Économie internationale 94-95 (2003), p. 261-282.

ÉCONOMIE INTERNATIONALE

REGIONAL TRADING ARRANGEMENTS FOR CHILE: DO THE RESULTS DIFFER WITH A DYNAMIC MODEL?

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Article received on March 6, 2002
Accepted on May 12, 2003

ABSTRACT. Starting from our earlier multi-region trade model, we develop two new 24 sector small open economy (SOE) computable general equilibrium models (CGE) of Chile. One is comparative static and the other is dynamic. We evaluate the impact of Chile forming free trade agreements with either NAFTA or MERCOSUR. Our principal result is that the dynamic SOE model does not produce welfare estimates significantly different from the comparative static SOE model. Our second result is that, although the difference is small, it is possible for a fully dynamic model to produce welfare estimates for a preferential trade area that are welfare inferior than those from a comparative static model. Finally, we develop two classes of comparative steady-state models and show that it is necessary to properly calibrate these models to the dynamic steady-state equilibrium path in order to produce estimates that are not significantly biased relative to the true dynamic estimates.

JEL Classification: F15; F17; C68; D58.
Keywords: Economic Integration; Trade Forecasting and Simulation; Computable General Equilibrium Models; Computable and Other Applied General Equilibrium Models.

RÉSUMÉ. À partir d'un précédent modèle des échanges à plusieurs régions, deux nouveaux modèles d'équilibre général calculable pour petite économie ouverte ont été construits et appliqués au Chili, comprenant vingt-quatre secteurs. L'un est en statique comparative, l'autre en dynamique. Ils permettent d'évaluer les conséquences pour le Chili d'accords commerciaux conclus soit avec l'Alena, soit avec le Mercosur. Le résultat le plus important est que le modèle dynamique ne donne pas de gains en bien-être sensiblement différents de ceux obtenus avec l'autre modèle. Par ailleurs, bien que la différence soit minime, un modèle complètement dynamique peut produire des estimations de bien-être pour une zone commerciale préférentielle, inférieures à celles obtenues avec un modèle en statique comparative. On définit alors deux classes de modèles en statique comparative et l'on montre qu'il est

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nécessaire de les calibrer correctement sur la trajectoire d'équilibre en dynamique afin de produire des estimations qui ne soient pas biaisées par rapport à celles obtenues en dynamique.

Classification *JEL* : F15 ; F17 ; C68 ; D58.
Mots-clefs : Intégration économique ; Prévision et simulation de commerce ; modèles d'équilibre général calculable (MEGC) ; MEGC et autres modèles d'équilibre général appliqué.

International trade economists have typically argued that an open trade regime is very important for economic development (e.g., The World Bank, 1987). What has been troubling is that the numerical estimates of the impact of trade liberalization have typically found that trade liberalization increases the welfare of a country by only about 1 percent of GDP, gains which are small in relation to the importance placed on trade liberalization in the policy debate. Authors have claimed that the welfare gains from trade liberalization would be much larger if the dynamic impact of trade liberalization were taken into account (see Thomas, Nash *et al.*, 1991). But if the dynamic model is simply Ramsey based, i.e., if there is no endogenous growth, the increases in the long run capital stock that are possibly induced by trade liberalization come at the expense of foregone consumption and reduced welfare during the transition. Then estimated welfare increases from a dynamic model may not be significantly different from those of a comparative static model. One question we examine in this paper is the contention that dynamics necessarily increases the estimated gains from trade policy changes.

During the 1990s, the number of regional trade agreements (RTAs) in effect in the world more than doubled. The number of RTAs in effect by August 1998 was 220, compared with 95 in 1990.[2] This has occurred despite the rather pessimistic assessment of the performance of regional trade arrangements in the some parts of the developing world during the previous two decades (see de Melo and Panagariya, eds., 1993; or Bhagwati and Panagariya, 1996). Although assessments of the comparative static effects of regional trade arrangements may sometimes be dominated by trade diversion, proponents may argue that dynamic effects will result in gains. But if the comparative static effect is negative, there will be less income for both current consumption as well as investment, and the dynamic impact could be worse. A second question we examine in this paper is the contention that dynamic effects necessarily lead to a superior welfare result for preferential trade arrangements.

We examine these questions with data and a model of Chile. Chile undertook a major reform of its trade policy between 1975 and 1979 during which it converted its non-tariff barriers to tariff barriers. There was a temporary setback in its movement toward liberal trade in the early 1980s, due to a fixed and overvalued exchange rate regime at that time

2. WTO Secretariat, *Basic Information on RTAs Notified to the GATT/WTO and in Force*, 1998, and WTO Secretariat, *Mapping of Regional Trade Agreements*, 1998.

(see Shatz and Tarr, 2001). Since 1984, the hallmark of Chile's trade policy has been its uniform tariff, which has been progressively reduced over time.[3] In 1998, the Chilean Parliament (supported by testimony from Chilean business interests) voted to reduce its then eleven percent uniform tariff by one percent a year until the tariff reaches a uniform six percent in 2003. In the 1990s, however, Chile adopted a strategy in which it appears willing to enter into a free trade agreement with virually all of its trading partners. In this paper we examine the impact of the regionalism strategy by examining Chile's free trade agreement with MERCOSUR and its potential free trade agreement with NAFTA. We ask how do various modeling assumptions impact on the quantitative assessment of the results.

The starting point of this paper is our earlier comparative static analysis of Chile's trade policy options (Harrison, Rutherford and Tarr, 2002). In that paper we employed a comparative static multi-region computable general equilibrium (CGE) model with perfect competition and constant returns to scale. Our first new construction in this paper is a 24 sector small open economy (SOE) comparative static, computable general equilibrium (CGE) model of Chile which replicates the results of our 24 sector multi-region trade model. While it is customary to employ an open economy model to study trade issues for a small economy, in our earlier work we adopted a multi-sectoral framework in order to assure that we could account for any changes in terms-of-trade induced by Chilean accession to MERCOSUR or NAFTA. In the present analysis, we begin by implementing a small open economy model which virtually replicates the results of a multi-region trade model. This key to this reconciliation is the inclusion of the terms-of-trade effects (derived from improved access in the regional arrangements) in the export demand functions for the small open economy. This reconciliation is the first result of our paper. To our knowledge this is the first time a small open economy CGE model has been constructed that replicates the results of a multi-region CGE model including the terms-of-trade effects.

After having validated the small open economy model, we construct a fully intertemporal model with which we evaluate Chile's free trade arrangement with MERCOSUR and its possible free trade arrangement with NAFTA. We examine the models in our preferred elasticity case that we call a central elasticity case as well as and a low elasticity scenario. Our preferred elasticities are high by the standards of many CGE models, but we believe they are justified by the work of Reidel (1988) and Athukorala and Reidel (1994).[4] We compare results across the multi-region trade, small open economy static model and small open economy dynamic model.

Our principal result is that the dynamic SOE model does not produce welfare estimates significantly different from the comparative static SOE model. Simply allowing dynamic capital

3. Chile has applied price bands for a few agricultural products which has allowed the tariff rate for these sectors to exceed the uniform rate during some periods. See Vlades (1996) and Schiff (2002).

4. Higher elasticities would effectively constitute a perfect substitution model. Since perfect substitution models have well known shortcomings as applied trade models we do not simulate "high elasticities". See de Melo and Tarr (1992, p. 16-17) for a description of why product differentiation is most appropriate in applied trade models.

accumulation in the style of Ramsey does not result in very different welfare estimates than a comparative static model. On the other hand, we have shown (see Rutherford and Tarr, 2002), that an endogenous growth model can result in significantly larger estimated gains than a comparative static model. But this paper shows that not any dynamics will do for large welfare gains.

We have estimated that Chile's agreement with MERCOSUR will result in losses for Chile under our central elasticity assumptions.[5] We estimate, however, that in one of our models the estimated losses from the dynamic SOE model are larger in absolute value than in the comparative static SOE model. Our second result then is that it is possible for a dynamic model to produce welfare estimates for a preferential trade area that are welfare inferior than those from a comparative static model. Thus, regional trade agreements that are immizerizing when evaluated in a comparative static framework do not necessarily have improved evaluations in a dynamic framework and these evaluations can be worsened.

In addition, we examine the impact of comparative steady-state models. In an attempt to obtain estimates of the long run benefits of trade liberalization without actually constructing a fully dynamic model, in recent years a number of authors have produced results using steady-state models (this includes Harrison, Rutherford and Tarr (1996, 1997a); Francois, McDonald and Nordström (1996); and Baldwin *et al.* (forthcoming)). Whereas static models hold the capital stock fixed and allow the rental rate on capital to adjust, the steady-state model allows the capital stock to adjust with a fixed ratio of the rental rate on capital to the cost of producing the capital good. Since the comparative steady-state model does not account for the foregone consumption of achieving a possibly larger capital stock, we have emphasized that (when the capital stock increases) estimates from the comparative steady-state model are upper bound estimates of results from a dynamic model. We show that in our basic steady-state model, the estimated gains are about four to five times larger than the gains from the comparative static model.

We have also developed estimates from a model we refer to as the calibrated steady-state model. This model corrects for inconsistencies in an unadjusted comparative steady-state model to assure that the model meets dynamic steady-state equilibrium conditions. These adjustments result in a lower initial capital stock and a smaller increase in the capital stock after the shock (when the capital stock increases) and lower estimated gains. The estimated gains are then closer to true gains which come from the dynamic model. These results suggest that if modelers wish to take the shortcut of using a comparative steady-state model to estimate the gains from trade liberalization, in order to get more accurate estimates, it is necessary to do further calibration to assure that the dynamic steady-state conditions are satisfied.

5. Specific results are dependent on elasticity assumptions. We have explained (see Harrison, Rutherford and Tarr, 2002) that Chile can nonetheless gain from a free trade agreement with MERCOSUR if it also lowers its external tariff to 6-8 percent, thereby reducing trade diversion.

In the next section we describe the model in some detail. Detailed results and interpretations are in the following section.

Model formulations

Because this paper is comparing results from a collection of related yet distinct models, it is helpful to lay out the algebraic formulations in some detail so that the similarities and differences in model structure are readily apparent. In this section, we first present the equilibrium structure of the static open economy model. We then indicate how the steady-state formulation differs from the static formulation. Finally, we describe the intertemporal links through which the static model is extended to a fully intertemporal framework through the use of dated commodities and endogenous capital accumulation. Core paramaters of the model are described in TABLES 1 through 4.

The static model

Our open economy model is based on the standard GTAP framework (Hertel, 1997). Commodities are produced using primary factors which include labor, capital and land. We have added a fourth primary factor to the dataset, sector-specific resources, which accounts for the decreasing returns characteristics of extractive industries (copper, in particular). Goods produced in the domestic economy may be exported or consumed domestically. Imported goods are distinguished by region of origin, and aggregate demand represents an Armington composite of domestic and imported varieties. The government levies import tariffs, value-added taxes, consumption taxes, excise taxes and export taxes, and it uses this revenue to purchase public goods. In a tax-reform scenario, the value-added tax rates are proportionately adjusted to hold public expenditure constant.

Consumer preferences

Consumer utility consists of a Cobb-Douglas utility index defined over Armington composites of domestic and imported commodities. Aggregate consumption is then expressed as:

$$U\left(c\left(c^D, c^M\right)\right) = \prod_i c_i^{\cdot_i}$$

where the domestic-import composite is defined:

$$c_i\left(c_i{}^D, c_i{}^M\right) = \left[\beta_i \left(\frac{c_i^D}{\bar{c}_i^D}\right)^{\rho} + \left(1-\beta_i\right)\left(\frac{c_i^M}{\bar{c}_i^M}\right)^{\rho}\right]^{1/\rho}$$

in which $\sigma_{DM} = \frac{1}{1-\rho}$ is the elasticity of substitution between domestic and imported goods. This elasticity is greater than unity, so domestic and imported varieties remain net substitutes in demand.

Consumer choice

Consumers select levels of domestic and imported demand which maximize utility subject to a budget constraint. That is, they solve:

$$\max U\left(c^D, c^M\right)$$

s.t.

$$r_K\bar{K} + p_L\bar{L} + p_N\bar{N} + \sum_i p_i^R \bar{R}_i + \bar{T} = \sum_i \left(p_i^D c_i^D + p_i^M c_i^M\right)\left(1 + t_i^C\right) + \sum_i p_i^D \bar{I}_i$$

Government budget

The government levies value-added taxes on production, taxes on consumer demand, indirect taxes on production and tariffs on imports. In a counterfactual equilibrium, we hold public expenditures fixed and multiplicatively adjust the value-added tax rate so that the present value of tax revenue equals the present value of public expenditure. That is, we choose a tax multiplier such that:

$$\tau \sum_i t_i^V VA_i + \sum_{i,r} M_{ir} p_{ir}^M t_{ir}^M + TX = \sum_i \left(p_i^D \bar{G}_i^D + p_i^M \bar{G}_i^M\right)$$

in which government income includes value-added taxes, import tariff revenue (accounted on a bilateral basis) and the sum of all other direct and indirect taxes (*TX*). The tax rate on factor inputs in sector i equals τt_i^V in which τ is a tax adjustment multiplier which increases from unity to replace declining tariff revenues and hold government expenditure constant.

Technology

Domestic producers supply goods to the domestic and export markets. Goods are produced as differentiated products for sale in these markets, and the share of sales at home and abroad are determined by relative prices. This is effectively an Armington-style differentiation of products in the export market. A constant elasticity of transformation function relates the composite output level to domestic and export sales. Firms in sector i maximize profit subject to the constraint:

$$Y_i = g\left(D_i, E_i\right) = \left[\theta_i^D \left(\frac{D_i}{\bar{D}_i}\right)^{1+\eta} + \left(1-\theta_i^D\right)\left(\frac{E_i}{\bar{E}_i}\right)^{1+\eta}\right]^{1/(1+\eta)}$$

In this equation parameters $\bar{D}_i$ and $\bar{E}_i$ are the base year (benchmark) levels of output to the domestic and export markets, and θ_i^D is the benchmark value share of domestic sales in total output for sector i.

Production of this composite is associated with a nested production function which has a Leontief aggregation of intermediate inputs and value added. In turn, value added is a constant elasticity composite of capital, labor, land and (for extractive industries) sector-specific resources. Intermediate demand for good j is a CES Armington aggregation of domestic and imported varieties. Hence, we have:

$$Y_i = h_{ji}\left(X_{ji}^D, X_{ji}^M\right) = \left[\beta_{ji}\left(\frac{X_{ji}^D}{\overline{X}_{ji}^D}\right)^{\rho} + \left(1-\beta_{ji}\right)\left(\frac{X_{ji}^M}{\overline{X}_{ji}^M}\right)^{\rho}\right]^{1/\rho} \quad \forall j$$

and

$$Y_i = f_i(K_i, L_i, N_i) = \left[\alpha_i^R + \alpha_i^K\left(\frac{K_i}{\overline{K}_i}\right)^{\rho} + \alpha_i^L\left(\frac{L_i}{\overline{L}_i}\right)^{\rho} + \alpha_i^N\left(\frac{N_i}{\overline{N}_i}\right)^{\rho}\right]^{1/\rho}$$

Producer choice

Given prices of domestic and export supply, intermediate goods, capital and labor, firms maximize profit taking the activity level as given. Input and output decisions are separable as are decisions regarding value-added shares and the shares of domestic and imported varieties in intermediate demand. We thus can decompose the producer profit maximization problem into separate subproblems which can be solved analytically (given the activity level). The choice between sales to domestic and export market solves:

$$\max\ p_i^D D_i + p_i^E E_i$$

s.t.

$$g_i(D_i, E_i) = Y_i$$

Domestic and imported intermediate demands solve:

$$\min\ p_j^D X_{ji}^D + p_i^M X_{ji}^M$$

s.t.

$$h_{ji}\left(X_{ji}^D, X_{ji}^M\right) = Y_i$$

and primary factor inputs solve:

$$\min\ r_K K_i + p_L L_i + p_N N_i$$

s.t.

$$f_i(K_i, N_i, L_i) = Y_i$$

Import composition

Import demand functions are nested to two levels. At the top level, consumers and producers choose between domestic inputs and an aggregate of imported varieties. At the next level, aggregate imports are composed of goods imported from a number of different regions. The regional composition of imports are common across all components of demand (e.g., imports of steel from the USA are assumed to represent the same share of total imports in investment and intermediate demand).

Regional shares of total imports are determined by cost-minimization, given a constant elasticity Armington aggregation of the form:

$$M_i = A_i(m_{ir}) = \left[\sum_r \beta_{ir}^M \left(\frac{m_{ir}}{\overline{m}_{ir}}\right)^\rho\right]^{1/\rho}$$

and the cost-minimizing composition of commodity i imports is determined by:

$$\min\ p_{ir}^M \left(1+t_{ir}^M\right) m_{ir}$$

s.t.

$$A_i(m_{ir}) = \overline{M}_i$$

Export demand

We use compensated demand functions from the multi-regional model to formulate export demand equations for the open-economy model. As is demonstrated in the results below, we find that this partial equilibrium approximation does not depart significantly from the multi-regional solution. Included in the export demand function are (i) demands arising from exports to all eleven regions in the multi-regional model, (ii) transportation cost coefficients, (iii) import tariffs applied on Chilean exports to each trading partner, and (iv) export taxes levied on Chilean exports. The constant elasticity export demand function is written: [6]

$$E_i\left(p_i^E\right) = \sum_r \overline{e}_{ir}\left[\theta_{ir}^T \frac{\left(1+t_{ir}^{MX}\right)}{\overline{p}_{ir}^T} + \left(1-\theta_{ir}^T\right)\frac{\left(1+t_{ir}^{MX}\right)\left(1+t_{ir}^X\right)p_i^E}{\overline{p}_{ir}^E}\right]^{-\sigma X}$$

in which θ_{ir}^T is the base year value share of transport costs on exports of good i to region r, t_{ir}^{MX} is the ad-valorem tariff on commodity i exports to region r, t_{ir}^X is the export tax, and the reference prices are defined such that in the benchmark equilibrium: $\overline{E}_i = \sum_r \overline{e}_i r$.

6. The shadow price of foreign exchange, sometimes referred to as the real exchange rate, is taken as numeraire and its price is set to one. If this price variable were in the model, it would appear in the denominator of the second term in the export demand function, under p_i^E . The first term inside the brackets accounts for international transport costs which are denominated in terms of foreign exchange.

Market clearance

Market equilibrium requires that supply equal demand for all traded goods. These include domestic output, imports, exports, and all primary factor markets (land, labor, capital and sector-specific resources).

The market clearance condition for domestic output is:[7]

$$D_i = \sum_j X_{ij}^d + c_i^D + g_i^D + I_i$$

and market clearance for composite imports is:

$$M_i = \sum_j X_{ij}^M + c_i^M + g_i^M$$

There are factor markets for labor, capital, and land:

$$\sum_i L_i = \bar{L}$$
$$\sum_i K_i = \bar{K}$$
$$\sum_i N_i = \bar{N}$$

Finally, there is a trade balance condition which relates the value of imports to the value of exports less any exogenous capital in ows $(\bar{B})$:

$$\sum_{ir} p_{ir}^M m_{ir} = \sum_i p_i^E \left(\sum_r e_{ir} \left(1 + t_{ir}^X\right) \right) + \bar{B}$$

Zero profit

Under the assumption of perfect competition and free entry, we have zero excess profits in equilibrium. This implies that the output prices net of indirect tax must equal the cost of primary factor inputs (gross value-added tax), plus the total cost of intermediate inputs (gross of taxes on intermediate demand):

$$\left(1 - t_i^Y\right)\left(p_i^D D_i + p_i^E E_i\right) = \left(1 + \tau t_i^V\right)\left[r_k K_i + p_L L_i + p_N N_i + p_i^R R_i\right] + \sum j \left(1 + t_{ji}^I\right)\left(p_j^D X_{ji}^D + p_j^M X_{ji}^M\right)$$

The steady-state model

The steady-state model is an extension of the comparative static model. The goal of a steady-state calculation is not to describe the full adjustment path following a change in trade policy (i.e., it is not a dynamic model), nor even to quantify the net long-run welfare

7. $I_i = 0 \quad \forall i \neq i_I$
Commodity i_I represents new vintage capital, produced with a vector of commodity inputs, each of which is an aggregation of domestic and imported varieties.

effects of that path taking into account the costs of transition to a higher steady-state growth rate. Rather, the goal is to evaluate the upper bound on welfare gains in a Solow type model.

Based on the original work of Hansen and Koopmans (1972) and Dantzig and Manne (1974), we assume that given the rate of return on capital and the cost of producing a unit of the investment good in the initial equilibrium, the capital stock in each country is optimal. That is, increases in the rate of return on capital relative to the cost of a unit of the capital good would induce an increase in investment until the marginal productivity of capital is driven down to the initial ratio of the rate of return on capital to the cost of producing the capital good. A change in trade policy will produce a new equilibrium, where for many of the changes we consider, the rate of return on capital increases (relative to the cost of investment) due to a more efficient allocation of resources. This implies that in a dynamic sense a fixed capital stock can no longer be optimal in the new equilibrium of the comparative static model-investment would be forthcoming until the marginal productivity of capital is reduced to the long run equilibrium where the ratio of rate of return on capital to the cost of the capital good is restored to its initial value. In the comparative static model we allow the price of capital to vary, while holding constant the aggregate stock of capital. The steady-state calculation essentially reverses this: we allow the capital stock (and investment demand) to be endogenously determined while holding constant the price of capital.[8]

Since our calculation ignores the forgone consumption necessary to obtain the larger capital stock, we believe that this calculation measures an upper bound on potential welfare gains in a long run classical Solow type growth model.[9] Of course, it could be an underestimate of the long run gains since it fails to capture endogenous growth effects. This approach to steady-state evaluation in a multi-regional trade model was implemented in Harrison, Rutherford and Tarr (1996; 1997a), and has also been used by Francois, McDonald and Nordström (1994; 1996).

Since we observe an increase in the rental rate of capital relative to the cost of the investment good in virtually all of the scenarios we examine, the capital stock must grow in the steady-state version to keep the ratio at its benchmark value. This expansion of the capital stock then works through our model like an "endowment effect", generating larger welfare gains since there are more resources to be employed.

8. This approach is in the spirit of the equilibrium concept proposed for multisectoral planning models: solve for a time-invariant capital stock. An invariant capital stock equilibrium is a set of prices, production and investment levels for which the economy is able to grow at a steady rate with constant relative prices. In our model the optimal capital stock is defined as the stock such that the cost of investment, including depreciation and interest, is exactly equal to the discounted stream of rents on installed capital. This can be viewed as a multi-sectoral version of the "golden rule" equilibrium.

9. In the public finance literature (see, e.g. Stiglitz) there exist examples in which steady state gains are large but in the corresponding intertemporal model the gains are virtually offset by adjustment costs. After all, the capital stock can only be produced through investment, and that requires reduced consumption along the transition path. For sufficiently high discount rates, the cost of the foregone consumption could easily outweigh the longer-run benefits of the capital accumulation it allows.

Equilibrium conditions for the steady-state

The steady-state equilibrium is characterized by all of the equations in the static model except that we add an additional variable which measures the overall magnitude of the capital stock, K. We choose units such that the value of the capital stock multiplier is unity in the benchmark equilibrium. This variable alters the supply of physical capital:

$$\sum_i K_i = \tau_K \bar{K}$$

and investment demand is scaled proportionally:

$$D_i = \sum_j X_{ij}^d + c_i^D + g_i^D + \tau_K I_i$$

Both of these effects enter into the representative consumer's budget constraint:

$$\max U\left(c^D, c^M\right)$$

s.t.

$$r_K \tau_K \bar{K} + p_L \bar{L} + p_N \bar{N} + \sum_i p_i^R \bar{R}_i + \bar{T} = \sum_i \left(p_i^D c_i^D + p_i^M c_i^M\right)\left(1 + t_i^C\right) + \sum_i p_i^D \tau_K \bar{I}_i$$

Let q represent the marginal cost of a unit of new vintage capital. In our model this cost function has the form:

$$q = \sum_i a_i^I \left[\beta_i^M \left(p_i^M\right)^\rho + \left(1 - \beta_i^M\right)\left(p_i^D\right)^\rho\right]^{1/\rho}$$

In the steady-state model, the capital stock adjusts so that the ratio of the rental rate on capital to the cost of producing a unit of the capital good is constant:

$$\frac{r_K}{q} = \rho + \delta$$

implying that in the long-run equilibrium, the return to capital is equal to the sum of the discount rate on future consumption plus depreciation.

The dynamic model

Consumer behavior

The intertemporal utility function of the infinitely lived representative consumer equals the discounted sum of the utility of consumption over the horizon:

$$U = \left(\sum_t \Delta^t C_t^\rho\right)^{1/\rho}$$

In this equation parameter controls the intertemporal elasticity of substitution[10] and Δ is the single period discount factor. As in the static and steady-state models, aggregate consumption in a given period C_t is a Cobb-Douglas aggregate of consumption of domestic and imported final goods:

$$C_t = \prod_i c_{it}^{\alpha i}$$

where

$$c_{it} = \left[\beta_i^D \left(c_{it}^D \right)^{\rho} + \left(1 - \beta_i^D \right) \left(c_{it}^M \right)^{\rho} \right]^{1/\rho}$$

The intertemporal and within period consumption decisions are weakly separable. Thus, the typical static first order condition applies on consumption decisions within a time period, given a decision on how much to spend on consumption in any period. In the standard manner, the intertemporal decision is based on the maximization of utility subject to the constraint that the present value of income less expenditures is zero:

$$\max U\left(c^D, c^M \right)$$

s.t.

$$p_0^K K_0 + \sum_t p_t^D D_t + \sum_{it} p_{it}^R R_t + \sum_t w_t L_t + \sum_t T_t = \sum_{it} \left(p_{it}^D c_{it}^D + p_{it}^M c_{it}^M \right)$$

In this expression, all prices are defined in present value terms, discounted to period 0 (1992). The present value of income includes the value of the entering (period 0) capital stock, the present value of land rents, the value of sector-specific resource rents, the present value of wage income and all other taxes and transfers, respectively. (The final term includes the net value of transportation sales and purchases which are fixed at benchmark level).

Government budget

We have implemented an intertemporal budget balance condition for public expenditure associated with a once-off change in value-added taxes. The model includes no period-by-period constraints on the public budget, and the model produces an endogenous time profile of public sector deficits through the adjustment period. The public sector constraint simply requires that, following a tariff reform, value-added tax rates are increased sufficiently to offset the present value of reduced tariff revenues through the model horizon.

10. The intertemporal elasticity of substitution is $\sigma = 1/1 - \rho$.

Table 1 - Sectors in the model

WHT	Wheat
GRO	Other grains
NGC	Non-grain crops
WOL	Wool and other livestock
FRS	Forestry
FSH	Fishing
ENR	Energy products
MIN	Mineral products
MEA	Meat products
MIL	Milk products
FOO	Other food products
B_T	Beverages and tobacco
TEX	Textiles and apparel and leather products
LUM	Lumber and wood
PPP	Pulp and paper
CRP	Chemicals rubber and plastics
I_S	Primary ferrous metals
NFM	Non-ferrous metals
FMP	Fabricated metal products
TRN	Transport industries
MAC	Machinery and equipment
T_T	Trade and transport
SER	Services
CDG	Savings good

Table 2 - Sector-specific elasticities

	σ_{DM}	σ_{MM}	σ_{KL}	η_{DX}
WHT	8	16	0.6	5
GRO	8	16	0.6	5
NGC	8	16	0.6	5
WOL	8	16	1.0	4
FRS	8	16	0.9	4
FSH	8	16	1.0	4
ENR	8	16	0.3	4
MIN	8	16	0.4	4
MEA	8	16	0.9	4
MIL	8	16	0.9	4
FOO	8	16	0.9	4
B_T	8	16	1.0	4
TEX	8	16	0.9	4
LUM	8	16	1.0	4
PPP	8	16	1.0	4
CRP	8	16	1.0	4
I_S	8	16	0.9	4
NFM	8	16	1.0	4
FMP	8	16	1.2	4
TRN	8	16	1.2	4
MAC	8	16	1.2	4
T_T	8	16	1.3	4
SER	8	16	3.1	4
CGD	8	16	2.0	4

Key:
σ_{DM} = Armington elasticity of substitution between imports and domestic goods.
σ_{MM} = Elasticity of substitution between imports from different regions.
σ_{KL} = Elasticity of substitution between capital and labor.
η_{DX} = Elasticity of transformation between exports and domestic products.

Investment and Physical Capital Formation

In the current version of the model, we model aggregate capital formation, neglecting capital adjustment issues which could be addressed in a putty-clay formulation with sector-specificity of existing capital. Instead, we track economy-wide capital stock and investment. In every period, there is a rental-market for capital through which capital is allocated to different sectors.

Table 3 - Benchmark tax rates

(%)

	t_Y	t_M	t_{LAB}	t_{CAP}	t_{LND}
WHT	3	11	17	17	17
GRO	3	11	17	17	17
NGC	3	11	17	17	17
WOL	1	11	4	4	4
FRS	1	11	2	2	2
FSH	1	11	7	7	7
ENR	12	11	14	14	14
MIN	0	11	0	0	0
MEA	0	11	18	18	18
MIL	0	11	18	18	18
FOO	0	11	18	18	18
B_T	28	11	18	18	18
TEX	1	11	18	18	18
LUM	1	11	18	18	18
PPP	1	11	18	18	18
CRP	1	11	14	14	14
I_S	1	11	6	6	6
NFM	1	11	18	18	18
FMP	0	11	12	12	12
TRN	–1	11	10	10	10
MAC	1	11	10	10	10
T_T	2	11	3	3	3
SER	2	11	3	3	3
CGD	0	0	0	0	0

Key:
t_Y = output tax
t_M = import tariff
t_{LAB} = tax on labor
t_{CAP} = tax on capital
t_{LND} = tax on land

We vary t_{LAB}, t_{CAP}, and t_{LND} together to represent a change in the value added tax.

Table 4 - Other parameters

Elasticity of substitution in consumption between commodity groups	1.0
Intertemporal elasticity of substitution	0.5
Baseline interest rate	0.05
Baseline growth rate	0.02
Baseline depreciation rate	0.07
Gestation lag in investment	2 years

Results

Comparison of static and fully dynamic models

Our key results are presented in TABLES 5 and 6, where welfare results are presented as the Hicksian equivalent variation as a percent of consumption (or the present value of consumption in the dynamic model). In the case of the potential NAFTA agreement, we find that in a Ramsey type growth model, the gains from the free trade areas are larger than in the static model, but only marginally larger; with low elasticities the welfare results are the same, and with central elasticities, the welfare gains increase in the dynamic model by only about one-tenth of a percent of consumption. These results show that simply adding forward-looking investment does not necessarily generate large estimated welfare gains from regional trade arrangements when these arrangements do not provide large gains in a comparative static analysis, i.e., not any kind of dynamics will do to produce large estimated gains from trade liberalization. It appears, therefore, that it is necessary to numerically implement endogenous growth models (see Rutherford and Tarr, 2002) to obtain significantly larger estimated gains.

In the case of the MERCOSUR agreement, with low elasticities the results of the static and dynamic models are the same. With high elasticities, however, the losses are slightly larger with the dynamic model. The reason for larger losses in the dynamic model is that with high elasticities, MERCOSUR induces a loss to Chile in the static model (due to trade diversion costs and terms-of-trade losses as partner countries increase their prices of exports) and the return to capital declines in the static model; but the static model holds the capital stock fixed. In the dynamic model, the adverse impact on the return to capital in Chile from MERCOSUR induces a decline in investment and the capital stock declines relative to a steady-state capital stock prior to MERCOSUR. This shows that a dynamic model may produce larger losses when there are estimated losses from a static model.

Table 5 - Welfare effects for Chile in NAFTA: alternative models

	Central elasticities		Low elasticities	
	% EV	% VAT	% EV	% VAT
1. Static multi-regional	1.3	26.0	0.5	46.0
2. Static open economy	1.3	41.8	0.5	24.6
3. Uncalibrated steady state	5.9	15.8	2.9	27.0
4. Calibrated steady state	2.3	20.8	1.1	36.7
5. Dynamic Ramsey	1.5	21.5	0.5	37.7

Key:
EV = Percentage change in Hicksian equivalent variation as a percentage of the present value of consumption along the calibrated steady-state growth path in the Ramsey model.
VAT = Required equiproportional increase in the VAT rate across all sectors to maintain constant government revenue.

Table 6 - Welfare effects for Chile in MERCOSUR: alternative models

	Central elasticities		Low elasticities	
	% EV	% VAT	% EV	% VAT
1. Static multi-regional	–1.0	45.1	0.1	17.0
2. Static open economy	–0.7	47.3	0.1	17.0
3. Uncalibrated steady state	–0.7	47.0	1.1	12.6
4. Calibrated steady state	–0.9	43.1	0.3	14.6
5. Dynamic Ramsey	–0.8	43.2	0.1	14.9

Results with the steady-state model

TABLE 5 shows that in the case of Chile joining NAFTA, where there are gains from the comparative static model, our basic steady-state model produces gains about four to five times larger than the gains from the comparative static model. Combined with our results from the dynamic model, these results verify what we have emphasized in prior work: when the capital stock increases the steady-state model produces upper bound estimates of the dynamic gains since the costs of foregone consumptions are ignored in the steady-state calculation.

We have also developed estimates from a model we refer to as the calibrated steady-state model. The first step in building the dynamic model is to construct a steady-state equilibrium growth path. This requires reconciliation of data on the value of capital earnings and the value of investment with depreciation, growth and interest rates. As has been emphasized by Mercenier and Michel (1995), data on the value of capital's earnings are typically too large for consistency, in part because the value of proprietor's income is attributed entirely to capital. Thus, we reduce capital's earnings and the implied capital stock in the initial data which allows us to calibrate a consistent reference steady-state growth path for the dynamic model. In particular, when the model is calibrated to a 2 growth rate, 7% capital depreciation rate and 5% interest rate, the capital value share is reduced by 33%. We impose the same adjustment in the benchmark equilibrium for the calibrated steady-state model. With a lower initial capital stock, the induced increase in the capital stock from NAFTA is also smaller, so that the gains from the calibrated steady-state model are less than in the unadjusted steady-state model. We conclude that it is important when using a steady-state model to calibrate the data set for dynamic consistency. In particular, there is a relationship between the interest rate, the depreciation rate and the growth rate that is consistent with the conditions necessary for steady-state equilibrium. In addition to theoretical consistency, doing so will typically produce estimates closer to the true estimates of the fully dynamic model.

Our primary conclusion in this subsection is methodological. In practical general equilibrium work it makes sense to initially analyze policy equations using a static general equilibrium model. These results can then be compared to the corresponding steady-state model, recognizing the importance of constructing a consistent steady-state growth path with plausible underlying parameter values for the interest rate, growth rate and depreciation rate. A dynamically consistent steady-state model is likely to produce estimates closer to the true dynamic model.

If the static and steady-state equilibrium results are close, then it may be ill-advised to spend time developing a fully dynamic model of the transition path. If they are quite different, then the transition effects may play a crucial role in evaluating the efficiency effects of a policy change.

Should dynamic models produce larger gains?

Although authors have for some time alleged that dynamic models would produce larger gains from trade liberalization (e.g. Baldwin (1992)), gains which would correspond to the intuition that trade liberalization is responsible for larger welfare gains than is obtained from comparative static models, there is a question of whether this intuition is appropriate in a Ramsey type growth model or a comparative steady-state model without endogenous growth. Focusing first on the comparative steady-state model, if the capital stock increases in the new steady-state then there is likely to be more output and consumption than in the comparative static model, which will typically lead to larger welfare gains. The question devolves then to whether we should expect an increase in the long run equilibrium capital stock.

Let q represent the marginal cost of a unit of new vintage capital. In our model this cost function has the form:

$$q = \sum_i a_i^I \left[\beta_i^M \left(p_i^M\right)^\rho + \left(1-\beta_i^M\right)\left(p_i^D\right)^\rho \right]^{1/\rho}$$

In the steady-state model, the capital stock adjusts so that the ratio of the rental rate on capital to the cost of producing a unit of the capital good is constant:

$$\frac{r_K}{q} = \rho + \delta$$

implying that in the long-run equilibrium, the return to capital is equal to the sum of the discount rate on future consumption plus depreciation.

When this ratio rises as a result of a shock, there will have to be an increase in the capital stock to reduce the marginal productivity of capital to restore equilibrium. A fall in this key ratio, however, will induce a fall in the long run equilibrium capital stock.

It is known result in the Hecksher-Ohlin literature that the rental rate on capital relative to the wage rate can go up or down depending primarily on whether the shock induces an increase or decrease in the relative price of the capital intensive good. In general, trade liberalization could favor labor intensive industries as easily as capital intensive ones, so there should be no presumption that the rental rate of capital will increase relative to the wage rate. In some developing countries, trade liberalization would be expected to favor agriculture, which is likely to be labor intensive. In these countries we would expect to see a fall in the rental rate of capital relative to the wage rate.

But it is not the rental rate on capital relative to the wage rate that is important for the long run capital stock. The relevant denominator in the ratio which determines the long run equilibrium level of the capital stock is the price of a unit of capital, *q*. In a model of homogeneous goods, the Stolper-Samuelson theorem implies that if the rental rate falls relative to the wage rate, the rental rate must also fall relative to the price of the goods in the model. That is, if the rental rate falls relative to the wage rate, then the ratio r_K/q would also fall in a Hecksher-Ohlin model of trade.

But we employ the Armington assumption, in which imported and domestic goods are imperfect substitutes. Due to the Armington assumption, it does not follow that the rental rate must fall relative to the price of all goods, if the rental rate falls relative to wages. As indicated in the cost function above, the capital good is produced by both domestic and imported inputs as well as labor and capital, and a trade liberalization will reduce the price of imported inputs. Thus, there is a general presumption that q will decline. Even when trade liberalization shifts resources to labor intensive industries and induces a fall in the rental rate of capital relative to the wage rate, the price of a unit of capital, *q*, could fall more inducing a rise in the capital stock. Although the ratio r_K/q could fall, we would normally expect it to rise. This explanation justifies the presumption that a steady-state model will produce greater estimated gains than a static model, when the static model produces gains.

In Harrison, Rutherford and Tarr (1997a, TABLE 5) we estimated the gains from the Uruguay Round on 24 regions in both comparative static and steady-state models, under four different policy trade liberalization policy shocks, i.e., 96 numerical simulations were presented. In the vast majority of the cases we found that the steady-state gains were larger than the comparative static gains. Other authors, such as Francois, McDonald and Nordstom (1996) found similar results. There were a few cases, however, where we found that the gains in the comparative steady-state model were smaller than the gains from the comparative static model.[11] These exceptional cases illustrate that the rental rate on capital can decline by even more than the cost of capital such that the capital stock and the welfare estimates decline in the steady-state. But the fact that the large majority of cases result in larger gains in the steady-state reflects the decline in the cost of the capital good due to the trade liberalization.

Conclusions

We began by constructing a static small open economy model of Chile that has replicated the results for Chile of the Harrison, Rutherford and Tarr (2002) static multi-region model. There has been some controversy in the literature as to whether this is possible.

11. For example, Singapore was estimated to gain 1.9% of GDP is steady state and 2.3% of GDP in the static model. Examing agriculture reform alone, Singapore, Brazil and Canada were all estimated to gain less in the steady state model than in the static model.

We developed a fully dynamic small open economy model of Chile with constant returns to scale in all sectors The principal difference between the static and dynamic models is that in the dynamic model the capital stock is optimized along the steady state growth path based on the consumption-investment tradeoff. Our key result is that this kind of dynamic model need not produce estimated welfare gains signficantly different from a static model. The reason is that since the capital stock is already optimized on the steady state path based on the consumption-investment tradeoff, trade liberalization that induces a larger capital stock does not necessarily improve welfare. So not any kind of dynamics is sufficient to produce larger gains from trade liberalization and gains from a regional arrangement that is welfare reducing in a static model. Moreover, in the case of the Chile-MERCOSUR agreement, we estimate slightly larger losses in the fully dynamic model that we estimate in the static model. Thus, when dynamic impacts are taken into account, there may be larger losses than in a static model.

We estimated the impact of Chile-NAFTA and Chile-MERCOSUR in steady state models. We found little difference in the static and steady state results for Chile-MERCOSUR. For Chile-NAFTA, the gains are substantially larger in a comparative steady state model. It is known that comparative steady state models systematically overestimate the gains compared to a fully dynamic model with the same features, since the foregone consumption costs of attaining a higher capital stock are ignored. But we show that an additional bias is that the calibration may be inconsistent with a steady state growth path. When we reduce the calibrated capital stock to be consistent with a steady state growth path, the estimated gains in a properly calibrated comparative steady-state growth model may be significantly less than in a comparative steady-state growth model that is not consistently calibrated.

Going beyond the models of this paper, proponents of regional trade agreements might argue that learning and technology transfer effects from RTAs would result in much larger gains, and would produce gains even if the static effects are dominated by trade diversion. That is, an endogenous growth model would produce estimated gains for Chile forming a free trade arrangement with MERCOSUR even though a comparative static model does not. Rutherford and Tarr (2002) have estimated that when these learning and technology effects are taken into account endogenously in a fully dynamic model, the estimated gains from trade liberalization will be many multiples of the estimated gains from a static model. Moreover, foreign direct investment could increase as a result of a RTA, and this could have additional benefits.

But there is a dynamic form of trade diversion in models that allow for productivity impacts and technology transfer from imports as well. That is, while regional preferences will encourage additional varieties and technology imports from regional partners, it will discourage imports and additional varieties from the rest of the world. It is likely to be very important in this context to question how technologically advanced and how big is the prospective partner. For large developed regions like the European Union or NAFTA, the additional technology imports are likely to be sufficiently large to offset the losses from the rest of the world. Then the dynamic model will produce gains from regional arrangements with technologically advanced partners that are several multiples of the estimated gains from static models. On the other hand, if a RTA is made with a technologically less advanced region, the diversion of new technologies or varieties from the rest of the world could hinder productivity advances in the home country. On balance growth and welfare may be reduced and it may result in losses several multiples of the estimated static losses[12].

T.F. R. & D.G. T.

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12. An earlier version of this paper was presented at the ASSA meetings in New Orleans, LA., January 1997, and at the conference, *Using Dynamic Computable General Equilibrium Models for Policy Analysis*, in Assens, Denmark, June 1998.
The authors would like to thank Glenn Harrison, Maurice Schiff, Alan Winters, and seminar participants at both conferences, for helpful comments. We are especially grateful for the comments of James Markusen, and we have added section 3.4 in response to his comments. Research support was provided by the World Bank under RPO N° 68140. The views expressed are those of the authors and do not necessarily represent those of the World Bank.

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