based on cross-country regressions are too numerous to be listed, let alone surveyed. These include Ben-David (1995, 1996), Coe and Helpman (1995), Sachs and Warner (1995), Barro and Sala-i-Martin (1997), Coe, Helpman, and Hoffmaister (1997), Ben-David and Loewy (1998), and Bayoumi, Coe, and Helpman (1999).

that make them skeptical "that there is a strong negative relationship in data between trade barriers and economic growth, at least for levels of trade restrictions observed in practice," and they view "the search for such a relationship as futile" (p. 38). Their summary assessment of "the modern theory of trade policy as it applies [to] a small economy that takes world prices of tradable goods as given" leads them to conclude that

> there should be no theoretical presumption in favor of finding [an] unambiguous negative relationship between trade barriers and growth rates in the types of cross-national data typically analyzed. . . . Moreover an increase in the growth rate of output is neither a necessary nor a sufficient condition for improvement in welfare (p. 5).

Rodrik (1999), in a policy-oriented analysis, goes further than Rodriguez and Rodrik (1999). He states:

> First, openness by itself is not a reliable mechanism to generate sustained economic growth. Second, openness will likely exert pressures that widen income and wealth disparities within countries. Third, openness will leave countries vulnerable to external shocks that can trigger domestic conflicts and political upheavals (pp. 13-14).
>
> The import substitution (IS) policies that followed in much of the developing world until the 1980's were quite successful in some regards and their costs have been vastly exaggerated (p. 64).
>
> ISI worked rather well for about two decades. It brought unprecedented economic growth to scores of countries in Latin America, the Middle East, and North Africa, and even to some in Sub-Saharan Africa (p. 99).
>
> The evidence in favor of the small government/free trade orthodoxy is less than overwhelming. Investment and macroeconomic policies remain key. There is no magic formula for surmounting the challenges of economic growth. If there is, openness is not it (p. 141).
>
> The economies that have done well in the post-war period have all succeeded through their own particular brand of heterodox policies. Macroeconomic stability and high investment rates have been common, but beyond that many details differ (p. 47).

This is quite a list of criticisms. The implication is that the postwar case for openness in trade policy, especially when linked to improved performance in economic growth and, in turn, to improvement in welfare, should be rejected. An evaluation of these arguments leads to the conclusion that they amount to little that policymakers need to worry about when recommending a policy of trade openness.

First, the criticism is that, in theory, there is no presumption that openness in trade (that is, the export-promoting [EP] strategy) will accelerate growth more than the import-substitution (IS) strategy will. It is true that in the conventional economic models, freer trade raises income once and for all but that it cannot raise its growth rate in a sustained fashion. As demonstrated above, this is so in the standard version of a Cass-Koopmans model. In the version of that model without the Inada condition, however, or in the Harrod-Domar model and Fel'dman-Mahalanobis putty-clay models, it is not the case. In fact, Rodriguez and Rodrik (1999, p. 5, n. 7) recognize this. Even if one were to reject as unrealistic models that have positive lower bounds on the marginal product of capital, one could still argue that the relevant time horizon for growth for developing countries is not the very long run, but the short to medium run. Even though openness to trade does not alter the long-run growth rate in standard neoclassical models, it does raise the growth rate in the transition to the long-run steady state, that is, within the time horizon of relevance to developing countries.

At another level, countless arguments and models can be, and have been, made that show that free trade will reduce current income and even growth compared to autarky, if market failures are present. Bhagwati (1958) shows that growth under free trade may even lower welfare. This can happen if there are distortions in place as growth occurs. However, this finding argues against the IS strategy. One reason why the IS strategy has not worked well is that it used quantitative restrictions and other trade barriers to attract foreign investment. Given the trade distortion, this investment reduced the social returns and may even have created social losses.[8]

Sure enough, therefore, one can ingeniously formulate anti-free-trade theories. But in formulating policy, one must next ask: Do we view such theories as representing a "central tendency" in the real world or merely as "pathologies"? These policy judgments cannot be avoided, because to do so is to become a prisoner of the nihilistic view that because anything can be logically shown, nothing can be empirically believed and acted upon. In making such judgments, the most useful evidence can come only from care-

[8] See Brecher and Díaz-Alejandro (1977) for a formal demonstration and Bhagwati (1974) for application of the argument to an evaluation of the IS strategy's demerits.

ful studies of policy regimes of individual countries, preferably in a comparative framework.

Export Promotion versus Import Substitution: Findings from Comparative Country Studies

Among the comparative country studies, those by the Organisation for Economic Co-operation and Development ([OECD] Little, Scitovsky, and Scott, 1970), the National Bureau of Economic Research ([NBER] Bhagwati, 1974; Krueger, [1978] 1997), and the World Bank (Balassa, 1971) were the most influential. They played a critical role in shifting policies in several developing countries away from the IS strategy and in getting the World Bank to enforce trade reforms more fully. These policy studies strongly suggest that the theoretical possibilities that could inversely relate growth to openness were not *forgotten*. Rather, they were *discounted* in light of the systematic in-depth and nuanced analyses of country experiences in these projects. The policy judgment that many drew from these studies was that the EP strategy was conducive to significantly higher growth on a sustained basis than was the IS strategy, which produced, after an early period of often-government-stimulated investments, an unsustainable growth path.

Little, Scitovsky, and Scott (1970) directed seven case studies for the OECD of industrialization in Argentina, Brazil, India, Mexico, Pakistan, the Philippines, and Taiwan. They find that, first, in all of these countries, the industrialization strategy had initially protected the internal market through high customs duties and import quotas; second, the countries had then reached a stage at which policies to promote IS were proving harmful and had led to the creation of high-cost enterprises; and third, these enterprises had come to depend for their profits on government decisions and, so, had developed a habit of devoting their efforts to obtaining privileges by putting pressure on the government, instead of cutting costs. The authors conclude that the emphasis should be shifted from IS to EP to replace high-cost internal production by reorganized agricultural and industrial sectors capable of gradually becoming competitive and assuming their place in the world market.

Bhagwati (1974), one of the codirectors of the NBER studies, attributes the superiority of EP to IS strategy to several possible factors, including the "neutrality" of the incentives that define the pattern of industrial and export composition under EP as opposed to the "chaotic" non-neutrality of the incentives that arise under IS and the improved economic performance that follows the removal of the bias against exports under IS. The improved economic performance was, in his view, caused not so much by the more efficient export-competition pattern under EP, as by the vastly improved export performance under EP.

Under EP, the effective exchange rate for exports is not raised a great deal relative to the rate for imports—in other words, the distortionary effects of export incentives are modest. This is true for a number of reasons. EP often occurs within a context in which the IS strategy is still in place, and the objective is to offset or reduce the bias against exports caused by IS, rather than to create an excessive bias in favor of exports. In addition, unlike import tariffs (and import quotas, if these are auctioned), export subsidies have to be financed from other revenues. The ability to subsidize exports is therefore limited by its budgetary cost. Moreover, to the extent that EP succeeds in raising export earnings, it will ease the balance-of-payments position, which, in turn, will ease the excesses of IS strategy.

Finally, the EP strategy can influence the access to, and quality of, foreign-capital flows. The improved ability to service debt, because of improved export performance, will not only enhance the capacity to borrow abroad, it will also attract more and better foreign direct investment, because an emphasis on exports will induce foreign investors to take advantage of low production costs to produce for export markets. This means that under the EP strategy, investment will flow to export industries, that is, to those industries in which the economy has a comparative advantage, rather than to sectors protected by import tariffs, as under the IS strategy. Such investments will be welfare-improving, rather than welfare-worsening, as tariff-jumping investments attracted by the IS strategy are. Bhagwati finds empirical evidence supporting one or more of these mechanisms through which the superiority of the EP strategy manifests itself.

Anne Krueger ([1978] 1997), in her synthesis of the NBER studies, also affirms the superiority of the EP to the IS strategy. She finds two classes of influence that appear to make the EP strategy more conducive to rapid growth. One class consists of economic factors. These include the exploitation of scale economies and efficiency induced by the greater competition created by serving a large global market under the EP strategy, rather than a limited domestic market under an IS strategy. The other class consists of restraints imposed by the EP strategy on the government's ability to pursue and implement dysfunctional economic policies. These restraints arise from the fact that unlike the IS strategy, which can be implemented through quantitative restrictions and tariffs that generate revenues, the EP strategy almost certainly cannot be implemented through quantitative restrictions. It necessarily has to rely on influencing prices received by exporters—for example, through subsidies—and, as noted above, the budgetary cost of subsidies limits their excessive use.

Cross-Country Regressions

Policy-evaluation studies in effect ask a counterfactual question: What would have happened if a country had a set of policies different from the one it actually followed? There are several empirical methods for answering this question. If some countries have changed policies, one can use data from these countries from before and after their policy change (the so-called "before-and-after" approach). Alternatively, one can compare the outcomes in countries that have changed policies with those of a similar group of countries that have not (the so-called "control-group" approach). The NBER, OECD, and World Bank studies represent a combination of these two methods. Their comparisons of the performance of individual countries as their policy regimes change over time are the equivalents of the before-and-after comparisons. Their intercountry comparisons are similar to, although not quite the same as, comparisons in the control-group approach.

Other methods include simulations of the effects of a policy change in a country, typically from an applied general-equilibrium model, and versions of a difference-in-difference approach, in which one compares the difference in outcomes between countries that have changed policies with the control group before the former changed policies with the difference after they changed policies. There is also the recently popular cross-country-regression approach. Each of these methods has its own strengths and weaknesses.

Among the many reasons to be skeptical of the findings of most of these regressions are their weak theoretical foundations, the poor quality of their data bases, and their inappropriate econometric methodologies.[9] A typical regression of this genre will have some outcome variable (for example, average growth rate over some period) on the left-hand side (LHS) and a number of variables on the right-hand side (RHS) that are viewed as determinants of, or factors influencing, the LHS variable. The direction of influence is viewed as going from the RHS variables to the LHS variable. In an openness context, the RHS variables will include a proxy for openness, other possible *systematic* determinants of growth such as rates of investment (including proxies for human-capital investments or stocks), dummy variables to capture factors specific to a country, region, or period (even including dummies for civil wars, coups and revolutions, and religion of the majority of the population), and a host of factors that are viewed as *idiosyncratic* influences on growth. In a cross-sectional context, the same relation between RHS and LHS variables (other than country dummies) is assumed to apply for all countries. In a single-country time-series context, the same relation between RHS and LHS variables (other than time dummies) is assumed for all time periods. There are a number of problems with the use of such regressions.

[9] Rodriguez and Rodrik (1999) are rightly critical of regressions showing a positive relation between trade openness and growth. However, they do not reject the regression methodology itself, but only the particular applications of the methodology by others. They run similar regressions but reach different conclusions by using different data sets and variables.

First, the postulated relationship is often not derived from any theoretical model. Even when it is, the link in the econometric specification of the relation between theory and the estimated regression is far more tenuous than is often realized, because economic theory rarely specifies the functional forms for the relationships, let alone the probability distribution of the stochastic error terms.[10] To assert, therefore, that a hypothesis (for example, a positive relation between growth and openness) is conclusively established or refuted by the regression is to claim too much.

Second, there is no reason to presume, even in theory, that the direction of the relationship runs only from the RHS variables to the LHS variable. If it goes both ways, then the LHS variable and a subset, if not all, of the RHS variables are jointly determined. The postulated regression is then only one of a set of relationships characterizing the interrelations among jointly determined variables. That being the case, unless treated econometrically, so as appropriately to address this simultaneity problem, parameter estimates from a single equation using ordinary least squares (OLS) will not be consistent and cannot be interpreted meaningfully. To be fair, a few careful empirical researchers do attempt to address the endogeneity of some of the RHS variables arising from simultaneity by using other than OLS estimation techniques, such as two-stage least squares or instrumental variables. Nonetheless, this remains an infrequent practice. In addition, if sufficient numbers of observations are available, it is also possible to test whether, rather than assume that, the relation between RHS and LHS variables is the same across countries or over time. One can even adopt a nonparametric specification of the relationship. Limitations of data, however, often preclude these options.

Third, many of the RHS variables not only are often poor empirical proxies for their theoretical counterparts but are also subject to errors and biases of measurement. For example, defining a variable that captures the influence of a nontariff barrier in a theoretical relationship and then finding a reasonable empirical proxy for it are not easy tasks. Measurement error in an RHS variable biases not only the estimate of the parameter embodying its effect but also the estimates of parameters embodying the effects of other RHS variables—the direction of bias not being predictable except in very simple situations. In addition, dummy variables are best described as "dumb" variables; they are introduced to capture the influence of factors (civil war, revolutions, coups) of which the analyst often has no knowledge.

[10] Except in empirical studies such as those based on real-business-cycle models, in which it is integral to the model, the stochastic error term is added on to a purely deterministic theoretical equation, a practice that can be justified only if the RHS variable is the sum of its "true" value and a stochastic measurement error.

The estimated value of the parameter associated with a dummy variable is merely a quantitative measure of this ignorance.

Fourth, in the context of relationships that have a temporal as well as cross-sectional dimension, there is the well-known problem that the estimated impact from a cross-section of an RHS variable on the LHS variable need not be the same as that from time-series data.

Fifth, it is highly unlikely that cross-country regressions, relying inevitably on simple proxies of critical explanatory variables such as trade policy, can reliably address the empirical reality of the trade-and-growth link in country experiences. In fact, even the LHS variable, the growth rate of GDP, needs to be handled with empirical and conceptual care. Not only do we know that the estimated growth rates and country rankings are sensitive to whether one uses conventional estimates or the Kravis-Heston-Summers estimates (Kravis, Heston, and Summers 1982; Summers and Heston, 1991). We also know that, from a welfare-theoretic viewpoint, there is a good case for reevaluating the growth rate of each country at its international prices, as suggested by Little, Scitovsky, and Scott (1970) and analyzed by Bhagwati and Hansen (1973). Studies by Balassa (1971) and others suggest that when this is done, the high early growth rates under IS strategy in countries such as Brazil will be revised drastically downward. The crude regressions on growth and trade, however, almost never face up to these difficulties, which can be, and often have been, faced squarely in nuanced and intensive country studies.

The stream of studies based on regressions is continuing, each new paper attempting to address the perceived econometric and data weaknesses of earlier studies. One such study, by David Dollar and Aart Kraay (2001), focuses on post-1980 "globalizers," defined as countries in the top one-third of developing countries in terms of the increase in the share of trade in their GDP from 1977 to 1997. This group cuts import tariffs by three times as much as the bottom two-thirds of "nonglobalizers." The authors find that although growth rates in rich countries and nonglobalizing countries have slowed in the past several decades, globalizers have shown exactly the opposite trend, with their growth accelerating during the 1970s and 1980s. The authors' selection of globalizers and the procedure for calculating changes in tariffs and trade shares can be criticized as either inappropriate (for example, trade shares represent outcomes of policies and not policies themselves) or faulty. Yet, the fact that the post-1980 globalizers, which were initially poorer and had similar levels of educational attainments and inflation in 1980 as the nonglobalizers, were able to surpass their counterparts in all these dimensions by 1997, is consistent with the hypothesis that their trade induced the faster growth that enabled them to do so.

Jeffrey Frankel and David Romer (1999) have published a study that, unlike the others that concentrate on trade and growth, examines the relation between openness and per capita income. Recognizing that the opportunity to trade can potentially increase the income of both trading parties, the authors postulate that income per capita is a positive function of domestic and international trade. Domestic trade, on which there are no data, is viewed as being determined by country size (population and land area). Endogeneity of international trade (defined as the share of trade in GDP) is addressed by replacing actual trade with predicted trade based on a gravity model. The results show that endogeneity of trade is not a serious problem and that trade has a quantitatively large and robust, though only moderately significant, positive effect on income. In addition to the fact that this study says nothing about the growth effects of openness to trade, it is silent about the mechanisms through which trade as a share of GDP influences the level of per capita income.

It is interesting, and suggestive, that vast numbers of regression analyses have supported the notion that openness to trade is associated with higher incomes and growth rates. I am wary, however, of drawing firm conclusions from cross-country regressions, especially in light of my foregoing criticisms (see Srinivasan 1999, p. 67). Although such regressions may suggest new hypotheses and may be valuable aids for thinking about the issue at hand, great caution is needed in using them at all as plausible, "scientific," support. The same caution is needed in using the regressions of Rodriguez and Rodrik (1999) as scientific critiques of other regressions. This is particularly true because the regressions (and the conclusions based on them) are likely to be critically dependent on the period, the sample of countries, and the variables chosen. In fact, given these numerous choices, one can confidently expect that there are enough de facto degrees of freedom at an analyst's command to reverse any "findings" arrived at by another analyst using similar regression methods. Using these cross-country-regression methods to argue the case for openness to trade, when nuanced and in-depth studies are much more persuasive, is to create the wrong impression that the case for openness to trade is illusory. The case continues to be strong, and it would be tragic, indeed, if developing countries ignore it.

In much of the recent literature on growth, the focus has been on the steady-state properties. This can be very misleading. Appendix B considers a two-sector (capital-goods and consumption-goods) neoclassical growth model. It uses a numerical example to show that per worker consumption in the autarky steady state can be higher than in the free-trade steady state, in which the economy is specialized in the production of consumer goods. Does this mean that it is not optimal for an economy in its autarky steady state to adopt free trade when the opportunity to do so arises, because consumption per worker is lower at its free-trade steady state? The answer is clearly no.

The reason is simple. As Srinivasan and Bhagwati (1980) argue, once the economy adopts free trade, along the transition to the free-trade steady state, per worker consumption rises above its autarky steady-state level for an initial interval of time, before declining and converging to the lower free-trade steady-state level. The gain in the discounted sum of felicities relative to the autarky steady state during this interval exceeds the loss in the subsequent period of decline in per worker consumption. Thus, the discounted sum of felicities along the free-trade growth path exceeds that along the autarky steady-state path. Free trade, therefore, is indeed the optimal dynamic policy for a small open economy.

Appendix A: The Mahalanobis Model

The Consumption-Goods Sector

Output of good $i = Q_i^c (i = 1, 2)$; domestic use of good $i = C_i^c (i = 1, 2)$; stock of capital $= K^c$

$$\text{Production frontier} \qquad \beta_1 Q_1^c + \beta_2 Q_2^c = K^c \tag{A.1}$$

$$\text{Utility function} \qquad U = (C_1^c)^{\alpha} (C_2^c)^{1-\alpha} \tag{A.2}$$

The Investment-Goods Sector

Output of good $i = Q_i^I (i = 1, 2)$; domestic use of good $i = A_i^I (i = 1, 2)$; stock of capital $= K^I$

$$\text{Production frontier} \qquad \gamma_1 Q_1^I + \gamma_2 Q_2^I = K^I \tag{A.3}$$

$$\text{Aggregate investment} \qquad I = \left(A_1^I\right)^{\delta} \left(A_2^I\right)^{1-\delta} \tag{A.4}$$

Capital Accumulation

Let λ be the share of investment devoted to the accumulation of K^I. Then,

$$\dot{K}^I = \frac{\mathrm{d}K^I}{\mathrm{d}t} = \lambda I \ , \tag{A.5}$$

$$\dot{K}^c = \frac{\mathrm{d}K^c}{\mathrm{d}t} = (1-\lambda) I \ . \tag{A.6}$$

Autarky

$$C_i^c = Q_i^c \text{ and } A_i^I = Q_i^I \text{ for } i = 1, 2 \ .$$

Maximization of (A.2) subject to (A.1) leads to

$$C_1^c = \frac{\alpha K^c}{\beta_1}, \ C_2^c = \frac{(1-\alpha) K^c}{\beta_2} \text{ and } U = \left(\frac{\alpha}{\beta_1}\right)^{\alpha} \left(\frac{1-\alpha}{\beta_2}\right)^{1-\alpha} K^c \ . \tag{A.7}$$

Maximization of (A.4) subject to (A.3) leads to

$$A_i^I = \frac{\delta K^I}{\gamma_1},\ A_2^I = \frac{(1-\delta)K^I}{\gamma_2}\ . \tag{A.8}$$

Substituting (A.8) in (A.4), one gets

$$I = \left(\frac{\delta}{\gamma_1}\right)^{\delta} \left(\frac{1-\delta}{\gamma_2}\right)^{1-\delta} K^I \tag{A.9}$$

$$\equiv \eta K^I \text{ where } \eta = \left(\frac{\delta}{\gamma_1}\right)^{\delta} \left(\frac{1-\delta}{\gamma_2}\right)^{1-\delta} . \tag{A.9$'$}$$

Using (A.9′) in (A.5) and (A.6) and solving:

$$K^I = K_0^I e^{\lambda \eta t}\ , \tag{A.10}$$

$$K^c \ = \ K_0^c \ + \left(\frac{1-\lambda}{\lambda}\right) K_0^I \left(e^{\lambda \eta t}\right)\ . \tag{A.11}$$

Thus, the long-run growth rates of K^I, K^c, I, and U are the same and equal to $\lambda\eta$.

Free Trade in Consumer Goods at a Relative Price of π^c of Good 2 in Terms of Good 1 and Autarky in Investment Goods

Without loss of generality, assume $\pi^c > \beta_2/\beta_1$. It is then optimal to produce only Good 2 and to import Good 1. It is easy to show that

$$Q_1^c = 0,\ Q_2^c = K^c/\beta_2,\ C_1^c = \alpha\pi^c K^c/\beta_2\ ,$$

and

$$U = \alpha^a (1-\alpha)^{1-\alpha} (\pi^c)^{\alpha} K^c/\beta_2\ .$$

It is easy to verify that given $\pi^c > \beta_2/\beta_1,\ U$ is higher than under autarky for any K^c. Because the investment-goods sector is closed to trade, the dynamics of the system are unaffected, so that the paths of K^I and K^c continue to be given by (A.10) and (A.11), respectively. Thus, the long-run growth rates K^c, I^I, and U are still $\lambda\eta$, although the level of U at each t is higher than under autarky.

Free Trade in Investment Goods at a Relative Price of π^I of Good 2 in Terms of Good 1 and Autarky in Consumption Goods

Without loss of generality, assume $\pi^I > \gamma_2/\gamma_1$. It is then optimal to produce only Good 2, to export part of the output, and to import Good 1.

It is easy to show that

$$Q_1^I = 0,\ Q_2^I = K^I/\gamma_2,\ A_2^I = \delta\pi^I K^I/\gamma_2,\ A_2^I = [(1-\delta)K^I]/\gamma_2 \ ,$$

and

$$I = \delta^\delta(1-\delta)^\delta(K^I/\gamma_2) \ .$$

It is easy to verify that given $\pi^I > \gamma_2\gamma_2$, investment under free trade is higher than under autarky for any K^I.

Using (A.5) and (A.6) and solving, one gets

$$K^I = K_0^I e^{\lambda\mu t} \qquad \mu = [\delta^\delta(1-\delta)^{(1-\delta)}(\pi^I)^\delta]/\gamma_2$$

and

$$K^c = K_0^c + \left(\frac{1-\lambda}{\lambda}\right) K_0^I e^{\lambda\mu t} \ .$$

Given $\pi^I > \left(\frac{\gamma_2}{\gamma_1}\right)$, it follows that $\mu > \eta$.

Thus, the values of K^I and K^c at each time t under free trade in investment goods are higher than their corresponding values under autarky. The common long-run growth rates of K^I, K^c, and I, namely, $\lambda\mu$, are also higher than their value $\lambda\eta$ under autarky. Because the consumption-goods sector is under autarky,

$$Q^c = C_1^c = \alpha K^c/\beta_1,\ Q_2^c = C_2^c = [(1-\alpha)K^c]/\beta_2 \ ,$$

and

$$U = (\alpha/\beta_1)^\alpha \left[(1-\alpha)/\beta_2\right]^{1-\alpha} K^c \ .$$

Because K^c at each t under free trade in investment goods is higher than under autarky, U is higher as well. Because K^c grows faster, U also grows faster.

Appendix B: The Two-Sector Neoclassical Growth Model

Let the average physical product of labor in the investment-goods sector be $f_I(k_I)$, where k_I is the capital-labor ratio. Let the corresponding function in the consumption-goods sector be $f_c(k_c)$, where k_c is the capital-labor ratio in that sector. The aggregate capital-labor endowment ratio k is

$$k = l_c k_c + (1 - l_c)\, k_I \ , \tag{B.1}$$

where l_c is the share of the labor force employed in the production of consumer goods. In any competitive equilibrium in which both goods are produced in positive amounts, the wage-rental ratio ω equals the marginal rate of substitution between capital and labor in each sector, that is,

$$\omega = \frac{f_I(k_I) - k_I f_I'(k_I)}{f_I'(k_I)} = \frac{f_c(k_c) - k_c f_c'(k_c)}{f_c'(k_c)} \ . \tag{B.2}$$

Assuming, for simplicity, $f_I(k_I) = k_I^{\beta},\ f_c(k_c) = k_c^{\alpha}$,

$$\omega = \left(\frac{1-\beta}{\beta}\right) k_I = \left(\frac{1-\alpha}{\alpha}\right) k_c \ . \tag{B.3}$$

Assume that $\beta > \alpha$, so that $k_I > k_c$ at all ω, that is, that the investment-goods sector is capital intensive.

In an autarky steady state, both goods have, by definition, to be produced. Therefore, using superscript A to denote autarky and an asterisk to denote the steady state,

$$k_I^{*A} = \left(\frac{\beta}{1-\beta}\right) \omega^{*A}, \qquad k_c^{*A} = \left(\frac{\alpha}{1-\alpha}\right) \omega^{*A} \ . \tag{B.4}$$

The fact that the economy is in the optimal autarky steady state implies that the marginal physical product of capital in the capital-goods sector equals $n + \delta + \rho$, where n is the rate of growth of the labor force, δ is the exponential depreciation rate of capital, and ρ is the felicity discount rate. Thus,

$$\beta \left(k_I^{*A}\right)^{\beta-1} = (n + \delta + \rho) \ ,$$

or

$$k_I^{*A} = \left(\frac{\beta}{n+\delta+\rho}\right)^{\frac{1}{1-\beta}} \quad . \tag{B.5}$$

Using (B.3),

$$k_c^{*A} = \left[\frac{\alpha\,(1-\beta)}{\beta(1-\alpha)}\right] k_I^{*A} \ , \tag{B.6}$$

and

$$\omega^{*A} = \left(\frac{1-\beta}{\beta}\right) k_I^{*A} \ . \tag{B.7}$$

The price p^{*A} of consumption goods in terms of investment goods in the autarky steady state is given by the ratio of marginal physical product of capital (or labor) in the capital-goods sector to its marginal physical product in the consumption-goods sector. Thus,

$$p^{*A} = \frac{\beta\left(k_I^{*A}\right)^{\beta-1}}{\alpha\left(k_c^{*A}\right)^{\alpha-1}} = \frac{\beta}{\alpha}\left[\frac{\alpha(1-\beta)}{\beta(1-\alpha)}\right]^{1-\alpha}\left(\frac{\beta}{n+\delta+\rho}\right)^{\beta-\alpha} \quad . \tag{B.8}$$

Denoting by k^{*A} the aggregate capital-labor ratio and by l_c^{*A} the share of employment in the consumption-goods sector, and noting that along the steady state, the output of investment goods per worker must equal what is needed to replace depreciating capital and keep the capital-labor ratio constant, we get

$$k^{*A} = l_c^{*A} k_c^{*A} + \left(1 - l_c^{*A}\right) k_I^{*A} \ , \tag{B.9}$$

$$\left(1 - l_c^{*}\right)\left(k_I^{*A}\right)^{\beta} = (n+\delta)k^{*A} \ . \tag{B.10}$$

Eliminating l_c^{*A} between (B.9) and (B.10) yields

$$k^{*A} = \frac{\left(k_c^{*A}\right)\left(k_I^{*A}\right)^{\beta}}{\left(k_I^{*A}\right)^{\beta} - (n+\delta)\left(k_I^{*A} - k_c^{*A}\right)} \ . \tag{B.11}$$

If we set $\alpha = 0.25,\ \beta = 0.5,\ n = 0.02,\ \delta = 0.03,$ and $\rho = 0.05$, then,

$$\begin{aligned}
k_I^{*A} &= 5^2 = 25,\ k_c^{*A} = \frac{25}{3}\ , \\
\omega^{*A} &= 25,\ p^{*A} = 2\left(\frac{1}{3}\right)^{0.75} 5^{0.25} \simeq 1.3120\ , \\
k^{*A} &= \frac{\left(\frac{25}{3}\right)(25)^{0.5}}{(25)^{0.5} - .05\left(25 - \frac{25}{3}\right)} = \frac{125}{3\left[5 - \frac{2.5}{3}\right]} = 10\ , \\
l_c^{*A} &= \frac{k_I^{*A} - k^{*A}}{k_I^{*A} - k_c^{*A}} = \frac{25 - 10}{25 - \frac{25}{3}} = 0.9\ .
\end{aligned}$$

Consumption per worker c^{*A} in autarky steady state is given by

$$c^{*A} = l_c^{*A}\left(k_c^{*A}\right)^{\alpha} = 0.9\left(\frac{25}{3}\right)^{0.25} \simeq 1.5291\ .$$

Suppose an opportunity arises to trade with the rest of the world at a price $p^T = 2$ of consumption goods in terms of investment goods. It can be shown that in its free-trade steady state, the economy will specialize in consumption goods. Its aggregate capital-labor ratio in the free steady state k^{*T}, which is also the capital-labor ratio in the production of consumer goods, will equal

$$k^{*T} = k_c^{*T} \simeq 8.5499\ .$$

This follows from the fact that the marginal-value product of capital (in terms of investment) must equal $n + \delta + \rho$ in the steady state or

$$p^T\alpha\left(k_c^{*T}\right)^{\alpha-1} = (n + \delta + \rho)\ ,$$

so that

$$k_c^{*T} = \left(\frac{\alpha p^T}{n + \delta + \rho}\right)^{\frac{1}{1-\alpha}} = \left(\frac{0.5}{0.1}\right)^{\frac{4}{3}} = (5)^{\frac{4}{3}} = 8.5499\ .$$

The steady-state level c^{*T} of consumption per worker is given by the difference between the output of consumption goods per worker $(k^{*T})^{\alpha}$ and the export of consumption goods needed to finance the imports of investment goods to maintain capital per worker at k^{*T}, that is, $(n+\delta)k^{*T}/p^{T}$. Thus,

$$\begin{aligned} c^{*T} &= (k^{*T})^{\alpha} - (n+\delta)\frac{k^{*T}}{p^{T}} = (8.5499)^{\frac{1}{4}} - \frac{0.05 \times 8.5499}{2} \\ &= 1.4962 < c^{*A} \ . \end{aligned}$$

Starting from the autarky steady state with an aggregate-capital-labor ratio of 10, at the instant trade opens at price $p^{T} = 2 > p^{A} = 1.3125$, the economy can be shown to be initially incompletely specialized, using a capital-labor ratio of 9 (instead of the autarky value of 8.33) in the production of consumption goods, and of 27 (instead of the autarky value of 25) in the production of investment goods. However, the share of labor devoted to the production of consumer goods increases to 0.94 (compared to its autarky value of 0.9). Because the aggregate-capital-labor ratio in the free-trade steady state of 8.5499 is below its initial (autarky) value of 10, the economy does not have to invest (in gross terms) as much under free trade as under autarky. Thus, for three reasons—a higher capital-labor ratio, a higher share of employment in the production of consumption goods, and a lower gross investment per worker—consumption initially rises above its autarky value.

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