Transition Dynamics and Trade Policy Reform in Developing Countries[1]

by

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November 1997
(revised)

Keywords: transition dynamics, trade and growth, trade liberalization and development

JEL codes: [F43], [F13]

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[1] The views expressed in this paper are strictly those of the authors and are not meant to represent those of any institution with which they are or have been affiliated, including the International Monetary Fund and the World Trade Organization.

NON-TECHNICAL SUMMARY

Dynamic effects have featured prominently in recent studies of trade liberalization and integration. Recent calibration studies of the North American Free Trade Agreement (NAFTA), the European Community's economic integration (EC92) programme, and the Uruguay Round of multilateral trade negotiations have all attempted to quantify potential dynamic effects of trade liberalization on economic growth, both due to standard transitional growth effects (i.e., level effects) and due to permanent endogenous growth effects. Dynamic effects have also featured in the policy debate during negotiation and ratification of these agreements and programmes. While the understanding of the relevant mechanisms is incomplete, it is clear that dynamic effects are important, and can probably overwhelm the static efficiency gains. This may be especially true for developing countries, as demonstrated in this paper.

There is now a sizeable theoretical literature linking international trade with endogenous growth. This literature attempts to provide formal mechanisms for the interplay between trade policies and domestic growth, without recourse to exogenous assumptions regarding the sources of growth. The empirical foundations for believing in such a linkage seem compelling, with numerous studies reporting a positive correlation between an "open" trade regime and growth. However, while there appears to be a positive linkage between openness and growth, and while this linkage seems to work indirectly through investment, the results of the cross-country literature do not yet offer strong evidence of any endogenous growth mechanisms at work. Endogenous growth models predict *permanent* growth effects following policy regime changes, the existence of which cannot be detected through standard cross-country correlation analysis. Indeed, the recent studies that test directly for the implications of endogenous growth models have so far failed to establish anything but a *transitory* impact from policy reforms.

In parallel with the development of the new endogenous growth theory, some authors have gone back to take a second look at classical growth theory, associated foremost with Solow. Perhaps surprisingly, these authors have found that an augmented version of the Solow growth model that includes accumulation of human capital as well as physical capital provides a good description of the cross-country data. For example, recent evidence points to "conditional convergence," that is, convergence in income per capita across countries controlling for differences in savings rates, human capital and population growth. According to these studies, poorer economies, everything else given, tend to grow faster than their richer counterparts. This is consistent with the transitional dynamics of the Solow model, but somewhat at odds with the endogenous growth theory that (absent adjustment costs or imperfect knowledge transmission) downplays transitional dynamics.

The emphasis of this paper is on the relevance of transitional dynamics in a classical sense, particularly for developing countries. To make the point as clearly as possible, the paper employs a simple Solow growth model, developing the transitional dynamics in detail, and contrasting policy reforms in countries near steady state (developed countries) with countries far from steady state (developing). It is demonstrated that policy reforms that appear identical in a static framework can have a substantially greater impact on growth of developing country incomes, once induced accumulation affects during transition to steady state have been accounted for. This follows from the acceleration of transitional growth to steady state, which allows higher incomes to be realized at an earlier date. In present value terms, apparently identical trade policy reforms (based on steady state comparisons of real incomes) may be worth, in relative terms, substantially more to developing countries than to developed ones.

Our conclusions may be summarized as follows. Policy reforms have important implications for developing countries that are qualitatively different from those for developed ones. This is because of the impact on transitional growth. By setting their economies on a steeper transitional growth path, a policy reform allows the fruits of development to be realized at an earlier date. Even a modest policy reform worth one percent in static income is in present value "worth" perhaps 50 to 150 percent of initial GDP, depending on initial conditions. The more underdeveloped the economy is initially in relation to its steady state potential, the greater the present value income gain of being set on a steeper transitional growth path. The impact of policy reforms depends crucially on the initial state of development, a lesson that has been largely overlooked in the applied modelling literature.

Transition Dynamics and Trade Policy Reform in Developing Countries

Abstract: This paper emphasizes the relevance of classical transition dynamics for trade policy, particularly for developing countries. The empirical evidence from cross-country growth regressions points to important transitional growth effects related to trade policy reforms. The paper employs a simple growth model to examine these effects, formally developing the transitional dynamics and contrasting policy reforms in countries near steady state (developed countries) with countries far from steady state (developing). Policy reforms that appear identical in a static or steady state framework can have a substantially greater impact on developing countries, once transitional accumulation effects have been accounted for.

I. Introduction

There is now a sizeable theoretical literature linking international trade with endogenous growth. This literature attempts to provide formal mechanisms for the interplay between trade policies and income growth, without recourse to exogenous assumptions regarding the sources of growth. The empirical foundations for believing in such a linkage seem compelling, with numerous studies reporting a positive correlation between an "open" trade regime and growth. However, while there appears to be a positive linkage between openness and growth, and while this linkage seems to work indirectly through investment (See, e.g., Levine and Renelt (1992), and Baldwin and Seghezza (1996)), the results of the cross-country literature do not offer strong evidence of an endogenous growth mechanism at play. Endogenous growth models predict *permanent* growth effects following policy regime changes, the existence of which cannot be detected through standard cross-country correlation analysis. Moreover, the recent studies that test directly for the implications of endogenous growth models have so far failed to establish anything but a *transitory* impact from policy reforms on growth rates (See Jones, 1995).

In parallel with the development of the new endogenous growth theory, some authors have gone back to take a second look at classical growth theory, associated foremost with Solow (1956). They have found that an augmented version of the Solow growth model that includes accumulation of human capital as well as physical capital provides a surprisingly good description of the cross-country data. For example, Mankiw, Romer, and Weil (1992) have found evidence of "conditional convergence," that is, convergence in income per capita across countries controlling for differences in savings rates, human capital, population growth, and other variables that predestine countries for different steady state incomes. In their regressions, the (logarithm of) income per capita in the initial year of their data set (1960) enters with a negative sign, indicating that poorer economies, other things equal, tended to grow faster than their wealthier counterparts. This is consistent with the transitional dynamics of the Solow model, but somewhat at odds with the endogenous growth theory that (absent adjustment costs or imperfect knowledge transmission) downplays transitional dynamics.

At the same time, Mankiw et al. have found that the Solow model performs worse for a sub-sample of 22 OECD countries. (The full data set covers 98 countries). This suggests, perhaps, that the Solow model is useful for explaining growth based on capital deepening (human and physical) in transition to steady state, which intuitively is a dominant source of growth for developing countries, while being less useful in shedding light on the determinants of steady state growth for developed countries at the technological frontier. Indeed, the Solow model treats steady state growth as exogenous. Hence, the determinants of worldwide technological change, and the adoption and assimilation of technology to local conditions, lie outside the scope of the traditional model. This is an area where the endogenous growth literature has and will continue to play an important role, although the empirical literature has yet to establish which model specifications and assumptions are empirically relevant.

A common approach in numerical simulation models has been to treat countries at all levels of development as being in steady state,[2] although this is clearly an invalid assumption as shown by the negative coefficient on initial income per capita in cross-country growth regressions. Arguably, if just a single country is out of steady state, the global system, and its regional subcomponents (including OECD), must be out of steady

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[2] At a recent World Bank sponsored conference on the Uruguay Round and developing countries, documented in Martin and Winters (1995), several of the efforts to assess capital accumulation effects of the Round involved implicit steady state assumptions, including Francois, McDonald and Nordström (1995).

state as well. If the focus of the analysis is on short term issues, it may not matter much whether a country is (falsely) assumed to be in steady state or not. However, as far as the medium- and long-term impacts of trade policy are concerned, the steady state assumption may overlook important transitory growth effects.

This paper shows theoretically that policy reforms can spur growth temporarily, and more so for countries that are far away from their steady state income levels. Thus, policy reforms that appear identical in a static framework can have a qualitatively different impact on developing countries than on developed ones. This is because they may accelerate growth along the transition path, thereby allowing higher incomes to be realized at an earlier date.

The remainder of the paper is organized as follows. Section II briefly reviews the empirical literature on trade and growth, arguing that the positive linkages typically found do not, so far, firmly establish the existence of particular endogenous growth mechanisms. Our maintained hypothesis is instead that cross-country regressions highlight the transitory impact on growth of trade reforms. Section III provides an overview of the treatment of accumulation effects in numerical trade models. Essentially, starting from the assumption that all countries are initially in steady state, these models solve for the new, post-reform steady state using a macro closure of either a fixed savings rate or a fixed net real return to savings and investment. This assumption may prejudice the results quantitatively, as demonstrated in Section IV. The paper concludes with observations on the implications of this differential impact for quantitative analysis of trade policy, particularly for multi-country models mixing countries at different stages of development.

II. Empirical Studies of Trade and Growth

There is a large literature that has examined the importance of trade liberalization and international openness in fostering economic growth. These studies will be reviewed briefly in subsection II.A.[3] They generally find a positive association between an "open" trade regime and economic growth both for developed and developing countries, and over different time periods. While the evidence seems compelling, linking trade to

[3] For a thorough review, see Edwards (1993).

growth through investment, one should keep in mind the conceptual and methodological problems facing this literature. One problem has been the construction of satisfactory measures of concepts like "openness" and "trade orientation." It is difficult to form comparable indexes across countries of the myriad of trade and commercial practices employed at a single point in time, much less to form a time series of such measures.[4] Further, these studies have not always been based on rigorous theoretical models, so the channels through which trade influences economic growth remain unclear.[5]

Recently, some studies have explicitly examined the empirical validity of the theory of trade and endogenous growth. Coe and Helpman (1993) have examined the extent of international R&D spillovers in relation to economic growth, while Irwin and Klenow (1994) have looked at learning-by-doing spillovers in the semiconductor industry. Jones (1995) has conducted time-series tests of R&D based models of trade and economic growth. Subsection II. B briefly reviews endogenous growth theory to pinpoint testable hypotheses, and then discusses the associated empirical work.

II.A. Empirical Linkages

A pioneering attempt to classify trade regimes was conducted in an NBER study directed by Bhagwati (1978) and Krueger (1978). They classified trade regimes according to five phases of liberalization, defining phase I as the most restrictive regime with across-the-board quantitative trade restrictions and phase V as the most liberal trade regime. On the basis of this classification, two hypotheses were tested. The first was that countries with more liberal trade regimes have higher rates of export growth. This hypothesis was confirmed for both traditional and non-traditional exports on a sample of 10 countries for the period 1954-72. The second was that a more liberal trade regime is correlated with higher real GDP growth. This hypothesis was indirectly

[4] Pritchett (1993) reviews some commonly used indexes and reaches the disconcerting conclusion that the correlation between them is low. Also, a country may choose to liberalize when general economic conditions are good, so that the direction of causation underlying the positive cross-country correlation between trade liberalization and economic growth is unclear.

[5] Some recent studies, such as Edwards (1992) and Lee (1993), have attempted to use endogenous growth models as a guide to their empirical work.

confirmed by data. The degree of openness of the trade regime was positively correlated with export growth, which was in turn positively correlated with real GDP growth.

A second large-scale attempt to classify countries by trade orientation was conducted by the World Bank (1987). Four groups of countries were distinguished: (1) strongly outward oriented; (2) moderately outward oriented; (3) moderately inward oriented; and (4) strongly inward oriented. Data on average growth rates per capita over the periods 1963-73, 1974-85, and 1986-92,[6] respectively, suggest that outward-oriented countries on average grow significantly faster than inward-oriented countries (Figure 1). Formal statistical confirmation of this pattern has been provided by Alam (1991).

[Figure 1 about here]

A recent attempt to classify the trade regimes of the 135 countries included in version 5.5 of the Summers and Heston (1991) data set has been undertaken by Sachs and Warner (1995). They judged a country to have a closed trade policy (during the sample period 1970-89) if it had at least one of the following characteristics: (1) nontariff barriers (NTBs) covering 40 percent or more of trade; (2) average tariff rate of 40 percent or more; (3) a black market exchange rate that had depreciated by 20 percent or more relative to the official exchange rate, on average, during the 1970s or 1980s; (4) a Socialist economic system (as defined by Kornai (1992)); or (5) a state monopoly on major exports.

Sachs and Warner ran a series of Barro (1991) type cross-country regressions, using their classification of trade regimes (open or closed) as an additional explanatory variable. They report positive effects for the standard variables--educational attainment and investment-to-GDP ratio. As expected, the openness variable entered with a significant positive sign. On average, open economies were estimated to grow by 2.5 percentage points more per annum than closed economies. They also found evidence of "conditional convergence." Countries tended to grow faster the greater the gap between

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[6] The data for 1986-92 are from IMF (1993), Chapter VI.

their initial income level and their *own* long-run (steady state) per capita income level, the latter being determined by policies affecting savings rates, human capital formation, etc. (Note that this finding is consistent with the transitional dynamics of the simple Solow model). The link between an open trade regime and growth seems at least partially to be an indirect one, operating through investment. The open economies in their data set had significantly higher investment-to-GDP ratios, on average 5.4 percentage points, and since a high investment ratio tends to be positively associated with growth, this suggests an indirect link between the trade regime and growth through investment.

Given the inherent problem of classifying multidimensional trade regimes with a single index, some authors have used actual trade flows as a proxy for trade orientation. The assumption is that more open economies experience faster export growth than less open ones. In a second stage, real GDP growth is correlated with export growth, and a positive correlation indicates that open economies experience more rapid average rates of economic growth than closed economies. Following this approach, Michaely (1977) and Feder (1983), for instance, have found positive correlations between exports and growth.

However, trade flows are at best imperfect proxies for trade policy orientation. Small countries, for instance, tend to trade more than large countries, given the level of trade barriers. To isolate the effect of the trade regime on trade flows it is necessary to control for other factors affecting trade: country size, resource endowments, natural trade barriers, etc. For instance, Syrquin and Chenery (1989) grouped 106 countries according to size and export specialization. Approximating outward orientation by the share of exports in GDP, they found real GDP growth to be higher on average for outward-oriented countries within each of the following groups: small primary good exporters; large primary good exporters; small manufacturing good exporters; and large manufacturing good exporters. The annual growth premium from outward orientation ranged from 0.2 percentage points for large manufacturing exporters to 1.4 percentage points for small primary exporters. (Note that large manufacturing exporters tend to be OECD countries closer to steady state.)

Balassa (1985) constructed an index of trade orientation based on the deviation of actual exports from that predicted by a structural model of trade. Specifically, exports were assumed to depend on per capita income, population, and natural resource endowments. After estimating a linear export equation for a sample of 43 countries, Balassa used the difference between actual and predicted exports as a measure of trade orientation. A positive difference was interpreted as a sign of outward orientation, and a negative difference as a sign of inward orientation. Using this index as an explanatory variable for growth, he found a statistically significant positive correlation and concluded that countries with more outward-oriented trade policies grow faster on average.

Balassa's approach was refined by Leamer (1988), who used an empirical Heckscher-Ohlin model with nine productive factors to estimate net trade flows for 183 commodities and 53 countries (30 of which were LDCs). Based on the difference between predicted and actual trade flows, he constructed two sets of trade policy indexes: openness indexes measuring the way in which trade policy restricts imports, and intervention indexes capturing the way overall commercial policy distorts trade (imports and exports). Using the Leamer indexes, Edwards (1992) specified a theoretical endogenous growth model based on the Lewis (1955) "learning-by-looking" idea that more internationally integrated economies have an advantage in absorbing new technologies. This link was confirmed empirically using a sample of 30 LDCs for the period 1970-82. Two other variables were included in the regressions: investment as a share of GDP, and initial per capita real GDP. The positive estimated coefficient corresponding to investment supports the view that investment in physical (and human) capital is conducive to growth. Moreover, the negative coefficient on initial GDP supports the "catching-up" hypothesis--that countries starting at a lower level of income per capita tend, other things equal, to grow faster during the catch-up process of absorbing the knowledge and technology of the more advanced countries.

Price comparisons have also been used to measure trade orientation. Barro (1991), for instance, formed a price distortion index of investment goods for a sample of 98 countries over the 1960-85 period. He found a significant negative relationship between price distortions and growth. The estimates imply that increasing the price distortion for investment goods by one standard deviation from the sample mean would have reduced per capita growth by 0.4 percentage points.

Dollar (1992) computed a real exchange rate index, measuring the extent to which the trade regime distorts relative prices away from world market prices. Defining outward orientation in terms of relatively low real exchange rate distortions and low variability of the index over time, he found a positive correlation between openness and growth in per capita GDP using a sample of 95 developing countries over the 1976-85 period. The average per capita growth rate in the least distortive quartile of mostly Asian countries was 2.9 percent, falling to 0.9 percent for the second quartile, -0.2 percent for the third quartile, and -1.3 percent for the most distortive quartile. The estimated coefficients imply that a reduction of the real exchange rate distortion to the Asian level would add 0.7 percentage points to Latin American growth and 1.8 percentage points to African growth.

Easterly (1993) has used a relative price distortion index similar to Dollar's. He first showed theoretically that distortions of relative input prices (caused by trade policy) have large effects on growth and welfare because they distort investment decisions. Testing the model on a sample of 57 countries over the 1979-85 period, he found a significant negative relationship between price distortions and growth.

Lee (1993) has developed a model in which trade distortions induced by tariffs and exchange controls reduce growth in countries where foreign inputs are essential for production. He showed that small, resource-scarce countries are hurt more by import restrictions than large, resource-abundant countries because of the larger dependence of the former countries on foreign inputs. Restricting or distorting the price of foreign inputs reduces the productivity of domestic industry, leading to slower per capita income growth. The empirical results confirm that tariff rates and exchange rate distortions (approximated by the black market premium) indeed had a significant negative effect on per capita income growth. The estimated coefficients suggest that a distortive policy, such as a 25 percent import tariff and exchange controls leading to a 50 percent black market premium, would reduce growth by 1.4 percentage points for a country whose size and resource endowment imply a trade share of 20 percent of GDP under free trade.

Harrison (1993) has drawn together a variety of openness measures to test the robustness of the relationships between trade restrictions and economic growth obtained previously in the literature. The first two measures were annual indexes of trade liberalization for two samples of developing countries over the period 1960-84 and 1978-88, respectively. The third measure was the black market premium, defined as the deviation of the black market rate from the official exchange rate. The fourth measure was the share of trade in GDP, defined as the ratio of exports plus imports to GDP. The fifth index measured movement of internal prices toward international prices in different countries. The sixth index was a modified version of the price distortion index used in Dollar (1992). The seventh index measured the relative bias against agricultural production. All indexes that were statistically significant showed a positive relationship between liberal trade regimes and economic growth. Harrison also found that causation between openness and economic growth runs in both directions. Periods of high growth seem to provide an impetus for more open markets, presumably because this alleviates adjustment problems and reduces resistance to change, while more open markets are in turn conducive to growth.

In a cross-sectional study using data for 1967-87, Matin (1992) tested whether the general finding that increased openness improves growth performance holds true for sub-Saharan Africa. This had been questioned by Helleiner (1986), among others, who argued that a certain level of development is required before the benefits of international trade can be fully realized. The evidence provided by Matin points to a positive link between openness and growth even for the poorest countries. The result was robust to different measures of openness (trade shares, black market premium, the Halevi-Thomas index of trade liberalization, and Dollar's index of outward orientation), and to the inclusion of other policy variables. Furthermore, the estimated coefficients did not differ significantly from those of a control sample of other North African countries. That is, the openness-growth performance link seemed to be as strong for sub-Saharan Africa as for other parts of the continent.[7]

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[7] However, there is some evidence based on a broader set of countries, which suggests that the trade-growth link may be stronger for medium-income countries than for low-income countries (see, for instance, Michaely (1977) and Ram (1985)). Nevertheless, the stronger link found for medium-income countries might simply reflect a more consistent set of economic policies in medium-income countries, and not an inherently stronger trade-growth linkage.

Levine and Renelt (1992) tested the robustness of cross-country regressions. They made the following intriguing observation: "Given that over 50 variables have been found to be significantly correlated with growth in at least one regression, readers may be uncertain as to the confidence they should place in the findings of any one study (p. 942)." Testing the robustness of coefficient estimates with respect to alteration in the set of explanatory variables, they were able to identify two "robust" correlations: first, a positive correlation between growth and investment as a share of GDP; and second, a positive correlation between investment as a share of GDP and trade as a share of GDP.[8]

The Levine and Renelt result of investment-induced growth stimulated by trade liberalization has recently been confirmed empirically by Baldwin and Seghezza (1996). First, they have shown that the theoretical impact of trade liberalization on growth is not always clear-cut. On the one hand, trade liberalization may reduce the return to capital if the import-competing sector is capital intensive (the Stolper-Samuelson effect). On the other hand, when imports and locally produced substitutes are inputs into capital formation, trade liberalization may encourage investment by lowering the cost of capital. While theoretically ambiguous, their empirical investigation showed a negative impact of domestic (and foreign) trade barriers on investment and thereby growth. This confirms the Levine and Renelt finding of two-stage linkage between trade and growth, through investment. Indeed, in contrast to the specification adopted in many endogenous growth models, they found no evidence for "direct" trade-induced technology-led growth. More precisely, system estimation found that trade barriers were not significant in the growth equation when they were also included in the investment equations. However, as they point out, the apparent absence of a direct linkage may be due to a close correlation between capital investment and technological progress that makes it problematic to isolate the impact of trade on endogenous growth.

In summary, this literature provides a striking set of stylized facts. Countries that are relatively open to trade tend to grow faster. This linkage seems to relate trade to investment, and investment to growth. Whatever the theoretical mechanisms, the

[8] Note that it does not matter whether trade is defined as exports, imports or the sum. This leads Levine and Renelt to conclude that "... studies that use export indicators should not be interpreted as studying the relationship between growth and exports per se but rather as studying the relation between growth and trade defined more broadly (p. 959)."

pattern of post-war development provides very strong evidence that trade liberalization is, on net, an important aspect of successful growth policies.

However, it does not follow that trade reforms necessarily give rise to *permanently* higher growth rates, as suggested by the endogenous growth literature (see discussion below). The overall pattern might be consistent with a series of trade liberalizations undertaken in the post-war period, foremost the eight rounds of multilateral trade liberalizations under the auspices of the GATT, but also unilateral trade liberalizations and liberalizations in the context of various regional agreements. In a classical growth context, the postwar liberalization process might be compared with a series of "level effects," shifting steady state incomes upwards, inducing temporarily higher growth rates in the course of adjustments to the new, higher steady state incomes for participating countries. Under this interpretation, it may be that no permanent trade-related growth effects are at work.

II.B. Endogenous growth: theory and evidence

This sub-section provides a brief recapitulation of the new trade theory with endogenous growth. This is followed by a survey of the empirical evidence. What are the testable implications of the theory, and what limited empirical evidence is available at this stage?

There are four main types of theoretical models used to explain growth due to endogenous technical change. The first relies on the existence of specialized intermediate inputs. Growth occurs if the range or quality of such inputs increases over time. A second theory is based on learning-by-doing in production. If knowledge obtained in accumulated production of old goods is partially applicable to newly developed goods, then learning-by-doing may lead to growth. Human capital accumulation is the basis for a third theory of economic growth. This refers to the accumulation of increased productive capacity by workers by virtue of their education or labour market experience. A worker's education, for instance, can yield productivity improvements for a wide range of products. The fourth theory models the development and introduction of new or more sophisticated products through research and development (R&D) activity.

In each theory, there is a dynamic spillover or externality of some type from the growth-generating activity to the rest of the economy (and possibly to the rest of the world), and this spillover allows economies to escape the strait-jacket of diminishing returns which otherwise inevitably brings growth back to the exogenous rate in traditional growth models. Learning-by-doing in the production of existing goods, for example, must be at least partially applicable to the production of other products. That is, there must be a spillover from learning-by-doing to generate sustained economic growth. In theories based on R&D investment, skilled labour is used to create blueprints for new products. To generate continual new product introduction and growth, external benefits must result from R&D activity. That is, the amount of skilled labour needed to develop a new blueprint must fall as the level of general knowledge increases. Without spillover benefits, improved incentives for R&D yield an increase in the level of output per worker, but with no permanent effects on growth.

The new growth theory emphasises how forward-looking investment by firms (and workers in the case of schooling) in response to market incentives could give rise to economic growth without the need to assume that technical change occurs exogenously. However, a significant additional step is needed to link trade and trade liberalization to models of endogenous innovation and growth. In particular, to affect growth, trade liberalization must change the conditions underlying growth.

The various linkages between trade and growth in endogenous growth models of knowledge accumulation via R&D have been thoroughly catalogued and analyzed in Grossman and Helpman (1992). International trade may affect the underlying conditions for growth by expanding the potential market size, allowing firms to spread the costs of R&D over greater volumes. This will stimulate innovative activities, but it will not lead to sustained growth unless the R&D sector generates spillovers or additions to the general stock of knowledge from which subsequent innovations can benefit. Essentially, the cost of each innovation must fall because of the larger stock of knowledge available to draw from. This is a testable hypothesis that seems to be partially refuted by data, which instead suggests that more resources need to be devoted to R&D over time to keep up the momentum in particular innovative activities.

One strand of the empirical literature tests for certain critical elements of the endogenous growth theory, such as learning externalities. Along these lines, Irwin and Klenow (1994) used data on the semiconductor industry to test for the existence of learning spillovers, both nationally and internationally. They employed quarterly data on the average industry selling price and on shipments by each of 32 firms from 1974 QI to 1992 Q4 for each of seven generations of dynamic random access memory (DRAM) chips. They have found that firms learned three times more from their own production experience than from that of other firms (domestic and foreign). Notwithstanding this, because world output was large in relation to a typical firm's output, international learning spillovers were still important sources of productivity growth for semiconductor firms.[9] However, Irwin and Klenow found little evidence of learning spillovers from one generation of DRAM chips to another, thereby providing little support for explaining the superior growth performance of countries like Korea based on endogenous growth models with learning-by-doing, as in Lucas (1993).

Coe and Helpman (1993) examined the empirical relationship between domestic and foreign R&D stocks and total factor productivity (TFP) growth using a pooled data set consisting of 21 OECD countries (plus Israel) during 1970-90. In addition to confirming the strong link between domestic R&D stocks and TFP growth found in previous studies, they found evidence of sizeable international R&D spillovers. In a subsequent paper, Coe, Helpman and Hoffmaister (1995) showed that R&D undertaken in OECD countries does not just spillover to other OECD trading partners but also to developing countries. In their preferred model specification, the foreign R&D capital stock only affected productivity when interacted with the import share. The more open the country, the larger the marginal benefit from foreign R&D.

While these studies provide empirical evidence for national and international R&D spillovers in line with theoretical R&D-based endogenous growth models, they do

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[9] These results should be viewed with some caution because firm-level rather than plant-level data were used, and because significant spillover effects were detected only when the effects of production experience on a firm's costs were misspecified. Notwithstanding these caveats, these results suggest that it might be reasonable as a starting point for modellers to specify learning spillovers along the lines of Irwin and Klenow's specification, assuming that marginal cost is a semi-logarithmic function of production experience, with production experience equal to cumulative firm output plus world cumulative output (net of the firm's output) multiplied by a constant (in the neighbourhood of 0.2 to 0.3 in Irwin and Klenow's sample).

not argue that these spillovers are sizeable enough to escape diminishing returns. In fact, the evidence presented by Jones (1995), discussed next, suggests the contrary.

Jones has formulated and implemented a time-series test of R&D models of endogenous growth. The basic idea behind this test is that endogenous growth models based on investment in R&D, formulated by Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992), imply that constant or declining economic growth should not be associated with an increase in the number of scientists and engineers, or in the amount spent on R&D. Yet, over the 1950-87 period, there was a strong upward trend in the number of scientists and engineers engaged in R&D in France, Germany, Japan, and the United States, while trends in total factor productivity growth have been stable or declining over this period. These results underscore the need to modify and refine the basic R&D-based endogenous growth models for empirical work, in particular calling into question their relevance for advanced OECD economies for which growth rates have been rather stable.

Jones also investigated the time serious properties of the historical growth rate between 1880 and 1987 for the United States in an effort to detect evidence of *persistent* effects of policy changes. Such evidence, if found, would be an indication of endogenous growth mechanisms at work. He considered the following thought experiment: "An economist living in the year 1929 (who has miraculous access to historical per capita GDP data) fits a simple linear trend to the natural logarithm of per capita income from 1880 to 1929 in attempt to forecast per capita GDP today, as in 1987. How far off would that prediction be? We can use the prediction error as a rough indicator of the importance of the permanent movements in growth rates."

The surprising result is that the prediction is off by only 5 percent. A time trend test (augmented Dickey-Fuller test) confirmed that the U.S. growth rates are well described by a process of constant mean and very little persistence. He concluded: "The implication for [endogenous growth] models is rather stark: either nothing in U.S. experience since 1880 has had a large, persistent effect on growth rates, or whatever persistent effects have occurred have miraculously been offsetting."

Finally, he investigated whether the strong positive trend of investment-to-GDP ratios for many OECD countries has had any persistent effect on growth rates, which would be the case if the simple *AK* model, associated with Romer (1987) and Rebelo (1987), held true. The *AK* model can be seen as a reduced form of the class of endogenous growth models with constant returns to scale in the factors of production that can be accumulated through investments. Investigating the time-series properties of individual OECD countries, he found no persistent upward shifts in GDP growth which would be associated with the documented upward drift in the investment-to-GDP ratio. He concluded: "a permanent increase in the investment rate does not produce a permanent increase in the growth rates, but rather the effects on growth are transitory."

To summarize, cross-country regressions provide strong evidence of a positive linkage between trade and growth. The linkages seem mainly be indirect through investment, though trade may also impact directly on growth by facilitating transmission of knowledge between countries. However, there is little evidence, so far, that trade reforms lead to permanent increases in growth rates. Rather, in spite of the continuous process of liberalization in the postwar era, time-series results fail to establish anything but a transitory impact. This is inconsistent with endogenous growth theory, but consistent with the traditional growth theory of temporarily higher growth rates during movement towards new, higher steady state incomes made possible by each stage of the reform process.

III. Trade Reforms and Steady State Effects

This section provides an overview of the treatment of growth effects in applied trade models. While some studies have started the process of incorporating endogenous growth mechanisms, large scale models have so far been confined to steady state comparisons.

One of the first efforts to quantify accumulation effects is due to Baldwin (1989, 1992), who computed estimates of potential dynamic gains from the EC92 program to eliminate all barriers to trade and factor movements within the European Community. He distinguishes between a "medium-term growth bonus" due to induced capital formation and a "long-term growth bonus" due to induced technical change. Using Solow's terminology, the medium-term growth bonus is a level effect whereas the long-term growth bonus is an endogenous growth effect. The medium-term growth bonus, derived from an initial steady state assumption and being identical to the steady-sate version of equation (10) below, is assumed to come about as EC92 increases the productivity of existing factor endowments, thereby leading to increased income, saving, and investment. Baldwin shows that the medium-term growth bonus can be quite substantial as compared with the usual static gains from economic integration, concluding that the Cecchini Report's estimates of the economic benefits of EC92 were at least 30 percent too low.

Baldwin (1989) also calculates the long-run growth impact of EC92 using two simple endogenous growth models. In the *AK* model, the steady state rate of output growth is equal to the savings rate times the steady state output-capital ratio, minus the rate of depreciation. Estimated static gains of EC92 point to an increase in the output-capital ratio of 2.5 to 6.5 percent and, based on a savings rate of 10 percent, this leads to an increase in the growth rate of one-quarter to three-quarters of a percentage point. This represents a permanent growth effect rather than a level effect because there are, by assumption, dynamic increasing returns to capital accumulation. He also calibrates the R&D based model of Krugman (1988). This model features investment in R&D to lower the cost of producing existing product designs (process innovation as opposed to product innovation). On this basis, 1992 would add between about 0.3 to 0.8 percentage points to the permanent growth rate.

Kehoe (1994) constructed rough estimates of the effects of economic reform in Mexico, including trade reform, on the steady state rate of economic growth, due to both learning-by-doing and specialization. Growth for the economy as a whole is a weighted average of growth rates for individual industries, with weights given by industry output shares. Levels of experience in production, and hence productivity, differ among industries. To the extent that trade leads to specialization in industries with high rates of productivity, this can lead to increased economic growth for the economy as a whole. Kehoe developed a specialization index to capture the relationship between trade, interindustry specialization, and economic growth. This index was subsequently used in a regression to estimate the effects of free trade on Mexican economic growth.[10] The

[10] Regressions using a cross-country data set for a large number of countries over the 1970-85

assumed policy changes, when combined with coefficient estimates from the regression, yielded an estimated increase in the growth rate of Mexican manufacturing output per worker of 1.6 percent per year.

Calibration studies of multilateral trade liberalization under the Uruguay Round have also incorporated medium-term growth effects related to capital accumulation. The results of this literature are driven by classical capital accumulation mechanisms, and have not been extended to examination of endogenous growth effects. Essentially, starting from the assumption that all countries are initially in steady state, the post-reform steady state is solved using a macro closure of either fixed savings rates, or alternatively fixed net real returns to savings and investment that are based on an infinite horizon model. For example, Francois, McDonald and Nordström (1995) report that the medium-term investment effect, conceptually identical to Baldwin's, multiplied the static gain by some 50 to 250 percent, depending on model specification. Other Uruguay Round studies including accumulation mechanisms include Haaland and Tollefson (1994), Harrison, Rutherford, and Tarr (1995), and Golden, Knudsen, and van der Mensbrugghe (1993).

IV. Policy Reform and Transitional Effects

As pointed out above, global trade models have so far been confined to steady state comparisons. This approach, while convenient, may prejudice the numerical estimates, especially for developing countries. This is shown next using a simple Solow(1956) model.

The key elements of the model are as follows. Production is aggregated across the entire economy. Physical capital and labour are combined to produce a single final output. The aggregate supply of labour is assumed to grow at a constant rate. Labour-augmenting technical change is assumed to occur at an exogenously specified rate. Final output can either be consumed directly or used as an investment good. We adopt the classical assumption of a fixed savings rate. This economy tends toward a steady state in which output per capita grows at a constant rate that is equal to the rate of technical progress. However, to reach the steady state takes time. Indeed the economy never

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period were reported in Backus, Kehoe, and Kehoe (1992).

quite gets there (Deardorff, 1971). The main point of the analysis is to show that policy reforms during the transition period may considerably speed up the process of reaching higher income levels.

A Cobb-Douglas production function is assumed. This facilitates explicit solution for the transitional growth path.

$$(1) \quad Y(t) = K(t)^{\alpha} \, [A(t)\, L(t)]^{1-\alpha} \;, \quad 0 < \alpha < 1,$$

The notation is standard: *Y(t)* denotes the output at time *t*, *L(t)* labour, *K(t)* capital, and *A(t)* efficiency. *L(t)* and *A(t)* are assumed to grow exogenously at rate *n* and *g*, respectively,

$$(2) \quad L(t) = L(0)\, e^{n\,t} \;, \qquad A(t) = A(0)\, e^{g\,t} \,.$$

The savings rate *s* is fixed and capital depreciates at rate δ. Define $k(t) = K(t)/A(t)L(t)$ as the stock of capital per effective unit of labour. The evolution of *k(t)* is governed by the following differential equation,

$$(3) \quad \dot{k}(t) = s\, k(t\,)^{\alpha} - (n + g + \delta\,)\, k(t) \,,$$

where a dot signifies a variable's time derivative. A simple solution procedure exists for this non-linear Bernoulli equation. Dividing (3) by $k(t)^{\alpha}$, using the variable transformation $z(t) = k(t)^{1-\alpha}$, and noting that $dz(t)/dt = (1-\alpha)\, k(t)^{-\alpha}\, dk(t)/dt$, results in a linear differential equation in *z(t)* which can be solved using normal procedures. Substituting back into *k(t)* we get the solution to the original non-linear differential equation,

$$(4) \quad k(t) = \left[\left[\left(\frac{k(0)}{k^*} \right)^{(1-\alpha\,)} - 1 \right] e^{-(1-\alpha\,)(n+g+\delta\,)\,t} \; + 1 \right]^{\frac{1}{(1-\alpha\,)}} k^* \,, \qquad k^* = \left(\frac{s}{n+g+\delta} \right)^{\frac{1}{(1-\alpha\,)}} ,$$

where *k(0)* and *k** are the initial and the steady state capital stock per effective unit of labour, respectively. The output per capita, $y(t) = Y(t)/L(t)$, evolves according to

$$(5) \qquad y(t) = \left[\left[\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)} - 1 \right] e^{-(1-\alpha)(n+g+\delta)t} + 1 \right]^{\frac{\alpha}{(1-\alpha)}} y^*(t) \quad , \qquad y^*(t) = (k^*)^{\alpha} A(0) e^{gt} ,$$

with a growth rate of

$$(6) \qquad \frac{\dot{y}(t)}{y(t)} = g + \alpha \frac{\dot{k}(t)}{k(t)} , \qquad \frac{\dot{k}(t)}{k(t)} = -(n+g+\delta) \frac{\left[\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)} - 1 \right] e^{-(1-\alpha)(n+g+\delta)t}}{\left[\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)} - 1 \right] e^{-(1-\alpha)(n+g+\delta)t} + 1} .$$

The growth per capita is equal to the exogenous rate of labour-augmenting technical change plus the capital-output elasticity α times the growth rate of the capital stock per effective unit of labour. The growth rate of capital per unit of effective labour has a simple diagrammatic representation. (See Figure 2). For a given $k(t)$, capital growth per effective unit of labour is given by the vertical distance between $sk(t)^{\alpha-1}$ and $(n+g+\delta)$, and growth in output per capita by $g + \alpha[sk(t)^{\alpha-1} - (n+g+\delta)]$. Because of diminishing returns, the growth rate slows down the closer the capital stock gets to the steady state.

[Figure 2 about here]

An increase in the savings rate shifts the $sk(t)^{\alpha-1}$ schedule upward, leading to a temporary increase in growth during the transition to the new steady state. While steady state incomes are affected, the long run growth rate is not.

The time needed to close a proportion ω of the gap between initial and steady state output is given by[11]

$$(7) \qquad t_{\omega} = -\frac{\ln(Z)}{(1-\alpha)(n+g+\delta)} , \qquad Z = \frac{\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)(1-\omega)} - 1}{\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)} - 1} .$$

[11] t_{ω} is solved from the following expression: $\ln y^*(t) - \ln y(t) = (1-\omega) [\ln y^*(0) - \ln y(0)]$.

The half-time of convergence increases slightly as the output per capita approaches the steady state. That is, the time that it takes to close half of the remaining gap becomes longer and longer, and the economy never quite gets there.[12] Figure 3 shows the convergence time for different values of the capital-output elasticity. The example assumes that the initial capital per unit of effective labour is 75 percent of the steady state value, and $(n+g+\delta)$ is 0.1. In this case, the first half of the distance (ω = 0.5) is covered in 9.7 to 20.1 years depending on the value of α. The next half (taking us to ω = 0.75) takes somewhat longer: 10.0 to 20.4 years depending on the value of α. The larger the α, the slower the convergence rate to steady state.

[Figure 3 about here]

Let us now calculate the static impact and the medium-run accumulation effect of a policy change undertaken during the transition to steady state. In our simple framework, we can represent trade policy reform (or any other reform) as an enhancement to the efficiency of productive resources, captured in the model by an increase in *A(0)*. We assume that an appropriate policy reform makes it possible to produce a greater quantity of output using the same quantities of productive factors. The increased productivity will also affect the incentives to accumulate capital, reinforcing the initial impact over time. Differentiation of (5) yields the following equation:

$$(8) \qquad \frac{d\,y(t)}{y(t)} = \left(1 - \alpha \frac{\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)} e^{-(1-\alpha)(n+g+\delta)t}}{\left[\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)} - 1\right] e^{-(1-\alpha)(n+g+\delta)t} + 1} \right) \frac{d\,A(0)}{A(0)}.$$

Equation (8) gives the percentage change in output per capita at time *t* due to a policy change at time *0* that raises the efficiency by a proportion *dA(0)/A(0)*, accounting

[12] In the limit, $k(0) \rightarrow k^*$, t_ω approaches $t_\omega = -\ln(1-\omega)/(1-\alpha)(n+g+\delta)$. As we rarely know how far the economy is from steady state, this formula can be used as a first approximation of convergence time. For example, the time it takes for half the initial gap to be closed, $t_\omega = \ln(0.5)/(1-\alpha)(n+g+\delta)$, is 10.4 years if α is equal to 1/3 and $(n+g+\delta)$ is equal to 0.1.

for the policy-induced capital accumulation between the time of the policy reform (0) and the time of evaluation (*t*). Equation (8) can be decomposed into a static and medium-run impact (super index *B*):

$$(9)\quad \frac{d\,y(0)}{y(0)} = (1-\alpha)\,\frac{d\,A(0)}{A(0)},$$

$$(10)\quad \frac{d\,y^B(t)}{y^B(t)} = \left(\frac{\alpha}{1-\alpha}\right)\left(1-\frac{\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)} e^{-(1-\alpha)(n+g+\delta)t}}{\left[\left(\frac{k(0)}{k^*}\right)^{(1-\alpha)}-1\right]e^{-(1-\alpha)(n+g+\delta)t}+1}\right)\frac{d\,y(0)}{y(0)}.$$

For the special case when the economy is initially in steady state, the medium-run growth bonus (for marginal policy changes) simplifies to

$$(11)\quad \frac{d\,y^{*B}(t)}{y^{*B}(t)} = \left(\tfrac{\alpha}{1-\alpha}\right)\left[1-e^{-(1-\alpha)(n+g+\delta)t}\right]\frac{d\,y(0)}{y(0)}.$$

In the limit, the medium-run impact collapses to the Baldwin multiplier: $dy^B(\infty)/y^B(\infty) = (\alpha/1-\alpha)\ dy(0)/y(0)$. For example, an α of 1/3 implies an eventual 50 percent growth bonus on top of the static impact gain. However, in finite time, the medium-run bonus is smaller. This observation may be of some importance since the process of convergence to the new steady state may be quite slow. Indeed, as shown above, it may take 10 to 20 years to close half the distance. On an applied level, this suggests, for example, that the income gains attributed to the Uruguay Round over the medium-run tend to be inflated. For example, Francois, McDonald and Nordström (1995) implicitly assume that the world has fully adjusted to the new policy regime by 2005. Yet a rough estimate, using equation (7) and Figure 3, suggests that only some 50 percent of the "medium-run" accumulation effects will have materialized by then.

On another level, applied studies may be guilty of under-estimating the value of the Round, especially for developing countries, by assuming that all countries (regions) are initially in steady state. As detailed above, cross-country regressions consistently find a significant negative impact of initial income on growth, suggesting that low-income economies, other things equal, tend to grow faster than their wealthier counterparts. Interpreted in the context of a Solow growth model, this evidence suggests that developing countries are (on average) further away from their steady state incomes than are developed countries.

This raises the following question. Does a policy reform undertaken during transition to steady state have a different impact than if initially in steady state? In other words, is the medium-run growth bonus larger in percentage terms for developing countries than for developed countries?

To study this issue, consider two economies with the same underlying parameters and policies, but where one economy is close to steady state (developed country) while the other is on the transition path far from the same steady state (developing country). It can be shown by comparing (10) and (11) that the medium-run growth bonus is larger for economies starting far <u>below</u> steady state for any finite time.[13] The transitional growth accelerates more for the economy out of steady state than for the economy near steady state. To see this, recall that for a given *k(t)*, growth in *k* is given by the vertical distance between $sk(t)^{\alpha-1}$ and $(n+g+\delta)$, and growth in output per capita by $g + \alpha[sk(t)^{\alpha-1} - (n+g+\delta)]$. An increase in *A(t)* shifts the $sk(t)^{\alpha-1}$ schedule in Figure 2 upward by $sk(t)^{\alpha-1}\, dA(t)/A(t)$. (Recall the definition of $k(t) = K(t)/A(t)L(t)$). Because the schedule is non-linear, reflecting diminishing returns, the impact of the shift is larger the lower the initial *k(t)*. Hence, the transitional growth rate accelerates more for economies out of steady state, and more so the further away from steady state an economy is initially. (The asymmetric growth impact can also be shown directly by differentiating equation (6)).

The time path of output per capita and the corresponding growth rates are illustrated in Figures 4 and 5. In the example, the underlying exogenous growth rate *g* has been set to zero for expositional reasons. However, the result holds irrespective of the underlying exogenous growth rate. At time zero, it is assumed that a policy change takes place which raises *A(0)* by 10 percent. This lowers the capital stock per unit of effective labour, inducing additional capital accumulation. Both economies experience a transitional increase in growth rates above what they would otherwise have been, but

[13] The <u>undiscounted</u> medium-run bonus of the policy reform are equal in the limit as time approaches infinity.

more so for the developing economy that embarks on a steeper transition path to the new steady state.

[Insert Figure 4,5 here]

Note that after the policy reform the developing economy reaches the old steady state income in just 10 years (in this example), whereas absent the policy reform it would have taken far longer, indeed an infinite number of years. This suggests that an important aspect of a policy reform for developing countries is that it may allow economies to reach higher levels of income in a much shorter time than otherwise. In present value terms, a policy change may hence be far more important than suggested by the static effects if it sets the economy on a higher transitional growth path.

To explore this issue further, let us consider the effect of a policy reform on the present value of GDP. Through numerical integration of equation (5), we provide an example to illustrate our point. Table 1 gives the change in present discounted value of per capita GDP, as a percentage of initial GDP, following a policy reform with a one percent static impact on GDP ($dA(0)/A(0) = .01/(1-\alpha)$). In terms of Figure 4, we calculate the discounted area between the solid (post-reform policy) and dotted (pre-reform policy) lines for the developed and developing country, respectively. The discount factor (real interest rate, r) is taken to be 5 percent, 3 percent above the assumed exogenous growth rate. The other underlying parameters of the example are given in the Table. We distinguish between a developed country that is initially in steady state, and three developing countries with initial capital stocks below steady state, as given by $k(0)/k^* = 0.25$, 0.5 and 0.75, respectively. A graphic illustration of the relationship between the initial development level (in relation to steady state) and the impact of a trade policy reform in terms of changes in present value GDP is provided in Figure 6.

[Figure 6, Table 1 here]

The results of our analytics suggest that the implications of policy reforms for developing countries are qualitatively different than those for developed ones. This is because of the impact on transitional growth. By setting their economies on a higher transitional growth path, a policy reform allows "the fruits of development" to be realized at an earlier date. Even a "modest" policy reform worth one percent in static income is in present value "worth" perhaps 50 to 150 percent of initial GDP, depending on the initial state of development and the rate of convergence to steady state (which depends critically on the value of α), and, of course, the discount factor. The more underdeveloped the economy is initially (in relation to its own steady state income), the greater the present value income gain of being set on a higher transitional growth path. The impact of policy reforms depends crucially on the initial state of development.

A final word of caution is called for when interpreting these income effects. In the present framework, with a single composite good and a fixed marginal propensity to save or consume, movements in the present value of consumption (and hence of temporal welfare) must, by construction, follow that of GDP. However, in a more general framework, and particularly in one with explicit intertemporal optimization, changes in the present value of GDP are not necessarily indicative of changes in intertemporal welfare. [14]

V. Concluding Observations

Dynamic effects have featured prominently in recent studies of trade liberalization and integration. Recent calibration studies of the North American Free Trade Agreement (NAFTA), the European Community's economic integration (EC92) programme, and the Uruguay Round of multilateral trade negotiations have all attempted to quantify various dynamic effects of trade liberalization on economic growth, both due to standard transitional growth effects (i.e., level effects) and due to permanent endogenous growth effects. These effects have also featured in the policy debate during negotiation and ratification of these agreements and programmes. While our

[14] Indeed, the current model specification does not allow comparison of intertemporal welfare in the context of intertemporal maximization, as such a process has not been modelled. The present analysis, with classical savings behaviour, is similar in some ways to the reduce form structure of simple variations of overlapping generations macro models with relatively inflexible savings rates. The extension to the case of an infinite horizon framework with endogenous savings, while straightforward in principle, is beyond the scope of this paper.

understanding of the relevant mechanisms is incomplete, it is clear that dynamic effects are important, and can probably overwhelm the static efficiency gains.

The literature on calibrated numerical models of international trade with endogenous growth is still at an early stage. The theoretical literature on endogenous growth has concentrated on highly stylized models in order to identify the various channels through which optimizing behaviour may give rise to economic growth, and the empirical literature has yet to establish which mechanisms are most relevant empirically.

Meanwhile, the incorporation of dynamic effects into applied trade models have focused mainly on comparison of steady states, abstracting from transition paths. Considerable effort appears necessary to bridge the gap between these simple stylized steady-state models, and large-scale applications involving transitional dynamics well outside the region of steady-state equilibria. Given the current level of understanding of trade and growth linkages, specifying the transition process based on classical growth theory would appear to be a practical and relevant area for current research as a complement to endogenous growth theory. This paper has shown that focusing on the steady-state involves suppressing crucial aspects of the dynamic story, particularly for developing countries. Trade policy reforms can spur growth, if not permanently than at least temporarily, and more so the further away a country is from its steady-state. Thus, the impact of policy reforms depends importantly on the initial state of development, a point that has been largely overlooked in the applied modelling literature.

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Table 1.

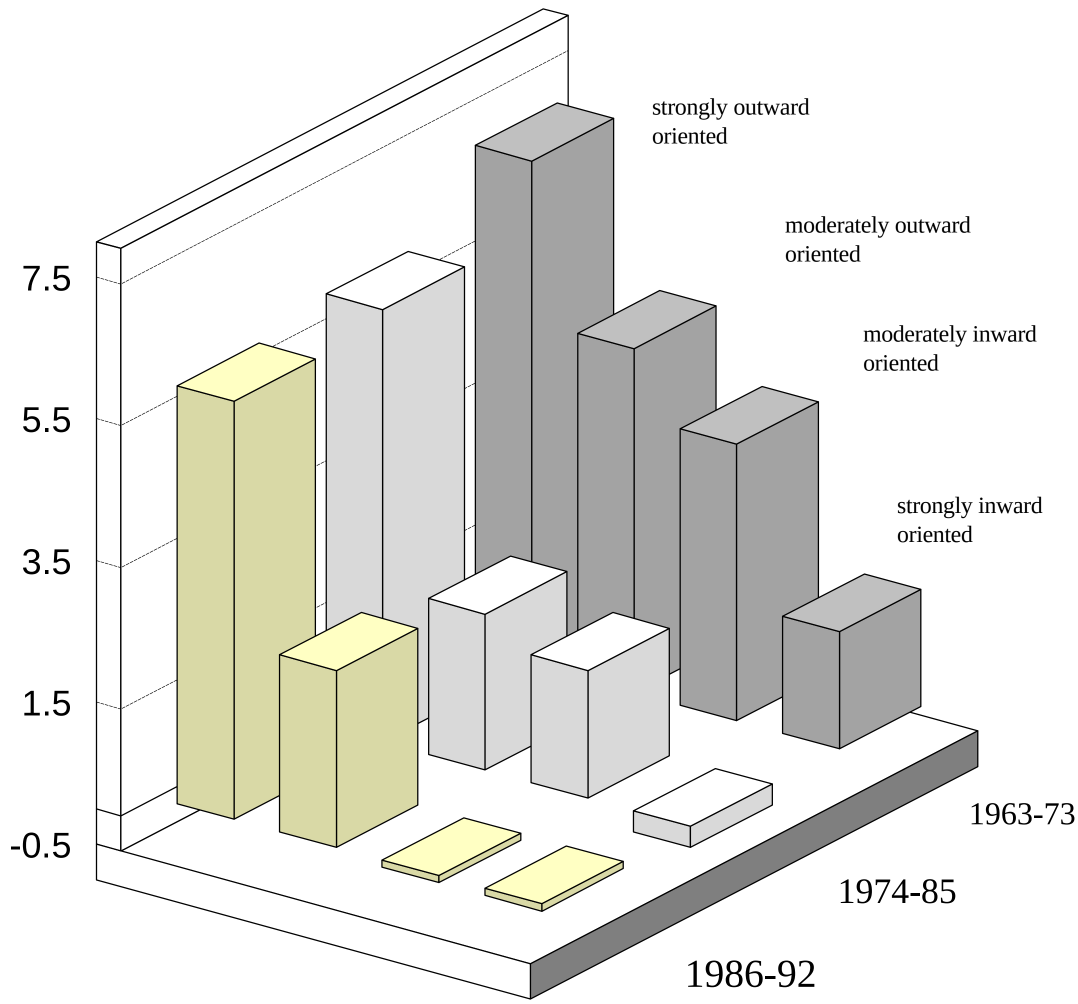
Change in the present value of per capita GDP, as a percentage of initial GDP, following a policy reform with a one percent static impact on GDP.

	Developing 1 ***k(0)/k* = 1/4***	**Developing 2** ***k(0)/k* = 1/2***	**Developing 3** ***k(0)/k* = 3/4***	**Developed** ***k(0)/k* = 1/1***
infinite horizon				
α = 1/3	69	56	50	46
α = 1/2	102	75	63	56
α = 2/3	151	104	84	73
10 year horizon				
α = 1/3	13.3	11.5	10.6	10.1
α = 1/2	15.3	12.7	11.6	10.9
α = 2/3	16.3	13.7	12.5	11.8

Note: $s = 0.2$, Organization.

Figure 1

Real GDP Growth (average annual rate)



Data are from Fig. 5.2, World Development Report, 1987,
and IMF World Economic Outlook, May 1993.
See these publications for classification of economies by trade orientation.

Figure 2. Growth in capital per unit of effective labour

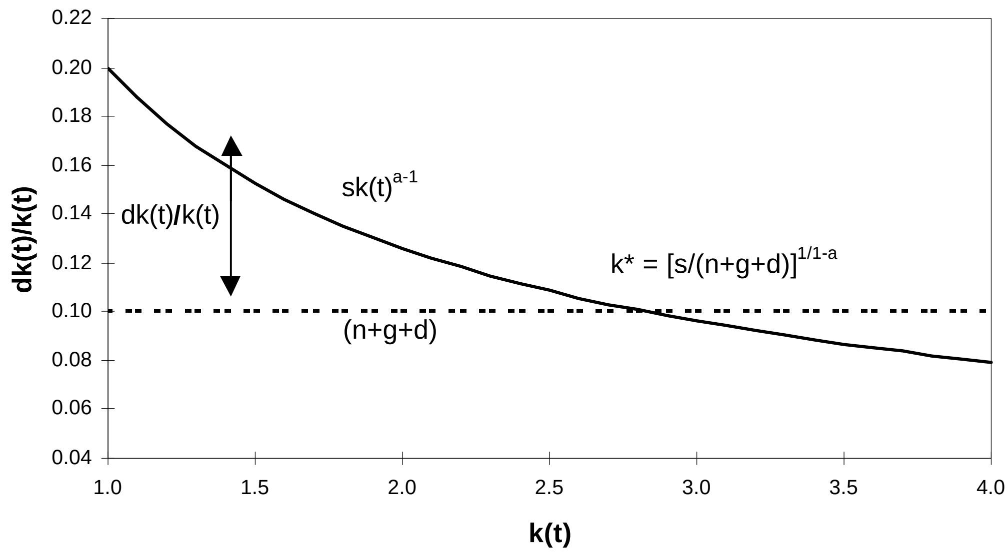
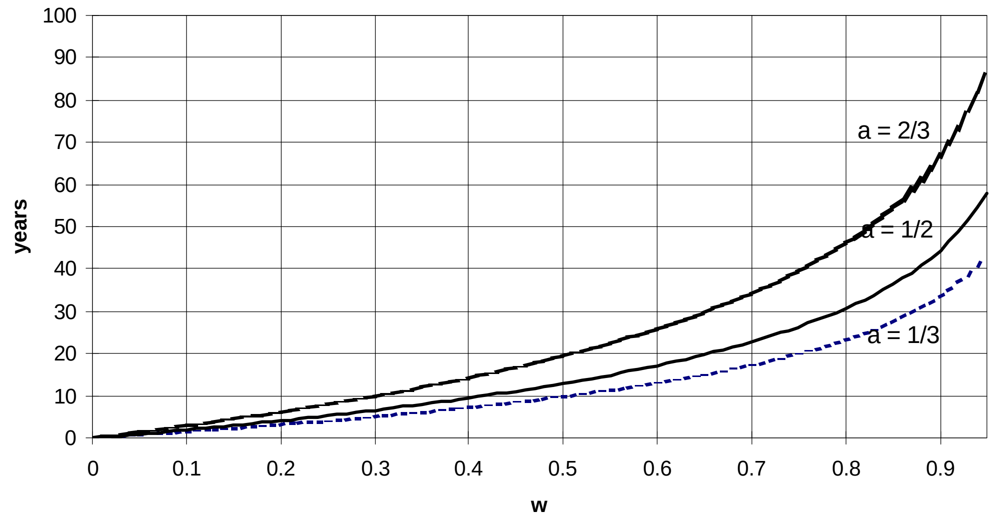


Figure 3. Time needed to close a proportion w of the gap between initial and steady state output



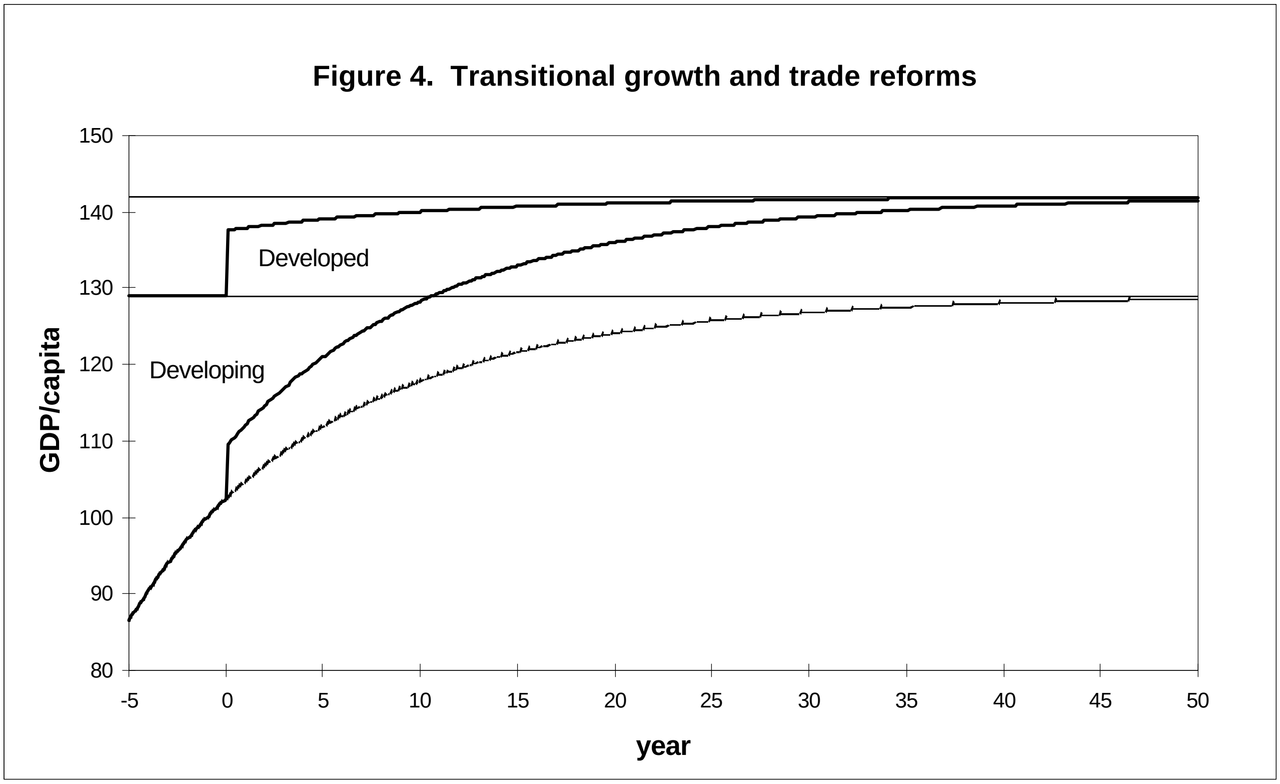


Figure 4. Transitional growth and trade reforms
150
140
130
120
110
100
90
80
-5
0
5
10
15
20
25
30
35
40
45
50
GDP/capita
year
Developed
Developing

Figure 5. Trade reforms and transitional growth

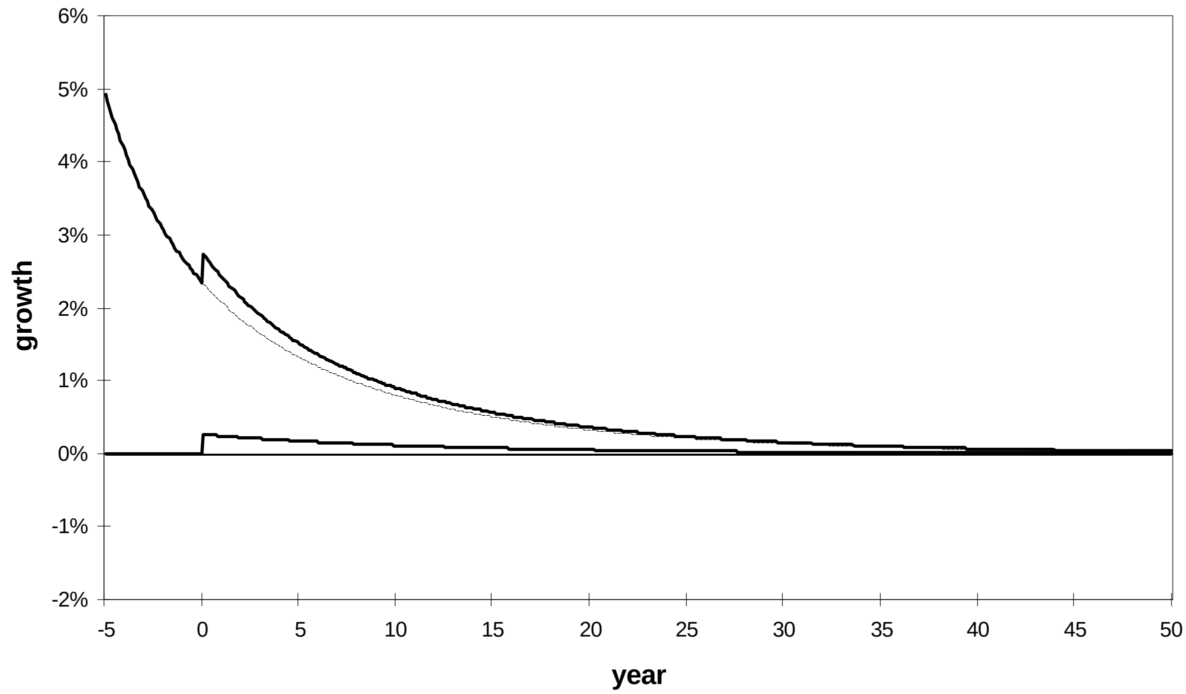


Figure 6. Change in present value GDP, as a percentage of initial GDP, following a policy reform with one percent static impact