Liberalization and Capital Accumulation in the GTAP Model

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GTAP Technical Paper No. 7

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Abstract

This paper explores trade policy and investment linkages in the GTAP Model. This is done under alternative steady-state closure rules linking trade to consumption, production, and investment, and emphasizing the general equilibrium nature of capital accumulation mechanisms. When policy shocks are *capital friendly*, induced investment may be greater than suggested by current savings rates. As a result, multiplier-type analysis can be very misleading. The importance and direction of this magnification hinges critically on the sensitivity of savings rates with respect to real returns. As illustration, we offer a numerical assessment of the Uruguay Round, highlighting such linkages using the GTAP model. The appendix outlines necessary modifications to the model and closure. These are quite simple.

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Nontechnical Summary

The gains from trade in static models stem from the increased efficiency of resource allocation and improved consumption possibilities. With the addition of imperfect competition, gains from trade may also follow from procompetitive effects related to increasing returns to scale, the erosion of market power, and increased product and input variety. Numerical estimates of basic static efficiency effects tend to be relatively small as a percent of gross domestic product (GDP). For example, static assessments of the Tokyo Round and Uruguay Round typically pointed to income effects of less than 1 percent of base GDP. This is hardly consistent with cross-country studies of trade and income, which suggest linkages between trade policy and incomes, through investment, much stronger than those identified in static numerical studies. Nor are such modest estimates easily reconciled with the expectations held on trade reforms of this magnitude.

One shortcoming of the basic static story is that it fails to account for the positive relationship between trade, investment and growth, a linkage which is fairly well established empirically. On a theoretical level, classical growth theory suggests the potential for a medium-run growth or accumulation effect through induced changes in savings and investment patterns. The magnitude and possible direction of such effects depends on whether savings are assumed to be fixed or endogenously derived from intertemporal optimization. On the basis of this literature, we explore the interaction between trade policy and capital accumulation in the GTAP Model. The trade policy reforms considered are the basic elements of the Uruguay Round. As expected, the results turn out to be sensitive to the savings specification. The medium-run impact of the Round tends to be a simple multiple of the static impact when saving rates are fixed, although terms-of-trade changes may upset this direct linkage. In contrast, with endogenous savings -- determined by the condition that the opportunity cost of postponed consumption (as given by the rate of time preference) should equal the net marginal return of capital -- the medium-run impact can differ quite substantially from the static impact. The induced impact on capital formation may reinforce or weaken the static impact, or even *reverse* the short-term impact if returns to investment fall.

Indeed, in our numerical examples, for some regions (like the EU and North America) the basic story of the Round remains intact when accumulation effects are accounted for. The numbers differ, but not the direction. In contrast, estimated effects for a number of developing countries hinge critically on our representation of savings and investment.

We conclude that the traditional focus on static effects is potentially misleading and that the underlying savings behavior matters crucially for the qualitative implications of trade policy reforms in a dynamic context.

Liberalization and Capital Accumulation in the GTAP Model

1 Introduction

The gains from trade in static models stem from the increased efficiency of resource allocation and improved consumption possibilities. With the addition of imperfect competition, gains from trade may also follow from procompetitive effects related to increasing returns to scale, the erosion of market power, and increased product and input variety. Numerical estimates of basic static efficiency effects tend to be relatively small as a percent of gross domestic product (GDP). For example, static assessments of the Tokyo Round and Uruguay Round typically pointed to income effects of less than 1 percent of base GDP. This is hardly consistent with cross-country studies of trade and income, which suggest linkages between trade policy and incomes, through investment, much stronger than those identified in static numeric studies. Nor are such modest estimates easily reconciled with the expectations held on trade reforms of this magnitude.

One shortcoming of the basic static story is that it fails to account for the positive relationship between trade, investment and growth, a linkage which is fairly well established empirically. (See, e.g., EDWARDS (1992), and LEVINE and RENELT (1992)). Also, on a theoretical level, classical growth theory suggests the potential for a medium-run growth or accumulation effect through induced changes in savings and investment patterns. The magnitude and possible direction of such effects depend on whether savings are assumed to be exogenously fixed or endogenously derived from intertemporal optimization.[1]

On the basis of this literature, in this paper we explore the interaction between trade policy and capital accumulation in the GTAP Model. The trade policy reforms considered are the basic elements of the Uruguay Round. As expected, the results turn out to be sensitive to the savings specification. The medium-run impact of the Round tends to be a simple multiple of the static impact when saving rates are fixed, although terms-of-trade changes may upset this direct relation. In contrast, with endogenous savings -- determined by the condition that the opportunity cost of postponed consumption (as given by the rate of time preference) should equal the net marginal return of capital -- the medium-run impact can differ quite substantially from the static impact. The induced impact on capital formation may reinforce or weaken the static impact, or even *reverse* the

1. It should be noted that the medium-run effects are qualitatively different from long-run effects arising from dynamic externalities. For an exposition of the more recent literature on endogenous linkages between trade policy, investment, and steady-state growth, see, for instance, GROSSMAN and HELPMAN (1991, 1995).

short-term impact if returns to investment fall. We conclude that the traditional focus on static effects is potentially misleading, and that more attention needs to be given to savings behavior in assessments of trade policy reforms.

The discussion is organized as follows. We start with a conceptual discussion of classical trade-investment linkages under fixed and endogenous saving rates. We show that the two specifications have identical steady-state implications for certain parameter values in the most simple, one-sector growth model. This a very special case, however. A more general treatment using duality theory reveals that the steady-state implications of policy reforms hinge critically on the savings specifications. This is shown in the appendix. The theoretical discussions are followed by a case study, using the GTAP model, of the Uruguay Round. The modeling exercise confirms the sensitivity of steady-state implications to the underlying savings behavior. For example, for some regions, like the EU and North America, the basic story of the Round remains intact when accumulation effects are accounted for. Individual numbers differ, but not the overall qualitative results. In contrast, qualitative results for a number of developing countries hinge critically on our representation of savings and investment.

2 *Accumulation Theory*

2.1 Accumulation effects with fixed saving rates

Some of the basic features of capital accumulation effects been illustrated nicely in a one-sector neoclassical growth model by BALDWIN (1989, 1992). The first element is a aggregate production function linking output (Y_t) at time t to the amount of capital (K_t) and labor (L_t) employed

$$Y_t = A\, K_t^a\, L_t^{1-a}\ ; \quad 0 < a < 1, \tag{1}$$

where A is an overall productivity parameter, and a and $1\text{-}a$ are the elasticities of output with respect to capital and labor, respectively. The relation between the stock of capital and output is plotted as YY in figure 1. Note the curvature of YY reflecting diminishing return to capital when the labor force is held constant.

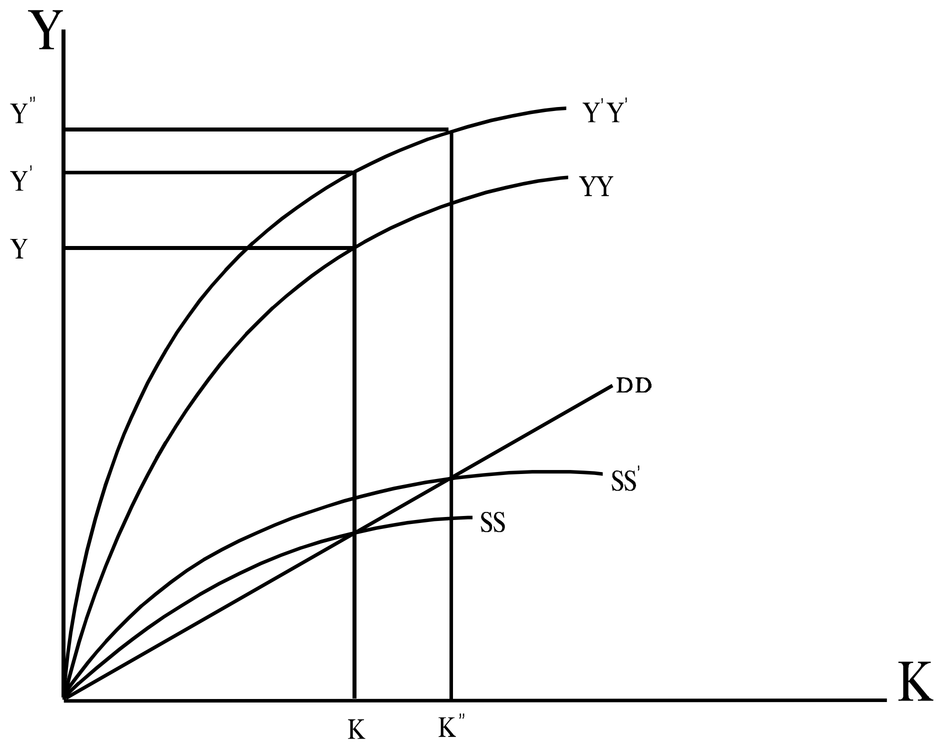
For a given flow of investment, the capital stock evolves over time according to

$$K_{t+1} = (1-\delta)\, K_t + I_t\ ; \quad 0 < \delta < 1, \tag{2}$$

where δ is the fraction of the capital stock that depreciates each year (due to wear and tear), and I_t is the flow of gross investment. The capital stock will be higher next period if today's investment is sufficiently large to both replace worn out capital and add new units to the stock.

To complete the model, we must specify how much of current output is set aside for savings and investment. For the moment, we adopt the classical assumption that consumers save a fixed share (s) of income,

Figure 1 Short-run and long run effects of an income shock



$$S_t = s\,Y_t, \tag{3}$$

where S_t is total saving. Abstracting from international capital flows, knowing savings means we also know investment. Furthermore, since savings depends on income that in turn depends on the capital stock, savings depends (indirectly) on the stock of capital.[2] The savings function is plotted as SS in figure 1. The final relation plotted in figure 1 is DD=δK_t, the amount of investment needed to replace worn out capital in each period. The capital stock grows over time if savings and investment are larger than the rate at which capital depreciates (SS > DD), it is constant if savings and investment are just enough to replace depreciated capital (SS = DD), and it falls otherwise (SS < DD).

Starting from a low capital stock with high returns on investment, income will grow over time as capital is accumulated through savings and investment. In the absence of technical progress, this process will eventually come to an end because of the diminishing returns of adding more capital per worker. In the long-run, growth in per capita income will stop at the point where savings is just

2. Of course, the savings investment link need not hold exactly for individual countries that can borrow abroad to finance their investment, though it must hold globally.

enough to replace depreciated capital. The "steady state" capital stock and output (distinguished by absence of time subscripts) are given by,

$$K = \left(\frac{s}{\delta}\right)^{\frac{1}{1-a}} A^{\frac{1}{1-a}} L \,; \qquad Y = \left(\frac{s}{\delta}\right)^{\frac{a}{1-a}} A^{\frac{1}{1-a}} L \,. \tag{4}$$

Now, consider the impact of efficiency-enhancing reform, here referred to as trade liberalization. We assume that the region we are modeling is initially in a steady-state, and that trade liberalization enhances the efficiency of capital and labor by moving resources into sectors where they are more valuable at the margin. In figure 1, this is represented by an increase in the economywide productivity parameter *A*, which shifts out the production function from YY to Y'Y' for any given level of capital and labor. That is, the same amount of labor and capital can now produce more than before, as illustrated by the difference between Y' and Y in the figure. This is the short-run or static gain. Part of the additional income will be saved and invested in new capital, which in turn yields an additional income gain. (Note the positive difference between S'S' and DD for the initial capital stock K, implying positive net investments). The economy will, over time, move up to a new higher steady state capital stock and corresponding higher output, marked in the figure by K" and Y" respectively.

Decomposing the total income gain into static and induced (medium-run) gains we have

$$(Y''-Y)/Y = (Y'-Y)/Y + (Y''-Y')/Y \tag{5}$$

where the first part is the static income gain and the second part is the induced (medium-run) gain. It turns out that the latter is simply a multiple of the static gain.

$$(Y''-Y')/Y = (a/1-a)(Y'-Y)/Y \tag{6}$$

That is, for each percentage increase in static income one gets an additional fraction in induced income gain over the medium-run. (Of course, *any* policy change that improves productivity will induce higher incomes with a savings-investment linkage). The size of the induced income gain depends on the curvature of the YY schedule, which in turn depends on the elasticity of output with respect to capital, measured by the parameter "*a*" in the production function. The larger the output-capital elasticity, the less the curvature of the YY schedule, and the larger the induced gain in income. For example, an "*a*" of 0.25 (low estimate) implies an accumulation-related growth multiplier of one-third on top of the initial income gain, and an "a" of 0.4 (high estimate) implies a multiplier of 2/3.[3]

3. The endogenous growth literature suggests substantially higher capital-output elasticities. Indeed, the simplest "AK" models assume an elasticity of one for a broad concept of capital, including human capital. In this limiting case, trade reform will lead to permanent growth effects as capital is not subject to diminishing return. Note that the "medium-run" growth bonus approaches infinity (i.e., a permanent growth effect) as "a" approaches one.

2.2 Accumulation Effects With Endogenous Saving Rates

Endogenising the savings rate does not change the basic story in this simple, one-sector Cobb-Douglas economy. Using standard dynamic optimization, it is easy to show that steady state levels of capital and income (abstracting from exogenous technological progress and population growth) are simply,

$$K = \left(\frac{a}{\delta + \rho}\right)^{\frac{1}{1-a}} A^{\frac{1}{1-a}} L, \qquad Y = \left(\frac{a}{\delta + \rho}\right)^{\frac{a}{1-a}} A^{\frac{1}{1-a}} L. \tag{7}$$

Comparing (4) and (7), note that the steady state capital stock and income with endogenous savings rates are identical to the fixed saving rate case for certain sets of parameters: $s = a\ (\delta/\delta+\rho)$. However, this "equivalence" between fixed and endogenous savings may break down if additional sectors are introduced, if the aggregate production function is not Cobb-Douglas, or if the relative price of capital in terms of consumption goods changes as result of the trade reforms. Indeed, a more general, dual treatment reveals that the steady state effects of trade policy reforms depends critically on the savings specification. This is demonstrated mathematically in the appendix and graphically below.

2.3 Accumulation Effects With Fixed and Endogenous Savings In A Two-Sector Model

So far, we have discussed capital accumulation effects with reference to neutral shocks to an aggregate Cobb-Douglas GDP function. However, a number of complicating factors should also be kept in mind. We have shown that accumulation effects can compound initial output and welfare effects over the medium-run, and can magnify income gains or losses. However, how much these accumulation effects will actually supplement static effects depends on a number of other factors as well. These include the economy-wide marginal product of capital, underlying savings behavior, sectoral interactions, and terms-of-trade effects. Results will also depend on the pattern of underlying distortions embedded in the GDP function.

To illustrate some of these factors, we have represented a capital-friendly tariff reform for a two good model in figure 2, where we assume that goods X1 and X2 are combined into a composite good used for consumption or investment. The initial equilibrium is at the tariff-distorted production point 1, with the world price line intersecting the PPF. Trade liberalization, in the short-run, implies a shift in production from point 1 to point 2, with an expansion of capital-intensive production of X1 and a contraction of labor-intensive production of X2. The result is an increase in the return to capital and investment, and an induced expansion of the capital stock under both a fixed savings rate and endogenous savings rate specification. The result is continued expansion of production of X2, as the PPF expands from AB to CD. The economy embarks on a new dynamic path, converging on the new steady-state at point 3.

Alternatively, the income and/or factor price effects of trade liberalization may also signal a draw-down of the capital stock. This is represented in figure 3. Tariff reform moves us, in the short-run, from point 1 to point 2. The increase in income leads, under fixed savings rates, to a rise in investment, and a further shift in production to point 3, with a rise in X1 production as we move from point 2 to point 3. However, the short-run effects of the tariff reform also imply a fall in the return to investment. With a savings rate sensitive to real returns, this induces a draw down of the capital stock, with production shifting from point 2 to point 4, implying a further contraction of X1 production. Note, however, that even with the draw-down in GDP, welfare should increase. This is because the earlier allocation of income to investment reflected distorted private returns relative to the social return of deferred consumption. Hence, in figure 3, welfare associated with production at point 4 will be higher than at point 1.

3. A Numeric Example: The Uruguay Round

We next turn to numeric examples. We use a multi-region general equilibrium model, the GTAP model, to examine the possible investment-related effects of the Uruguay Round. (Necessary modifications to the TABLO file and closure are outlined in Appendix 2.) Our policy simulations include industrial tariff liberalization, the elimination of the multi-fibre arrangement (MFA), the elimination of a number of other industrial non-tariff barriers, and reductions in protection for agriculture. The specifics of these agreements have been detailed elsewhere (see the Word Bank volume edited by Martin and Winters, 1995) and are not repeated here.

3.1 The Model

We work with a 10 sector, 10 region aggregation of the GTAP model. There are three factors: land, labor, and capital. The sectoring scheme and trade elasticities are detailed in tables 1 and 2. Social accounting data are based on a modified version of the basic GTAP version 2 database. The modifications include supplementary data on applied tariffs and certain industrial NTBs. Initial protection data, for the present application, are representative of the world as of 1992 (i.e. pre-Uruguay Round), with multi-fibre arrangement (MFA) protection and various industrial non-tariff barriers represented as export taxes. The basic pre- and post-Round protection data are described in FRANCOIS et al (1995).

In the GTAP model, composite household demand is specified, at the upper-tier, as Cobb-Douglas between government spending and private spending. Government spending therefore involves a fixed share of temporal consumption. Consumption across goods is determined by constant difference elasticity (CDE) preferences, as described in HERTEL (1996). Under our reference specification, which

Figure 2 A capital-friendly liberalization

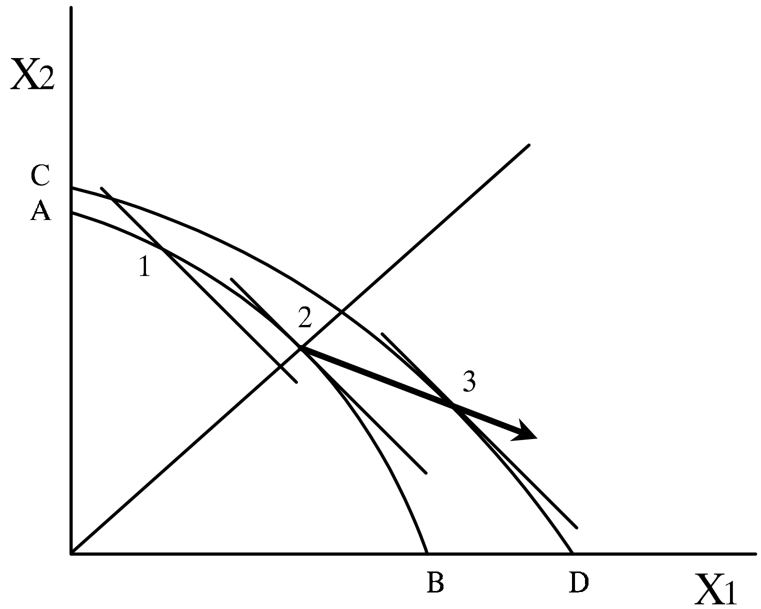


Figure 3 Divergence between effects with fixed and endogenous savings

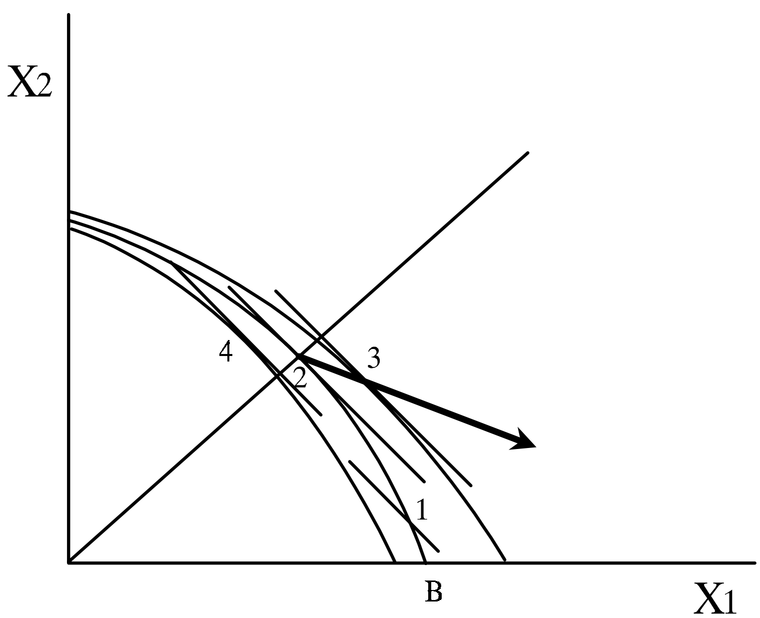


Table 1 Model Aggregation

Regions:	Sectors:
Australasia	Agriculture
North America	Extraction
Japan	Processed Food
European Union	Textiles
Asian NIEs	Clothing
ASEAN	Iron and Steel
China	Machinery and Equipment
South Asia	Transport Equipment
Latin America	Other Manufactures
Rest of World	Services

Table 2 Trade and scale elasticities

	substitution between imports and domestic	substitution between different imports
Agriculture	2.48	4.72
Extraction	2.80	5.60
Processed Food	2.38	4.77
Textiles	2.20	4.40
Clothing	4.40	8.80
Iron and Steel	2.80	5.60
Machinery and Equipment	5.20	10.40
Transport Equipment	2.80	5.60
Other Manufactures	2.27	4.86
Services	1.94	3.92

involves the standard, static GTAP model, the capital stock is fixed. Alternatively, with steady state capital accumulation, investment, savings rates, and the capital stocks adjust as described below. Factor markets are competitive, with labor and capital being mobile between sectors but *not* between countries.

Capital markets are modeled as regional markets, with capital fully mobile between sectors (and countries making up the relevant "regions"). We do not model changes in international (inter-regional) financial capital flows induced by trade policy changes. Rather, the capital market closure we adopt involves fixed net capital inflows and outflows. In the GTAP model, trade is modeled as trade in goods that are differentiated by country of origin (the Armington assumption). Different country varieties are combined through a CES aggregator into a composite good used as intermediates (in other sectors) or for final consumption.

To highlight capital accumulation effects, we adopt three alternative closure rules for the capital market. Our benchmark closure is the standard static specification with fixed aggregate capital stocks,

$$K_1 = K_0 = \bar{K} \tag{8}$$

where sub-indexes 0 and 1 denote pre- and post-reform values. This static closure is contrasted with two steady-state closures. Under the assumption of fixed savings rates, a fixed proportion of the static income gain will be saved and invested, leading to additional income, of which part is saved, and so forth. The steady-state capital stock is related to the initial GDP according to $K_0 = (s/(g+\delta)) (Y_0/P_0)$, where s is the fixed savings rate, g the steady state growth rate (equal to the exogenous rate of technical progress), δ capital depreciation, P is the relative price of the investment good in terms of the composite consumption good, and the composite consumption good is the numeraire. Similarly, in the post trade liberalization steady state, the associated new steady state capital stock is $K_1 = (s/(g+\delta)) (Y_1/P_1)$. Together these two steady-state relations, two for each region, allow us to solve for the post reform capital stocks.

$$K_1 = K_0 (Y_1/Y_0)(P_0/P_1) \tag{9}$$

The change in steady-state capital stocks, following a shock to the regional GDP functions, is proportionate to the change in the steady-state GDP functions, controlling for changes in the relative prices of the composite investment goods. The crucial assumption is that all regions are initially in steady state; a convenient although admittedly unrealistic assumption.[4]

4. FRANCOIS, NORDSTRÖM and SHIELLS (1996) show in a one sector growth model that trade policy reforms during transition to steady state will spur growth temporarily, bringing the fruits of policy reform forward to an earlier date. Trade liberalizations are therefore potentially more important for developing countries than for developed countries, assuming that developing countries are further away from their steady state incomes.

Turning next to the endogenous saving specification, and again assuming the composite consumption good is the numeraire, w equation for consumption (derived from standard dynamic optimization) is given by

$$\frac{\dot{C}}{C} = \sigma\left[\frac{r}{P} + \frac{\dot{P}}{P} - \delta - \rho\right], \tag{10}$$

That is, growth in consumption is a function of the difference between the net *private* return to capital in terms of the consumption good (*r/P* - *δ*) plus capital gain, and the rate of time preferences, ρ. In steady state, consumption grows at a constant rate g and the relative price between investment and consumption growth is constant.

Thus, the comparing the pre and post reform steady states, we have

$$\begin{aligned} &\frac{r_0}{P_0} - \delta = \rho + \frac{g}{\sigma} = \frac{r_1}{P_1} - \delta \\ &\therefore \quad r_1 = r_0 * (P_1 / P_0) \end{aligned} \tag{11}$$

Under this endogenous savings closure, if a trade reform boosts the return to capital, it will induce further capital accumulation. New investments will take place until the marginal return falls back to the steady state level. Conversely, a trade reform that reduces the return to capital will bring about capital decumulation as depreciated capital is not replaced.

Of course, a global trade reform may raise the returns in one country while reducing them in another. The country specific impact hinges on the interaction between the trade reform (which sectors are liberalized) and the specialization pattern (which, in turn, depends on factor endowments and initial trade barriers).

3.2 Results

Tables 3 through 7 present short- and medium-run changes in capital returns, capital stocks, terms-of-trade, wages and GDP under the alternative assumptions of (I) a fixed capital stock; (ii) a fixed savings rate; and (iii) a fixed steady state return on capital (endogenous savings). We also offer a comparison of steady-state welfare (based on a comparison of steady-state consumption levels).

Note first in table 3 columns 1 and 4 that the Uruguay Round boosts the short-run returns to investment in some regions, while returns fall in others. With endogenous savings, this initial impact induces accumulation or decumulation of capital to bring returns back to their steady state levels. The corresponding changes in steady state capital stocks are reported in column 3 of table 4. Compare this with the fixed savings rate specification. In the latter case, investments are unrelated to what happens

Table 3 Change in real returns to investment, percent

	static	endog K fixed s	endog K endog s
Australasia	3.3	1.8	*
North America	2.2	1.8	*
Japan	-0.8	-1.0	*
European Union	2.6	1.5	*
Asian NIEs	1.1	1.3	*
ASEAN	2.2	0.7	*
China	-2.6	-9.3	*
South Asia	-3.7	-4.2	*
Latin America	2.7	1.9	*
Rest of World	2.5	2.3	*

Table 4 Change in capital stock, percent

	static	endog K fixed s	endog K endog s
Australasia	*	1.8	4.4
North America	*	0.4	3.0
Japan	*	0.2	-1.5
European Union	*	1.4	3.3
Asian NIEs	*	-0.3	2.0
ASEAN	*	3.7	6.1
China	*	8.7	-3.4
South Asia	*	0.5	-4.5
Latin America	*	1.7	6.2
Rest of World	*	0.1	3.8

Table 5. Real wages, percent change

	static	endog K fixed s	endog K endog s
Australasia	3.2	3.2	3.2
North America	2.0	2.0	2.1
Japan	-0.8	-0.9	-1.2
European Union	2.4	2.4	2.3
Asian NIEs	0.9	1.0	1.4
ASEAN	4.1	5.7	7.0
China	-1.5	-0.4	-2.0
South Asia	-3.1	-3.0	-3.8
Latin America	2.7	3.0	4.9
Rest of World	2.1	2.1	2.6

Table 6. Terms of trade, percent change

	static	endog K fixed s	endog K endog s
Australasia	-0.2	-0.3	-0.6
North America	0.7	0.8	0.7
Japan	0.5	0.6	1.6
European Union	1.6	1.6	0.9
Asian NIEs	-1.5	-1.4	-1.6
ASEAN	-1.7	-2.0	-2.2
China	-1.2	-1.6	-1.0
South Asia	-2.2	-2.2	-1.8
Latin America	-1.1	-1.3	-1.7
Rest of World	-1.4	-1.4	-1.7

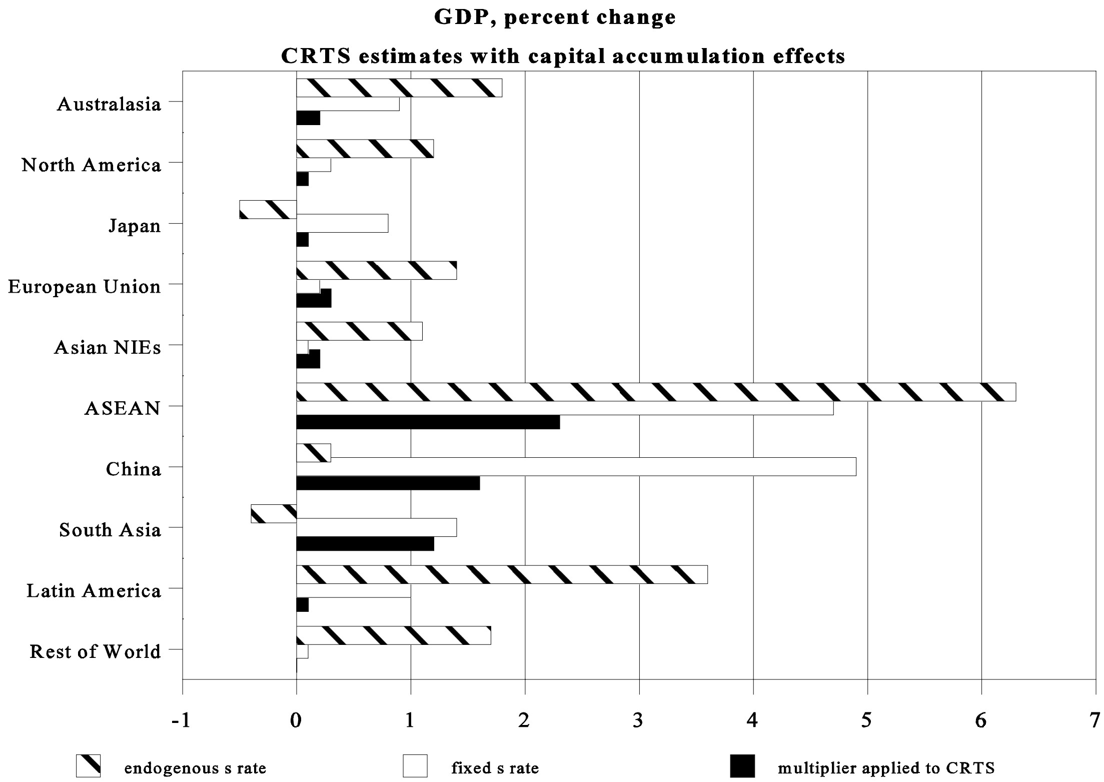
Table 7. Real GDP, percent change

	static	endog K fixed s	endog K endog s
Australasia	0.2	0.9	1.8
North America	0.1	0.3	1.2
Japan	0.1	0.8	-0.5
European Union	0.3	0.2	1.4
Asian NIEs	0.2	0.1	1.1
ASEAN	2.3	4.7	6.3
China	1.6	4.9	0.3
South Asia	1.2	1.4	-0.4
Latin America	0.1	1.0	3.6
Rest of World	0.0	0.1	1.7

Table 8. Welfare from personal consumption, percent change

	static	endog K fixed s	endog K endog s
Australasia	0.2	0.7	1.2
North America	0.3	0.5	1.1
Japan	0.0	1.6	-0.0
European Union	0.9	1.2	1.6
Asian NIEs	-1.1	-0.6	-1.0
ASEAN	0.4	4.6	3.1
China	0.1	6.9	0.6
South Asia	-0.0	6.6	-0.6
Latin America	-0.1	-0.4	2.6
Rest of World	-0.4	-1.7	0.6

Figure 4 Estimated changes in GDP



to capital returns. Instead investments are proportional to the static income gain. What is critical in this case is the change in income relative to capital goods prices. Hence, in the Asian NIE region, income gains are positive, based on GDP valued at base period prices. (See Table 7). However, rising capital goods prices dominate, leading to a fall in the capital stock. (Table 4, column 2).

3.3 How well does the Baldwin multiplier analysis hold up?

A rule of thumb for assessing potential medium-term accumulation affects is the Baldwin multiplier, which is defined in equation (6) above. In figure 4, we compare estimates based on the multiplier approach, for constant returns specifications, with those based on explicit accumulation mechanisms. For marginal trade reforms the multiplier analysis should yield identical results to the fixed and endogenous savings specifications. Yet, for discrete changes, the three approaches can and *do* lead to divergent results quantitatively, and sometimes also qualitatively. Clearly, marginal calculus is not always a good guide for assessing discrete policy changes in a general equilibrium framework.

4. *Conclusions*

The implications of trade and trade policy relate not only to static resource allocation efficiencies, but also to the accumulation of capital (human, knowledge, and physical) and to the negative accumulation (i.e. depletion) of natural resources. As the older and more recent growth literatures have emphasized, such effects have very real implications for the level and the growth of income. Empirical evidence also points (LEVINE and RENELT, 1992) to an important linkage between trade policy, investment, and the path of income.

In this paper we have examined linkages between trade liberalization and multilateral investment, emphasizing effects related to investment and the accumulation of capital. Trade and investment linkages in have been explored in the context of simple steady-state closure rules, where we specify explicit stylized linkages between investment and income levels, and between investment incentives (i.e. real factor prices) and capital accumulation. The importance of these linkages is shown to hinge on the sensitivity of savings rates with respect to real returns. Empirical evidence points to a sensitivity of the *level* of savings to income, such that income shocks can be magnified by induced savings. (See CARROLL and WEIL, 1993). However, we remain skeptical about whether we should expect trade policy shocks to induce first-order changes in the *rate* of savings. (See KOTLIKOFF, 1989).

The one consistent pattern to emerge from our results is the occasional lack of consistency. In particular, for some regions, like the EU and North America, the basic story told by our Uruguay Round simulations remains unchanged under a range of model structures. Clearly, capital accumulation effects and scale economies imply potential gains greater than those suggested by static, constant returns models. However, the story remains one of gains. The same cannot be said for all other regions. Estimated effects for a number of developing countries hinge critically on our representation of investment effects. As resulting shifts in the resource base interact with the terms-of-trade and potential scale economies, the order of magnitude and even the sign of estimated results can be affected. Hence, while we have not addressed here how likely it is that savings rates will increase in response to shifting incentives, it is clear that this response matters. At the same time, compared to explicit fixed or endogenous savings specifications, it is also clear that, at least for multilateral liberalization, multiplier type analysis can be a poor guide to potential accumulation effects.

Appendix 1

A1.1 A General Dual Treatment of Accumulation Effects

Consider a multi-sector, small economy that trades at given world market prices. The outputs of the different sectors are combined, through a linear homogenous aggregation function, into a composite good that can be either consumed or saved/invested. Formally, we can represent this economy by replacing equation (1) with the following reduced-form GDP function:

$$(A.1) \qquad Y = G(K', L' : P)\,; \qquad K' = \alpha_K K, \quad L' = \alpha_L L.$$

In equation (A.1), Y still represents national income, measured in units of the composite consumption/investment good. The α_i terms represent factor-specific efficiency parameters and *P* the vector of world market prices. A trade policy reform is analogous to a shock to the α vector. It can be shown that, in steady-state, a shock to the efficiency parameters will lead to the following change in steady-state GDP under fixed and endogenous savings, respectively.

A1.2 Fixed savings rates:

$$(A.2) \qquad \frac{dY}{Y} = (1 - \theta_{K'})^{-1}\left[\theta_{K'}\frac{d\alpha_K}{\alpha_K} + \theta_{L'}\frac{d\alpha_L}{\alpha_L}\right]$$

A1.3 Endogenous savings (fixed net real return to capital):

$$(A.3) \qquad \frac{dY}{Y} = \left[\theta_{K'}\frac{d\alpha_K}{\alpha_K} + \theta_{L'}\frac{d\alpha_L}{\alpha_L}\right] + \left[\theta_{K'}(-G_{K'K'})^{-1}G_{K'}(K')^{-1}\frac{d\alpha_K}{\alpha_K}\right]$$

$$+ \left[\theta_{K'}(-G_{K'K'})^{-1}G_{K'L'}(K')^{-1}\frac{d\alpha_L}{\alpha_L}\right]; \qquad \theta_i = \frac{G_i}{G}, \quad G_{K'} = \frac{\partial G}{\partial K'}.$$

With a Hicks-neutral shock to the GDP function, and with a composite GDP function that is Cobb-Douglas, both equations (A.2) and (A.3) collapse to equation (6), the simple Baldwin multiplier. Under other, more general conditions, we can expect to see divergence in steady-state income effects between the two savings specifications.

Appendix 2

A2.1 Specifying Accumulation Effects in GTAP

This appendix is concerned with the specification of accumulation effects in GTAP. The mechanisms emphasized in this paper can be implemented through the addition of the following variables and equations to the standard GTAP model.

A2.2 Additional Model Code

```
!-------------------------------------------------------------------!
!                capital accumulation variables                     !
!-------------------------------------------------------------------!

VARIABLE (all,i,ENDWC_COMM)(all,r,REG)            EXPAND(i,r)
    # Change in investment levels relative to endowment stock # ;

VARIABLE (all,r,REG)                              REAL_RET(r)
    # Change in real investment returns relative to price of consumption # ;

! ----------------------------------------------------------------- !
!                   CAPITAL ACCUMULATION                            !
!------------------------------------------------------------------ !

EQUATION BALDWIN  (all,i,ENDWC_COMM)(all,r,REG)
! change in investment levels relative to capital stock !
EXPAND(i,r) = qcgds(r) - qo(i,r) ;

EQUATION MUTH  (all,r,REG)
! change in real return to investment.
Note that this is calculated as the difference between
the price of the current composite consumption good relative
to the real return to the capital good !
REAL_RET(r) =  [ rorc(r) ] - [ yp(r) - up(r) ];
```

A2.3 Implementation through closure rules

The implementation of the alternative capital market closure rules is accomplished by alternative definitions of exogenous and exogenous variables.

For the standard static GTAP closure, the following variables are exogenous/endogenous.

qo("capital",REG)	exogenous
saveslack	exogenous
Expand(i,REG)	endogenous
REAL_RET(r)	endogenous

For the fixed savings rate closure with capital accumulation, the following variables are exogenous/endogenous.

qo("capital",REG)	endogenous
saveslack	exogenous
Expand(i,REG)	exogenous
REAL_RET(r)	endogenous

For the infinite horizon, endogenous savings rate closure with capital accumulation, the following variables are exogenous/endogenous.

qo("capital",REG)	endogenous
saveslack	endogenous
Expand(i,REG)	exogenous
REAL_RET(r)	exogenous

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