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ON THE REMOVAL OF AGRICULTURAL PRICE BANDS IN CHILE: A GENERAL EQUILIBRIUM ANALYSIS

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Resumen

Chile ha apoyado su agricultura con bandas de precios para ciertos productos, tales como trigo, aceites y mantecas vegetales, y azúcar. En este artículo se revisa la reforma agrícola y cómo el desempleo urbano y la migración hacia la ciudad puede alterar los efectos esperados de la reforma agrícola sobre el bienestar. Aquí se usa un modelo computable de equilibrio general para la economía chilena basado en Harris-Todaro, incorporando movilidad laboral imperfecta. También considera la eliminación de bandas y una reforma agrícola más extensa que elimina todos los aranceles sobre productos agrícolas y alimenticios en Chile. Los resultados muestran que si las reformas comerciales perjudican la economía rural en Chile, las eventuales ganancias de bienestar por la baja de los precios agrícolas son contrarrestadas por un mayor desempleo urbano y menores salarios rurales. El resultado de la reforma comercial es una pérdida neta de bienestar.

Abstract

Chile has supported its agriculture with the use of price bands on selected commodities namely wheat, vegetable oils and fats, and sugar. In this paper we consider agricultural reform and how urban unemployment, and rural-urban migration, may alter the expected welfare effects of agricultural reform. We utilize a new CGE model of the Chilean economy based on the Harris-Todaro framework, incorporating imperfect labor mobility, and consider both price band removal and more extensive agricultural reform that eliminates all tariffs on agricultural and food commodities in Chile. Results show that if trade reforms damage the rural economy in Chile, potential gains in welfare from lower agricultural prices are offset by increased urban unemployment and lower rural wages resulting in net welfare loss from trade reform.

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1. Introduction

A component of agricultural policy in Chile has been the use of price bands to stabilize domestic price movements in selected agricultural crops and processed agricultural commodities. For the decade of the 1990's the use of price bands for wheat, fats and oils and sugar has resulted in the equivalent of a roughly a 22 percent tariff on these commodities (Table 3). Depending on the result of pending discussions with the WTO following a complaint by Argentina and of ongoing discussions regarding Chile's participation in the North American Free Trade Agreement it is possible that constraints will be imposed on Chile's use of price bands to protect its agricultural economy. However, the prospect of agricultural trade policy reform in Chile leads to the emergence of a number related policy concerns.

One of these is rural-urban income divergence, which remains at high levels. Rural wages are roughly one third of the average wage in Chile's large cities (CASEN 1996). Carter (1997) notes the implications for political stability. Another consequence of income divergence is rural-urban migration (Harris and Todaro, 1970). Urban populations have been growing faster than rural populations throughout the 1990s. A closely related issue that has come into increasing prominence in the recent economic slowdown is the emergence of high levels of urban unemployment.

A question of considerable interest then, is what effect might these developments have on the economic analysis of the outcome of trade liberalization? There has been some interest in quantitative modeling of the likely effect of Chilean trade liberalization, and several recent applied general equilibrium studies have thrown light on the possible outcomes (Harrison, Rutherford and Tarr, 1997; Benjamin and Pogany 1998). However, the existing literature has utilized more aggregated models of a strongly neoclassical flavor. As the preceding discussion indicates, the Chilean economy exhibits certain features closely associated with the development literature – rural-urban migration, urban unemployment, and imperfect labor mobility. Since these economic features can have important consequences for analyzing the effect of a number of different policies including trade reform, it seems appropriate to consider Chilean agricultural reform in the context of a model that incorporates them. That is what this paper attempts to do.

The paper is organized as follows. In Section 2 we briefly discuss the policy background. In Section 3 we use a formal general equilibrium model to illustrate some important agricultural trade policy consequences of urban unemployment and imperfect labor mobility. This formal model also highlights the underlying structure of a larger (50 sector) numerical general equilibrium model that we describe in Section 4. In Section 5 we present the results of simulations designed to quantify the effects of removal of the price bands in Chile under the assumption of dual labor markets with imperfect labor mobility, and we discuss policy implications. Accounting for the second-best implications of urban unemployment and limited labor mobility is shown to affect outcomes of agricultural reform. A key result is that price band removal results in modest net welfare gains, but with more comprehensive removal of all agricultural and food tariffs, the welfare gains turn negative. This is a consequence of predicted increases in urban unemployment and declines in rural wages. Section 6 contains concluding comments.

2. Policy Background

Overall economic growth in Chile has been very uneven, and the division between rural and urban economies remains significant. Analysts have noted Chile's inability to integrate the poor rural regions with the rapidly growing industrial economy. Other researchers have focused on the phenomenon of rural-urban migration in response to rural-urban income differentials. These differentials persist in the face of high rates of unemployment in Chile's major urban centers.

There is considerable debate over the importance of different factors as determinants of migration responses. The general economic framework postulates that migrants make rational economic choices – considering the real income adjusted for the probability of obtaining employment at the destination, and the costs of migration. Costs may include transportation, job-search (expenses and opportunity cost), lodgings, etc. They may include 'upskilling' costs such as education and training necessary to obtain urban employment. They may also include less immediately obvious, but nonetheless real, opportunity costs such as giving up locational preferences, and attachments to existing arrangements. These costs may be offset by chain effects – the availability of information through networks of previous migrants. .

While labor migration may lead to a more efficient allocation of resources in a first-best framework, in a second-best framework, migration may worsen problems of urban congestion and unemployment, significant levels of which have developed in urban Chile in the early 2000's. In Santiago, the rate of unemployment in 2001 was more than 10 percent.

So, we have a number of important economic developments in Chile: high rates of urban unemployment; continuing flows of migrants from rural to urban areas in search of better income opportunities, and the attendant mix of urban congestion and poverty. Into this heady mix of domestic economic issues comes Chile's bid to join the North American Free Trade Agreement, which will clearly entail further reform of its external (trade) policy. The remainder of the paper explores the consequences of agricultural trade reform in Chile given the domestic problems of urban unemployment and rural-urban migration.

3. Theoretical Framework

In order to help reinforce the structure of the numerical model we describe in Section 4, we present a formal derivation of some key results concerning agricultural liberalization in a model with rural-urban migration, and how these may be altered by imperfect labor mobility. Consider a developing economy with distinct rural and urban regions. An industrial good *X* is produced in the urban region, and exported. An agricultural good *Y* is produced in the rural region. Full employment of labor prevails in the rural region, but a rigid wage in the urban region creates unemployment. Following Harris-Todaro (HT), migration occurs between the two regions until the expected urban wage is equal to the actual rural wage. Capital is fully mobile. To keep things simple, world prices and factor endowments are exogenous. A compact algebraic description of the model is then:

$$c_X(\overline{w}, r) = 1 \qquad (1)$$

$$c_Y(w, r) = p_Y \qquad (2)$$

$$w = p\overline{w} \qquad (3)$$

$$a_{XL}X + pa_{YL}Y = p\overline{L} \quad (4)$$

$$a_{XK}X + a_{YK}Y = \overline{K} \quad (5)$$

$$G(p_Y, \overline{K}, L_X, L_Y) + (p_Y - p_Y^*)M_Y = E(p_Y, u) \quad (6)$$

Equations (1) and (2) are zero profit conditions (we have chosen p_X as numéraire), which can be solved for the factor prices. Once these are known, Shepherd's lemma enables us to derive the optimal input-output coefficients (a_{ij}). Equation (3), the HT labor market equilibrium condition, can be solved for the equilibrium rate of employment p. Equations (4) and (5) are the factor market constraints, which can then be solved for output levels. Finally, (6) is the budget constraint expressed in terms of the GNP and expenditure functions, which can be solved for the welfare level. All the usual assumptions apply, production functions are homogeneous of degree one, continuous, and strictly concave, the utility function is continuous, quasi-concave and increasing in consumption of both goods. To guarantee stability, assume that *X* is capital intensive (the Neary condition). Now, totally differentiating the budget constraint yields:

$$dW = (p_Y - p_Y^*)dM_Y + \overline{w}\,dL_X + p\overline{w}dL_Y \quad (7)$$

where $dW \equiv E_u du$, and a superscript * designates a world price. Following Corden and Findlay (1975), define the total urban labor force as L_U, then $dL_X = pdL_U + L_U dp$. Substituting into (7) we have:

$$dW = (p_Y - p_Y^*)dM_Y + \overline{w}L_U dp \quad (8)$$

where we have simplified by making use of the fact that $dL_U + dL_Y = 0$. Thus the incremental change in welfare is the sum of a Harberger effect, and the effect of changes in the probability of employment. As is well-known, free trade is sub-optimal, since $dW \neq 0$ when $p_Y = p_Y^*$ (only the first term drops out).

Let *t* be an tariff imposed on *Y*, so that $p_Y^*(1+t) = p_Y$. Using this, and dividing both sides of (8) by dt we have:

$$dW/dt = tp_Y\,(dM_Y/dt) + \overline{w}L_U\,(dp/dp_Y)(dp_Y/dt) \qquad (9)$$

Which is the basic decomposition of the welfare effect of an agricultural import tariff. The first term reflects the deadweight loss, and is negative. However, $dp_Y/dt = p_Y^* > 0$, and hence a sufficiently small tariff will raise social welfare if it raises the probability of employment.

Factor prices are determined entirely by goods prices by construction, and so from logarithmically differentiating (1) and (2) and solving we obtain:

$$\hat{w} = \hat{p}_Y q_{KX} / (q_{LY}\, q_{KX}) \qquad (10)$$

where a circumflex denotes a proportional change, q_{ji} is the cost share of factor *j* in industry *i*, and $\hat{p}_Y = (p_Y^*/p_Y)dt > 0$. It is clear from (1) that the return to capital is fixed. Now from (3) we know that $\hat{p} = \hat{w} - \hat{\overline{w}}$, hence the probability of finding urban employment improves with a small tariff on *Y*. Reversing the arguments: liberalizing agricultural trade may lower welfare.

The preceding analysis has cast the neoclassical HT model of the developing economy in a slightly different light – the model is generally used to illustrate the negative welfare consequences of restricting imports of capital-intensive goods. Less often emphasized is the positive welfare effect of agricultural export subsidies, the clearly implied (second-best) role for agricultural protection.

Three recent papers have attempted to incorporate imperfect labor mobility into the HT framework (Parai and Beladi, 1997; Gilbert and Mikic, 1998; Gilbert and Wahl, 2000). The latter two introduce the concept of the 'elasticity of labor migration'. Consider a situation where there is a differential between the rural wage and the expected urban wage, r, and hence (3) becomes $w = p\overline{w} - r$. The variable r is positive and may represent locational preferences, attachments to existing arrangements, a high cost of relocation, and/or the effect of a restrictive government policy, as discussed in Section 2. The elasticity of labor migration can then be defined in a natural way as $e = \hat{L}_U/\hat{r}$, the proportional change in the total urban population induced per proportional change in the expected wage differential

($0 < e < \infty$). All other equations remain unchanged, as does the fundamental welfare derivation for a tariff on Y given above (9). However, the proportional change in the probability of employment is now:

$$\hat{p} = \frac{ew\hat{w} + r(\hat{a}_{XL} + \hat{X})}{ep\overline{w} + r} \tag{11}$$

which is of ambiguous sign in general.

A full analytical description of the properties of this model, while interesting, is beyond the scope of this paper. However, note that $\lim_{e \to 0} \hat{p} = \hat{a}_{XL} + \hat{X}$, which in the case of a tariff on Y discussed above can be shown to have negative welfare effects. Hence, the less labor movement is allowed, the greater the potential for gains from agricultural liberalization. Note also that $\lim_{e \to \infty} \hat{p} = (w/p\overline{w})\hat{w}$, and so this model converges to the standard HT case. It is also clear that there will be a critical value of e (such that $\hat{p} = 0$) beyond which the model will behave in the same manner (qualitatively) as the standard HT model.

The intuition behind the result is quite straightforward. An agricultural tariff in the standard HT model draws labor and capital out of the urban region, but because agriculture is labor intensive, more labor is drawn than capital. The end result is an improvement in urban employment. Now consider the limiting case of no labor migration. The rural wage rises as before and agricultural output expands. Now, however, labor cannot move to fill the needs of agriculture. A reduction in production of X then leads to higher urban unemployment. Welfare subsequently declines. Hence, the degree of labor mobility, in addition to the prevalence of urban unemployment, become important variables when evaluating the consequences of agricultural trade liberalization in a developing economy.

4. An Applied General Equilibrium Model

The simplified framework described above, while helpful in formalizing the issues involved, makes a number of major abstractions in the interests of tractability. The most obvious is the dimensions of the model, and the effect of other policy distortions in the equilibrium system, which can have important second best implications. While it is difficult if not impossible to take all of these factors into account within the constraints of an abstract formal model, applied general equilibrium (AGE, also known as computable general equilibrium or CGE) models are well-suited to the task. These models take data from an actual economy or set of economies, and combine it with a structural description of the behavior of agents within the system, and the constraints that they face. The system can then be solved numerically, and the effect of policy intervention can be quantitatively examined within a consistent framework that accounts for important market interrelationships.

In this section we describe an applied counterpart to the formal model analyzed above. A complete algebraic description of the model is presented in Table 1. Our notation uses the Greek alphabet to denote free and calibrated parameters, lower case letters to denote policy variables, and bars to denote those variables fixed by the closure assumptions. Full definitions are contained in Table 2. The basic structure is the well-established single-country Armington trade model, of which a number of accessible descriptions exist (see, for example, Devarajan and Lewis, 1990), so we present only brief details.

The production block consists of a set of CES production functions (1), with intermediates used in fixed proportions. Equations (2) are the corresponding demand functions for primary factors. Note that a subset of factors have prices fixed exogenously in a subset of sectors, corresponding to the rigid urban wages of the HT specification.[1] This implies unemployment of that subset of factors, with the rate of employment defined by (3). Equations (4) are our modified HT factor market equilibrium conditions, and (5) introduces an inelastic migration response as in our simplified model above.[2] Finally, (6) defines the factor market constraints.

The demand block consists of two levels. At the first level households maximize a Stone-Geary LES system, the objective function of which is (8), subject to their income as defined in (7). Equation (9) defines the corresponding household demand functions. Firms demand final goods in fixed proportions to their output (10). Final demands for government consumption and investment are fixed in quantity terms by (11) and (12). Having allocated their expenditure across the commodities, all agents then choose the optimal combination of imports and domestic production (the Armington composite). This is reflected in the demands for domestic production (13) and imports (14), for each agent.[3] Introduction of product differentiation via this mechanism is the major departure of the model from the models of standard trade theory.

Equations (15)-(19) describe the price equations of the model, and have straightforward interpretations. Equation (17) defines the price of a composite of imports and domestic production, and is derived from the assumption of CES Armington aggregation. Similarly, we have used CED functions to describe how world prices respond to changes in the trade volume (19). Equation (18) defines net prices. Note that the nominal exchange rate is the chosen numéraire for the system (all prices in the model are relative prices).

Lastly, we impose equilibrium conditions on the model. Equation (20) defines the familiar material balance conditions, and (21) the balance of trade. The current account balance is set exogenously. Since Walras' law implies the equilibrium conditions are not independent, any one of them can be dropped.

To summarize, the AGE model presented here incorporates the key features of our formal modeling: institutionally rigid urban wages and corresponding urban unemployment, rural-urban migration in response to expected wage differentials, and an imperfectly elastic migration response. It also makes a number of extensions. It can accommodate many endowment factors, each of which may be fully or partially employed, fully or partially mobile, or specific to a given economic activity. It can accommodate many sectors, each of which can be classified as rural/urban and traded/non-traded (note that for simplicity we have not differentiated between traded and non-traded goods in Table 1). The model incorporates product differentiation, allowing it to accommodate simultaneous export and import activities in the same sector, and varying domestic/import preferences by agent. Finally, the model incorporates a complete set of trade taxes and subsidies to ensure accounting for the second-best implications of policy interventions.

The GTAP4 database (McDougall et al., 1998) is used as the primary source of the production, protection and trade data used in the model, and also for many of the free parameters.[4] The base year of the data is 1995. Although virtually all of the now extensive applied general equilibrium literature based on the GTAP4 database utilizes the GTAP model described in Hertel (1997), or derivatives thereof, it is a straightforward procedure to extract the information necessary to construct a single-economy model such as that used here. Also, because we are using a single country model, we are able to work at a much greater level of detail (50 sectors, 4 non-traded and 46 traded – the full GTAP4 disaggregation) than most of the GTAP-based literature. Using the GTAP4 data ensures not only that our starting point is consistent with much of the existing research, but also that the data is widely available to other researchers to replicate our results.

We supplement the GTAP data with rural and urban labor force counts from the 1996 CASEN database (National Survey of Social-Economic Characterization), which are used to estimate rural and urban wages consistent with the GTAP4 payments data. Agricultural and resource based industries (forestry, fishing and mining), along with processing activities that are generally located close to a raw material source (food production, lumber production, etc.) are assumed to be rural activities, while textiles, heavy manufactures and services are classified as urban. In this model the urban region represents the cities of Santiago, Concepción, and Valparaíso. The rest of Chile is represented as rural. The initial (baseline) urban unemployment rate of 7.35 percent is from the CASEN survey. The implied expected urban-rural wage differential in 1995 is nearly 200 percent (i.e., the rural wage is just over one third of the expected urban wage) – reflecting the substantial impediments to labor mobility that remain a feature of the Chilean economy. As there are no available estimates of the elasticity of labor migration, we use two limiting values – low (0.1) and high (10). The model is implemented in GAMS and solved in levels form. In the following section we present the results of our policy simulations.

5. Results and Policy Implications

The results of the simulations are presented in Tables 3–6. Table 3 summarizes the recent history of commodity price bands in Chile in terms of tariff equivalents. Table 4 presents some important economy wide summary statistics for the estimated effects of removal of the agricultural price bands followed by estimated effects of removal of all tariffs on agricultural/food commodities. The first column gives the estimated change in welfare, measured as the equivalent variation in $US1995 millions. The second column is the estimated rate of urban employment (one minus the rate of urban employment gives the rate of urban unemployment). Finally, the third column gives the rural labor wage as a percentage of the urban labor wage. Table 5 presents estimated percent changes in baseline agricultural production, while Table 6 presents the estimated percent changes in baseline agricultural imports. Of course changes in trade and quantity supplied occur in all other sectors as well. We do not report those results in this paper but they are available from the authors.

Consider first the effect of removing the price bands on wheat, fats and oils, and sugar. When labor movement is relatively inelastic, welfare is estimated to rise by just over $6.28 million. When a high level of labor mobility is assumed, the gains drop by over $3 million but are still positive. This result leads us to two conclusions. First, it confirms the importance of the migration elasticity parameter. As our simple abstract model indicated would be the case, when labor is relatively immobile, removal of price bands improves the urban unemployment problem. When labor is more mobile, however, price band removal leads to expanded migration to urban areas, and hence to expanded urban unemployment compared to the low mobility scenario. This has a detrimental effect on the net welfare gains from liberalization.

When labor is relatively immobile price band removal improves urban unemployment because more capital than labor shifts to the urban economy and the increased capital allows more urban labor to be employed at the fixed wage. In the case of high mobility, the employment rate in urban still goes up, and the rural wage goes up compared to the base line. This is because more of the rural labor force has moved to the urban allowing the rural wage to be bid up for the remaining labor. However, there is less welfare gain in the case of high mobility because of the increase in urban unemployment.

The estimated effect of the reform scenarios on Chile's pattern of food and agricultural production as well as imports is presented in Tables 5 and 6.[5] Two main patterns emerge. The first is that removal of the price bands leads to substantial expansion of imports of the directly affected commodities, as we might expect. Second, the results also indicate that the next most substantial changes in import volumes (which are negative) are for the commodities, such as sugar beets that are inputs into the production of the directly affected commodities such as sugar. For example, with removal of the price band on sugar imports of sugar are increased 69 percent (Table 6.) and sugar production is reduced by nearly 5 percent (Table 5).[6] With reduced sugar production the inputs into domestic sugar production such as sugar beets are likewise reduced (Table 5).

Now consider the case of full removal of agricultural tariffs. This policy leads to a loss in welfare with increasing welfare loss as the elasticity of labor migration increases. The reduction in agricultural supply is more pronounced; the more labor mobility is allowed (Table 4). With high labor mobility, the urban employment rate falls relative to the baseline. As capital and labor is drawn out of rural areas the rural wage declines reflecting the relative reduction in capital in the rural region resulting from increased international competition. The result is a falling employment rate in the urban area, increased unemployment in the urban area and reduced wages in the rural area. While total returns to capital do increase, the harm inflicted on rural workers and the worsening of urban unemployment offset the efficiency gains from cheaper imports resulting in a net welfare loss. In the case of low mobility, the loss in welfare stems mainly from the reduction in rural wage relative to the urban wage. In this scenario, the urban employment rate manages to increase relative to the baseline but urban unemployment increases and the overall change in welfare is negative.

In summary, the results of the model generate several valuable policy lessons. The first and most important point is that, in a general equilibrium model that accounts for imperfect labor mobility and urban unemployment; removal of the price bands on wheat, sugar and fats and oils is welfare increasing, but the net effects of total agricultural tariff elimination are estimated to be negative. The elimination of all agricultural and food tariffs generates sufficient urban unemployment so as to negate the positive welfare effect stemming from lower agricultural and food prices. Chile's labor policy needs to be closely coordinated with possible trade liberalization. If reform results in significant harm to the agricultural sectors increases in urban unemployment will mitigate the beneficial economic efficiency effects.

6. Concluding Comments

Like all economic models, the applied general equilibrium techniques utilized in this paper are based on a highly stylized structural framework, and this raises a number of issues. One problem with the approach used here is that it is difficult to separate rural and urban activities cleanly using sectoral lines. Another is that the single country specification means we are unable to account for the effect of Chile gaining access to other markets, or the effect of Chile liberalization on other economies. In respect of the latter issue, there have now been several studies using global general equilibrium models, so there is little need to add to that literature. Most of the gaps that remain to be filled involve Chile-specific issues, and more detailed single-country models are an appropriate analytical tool. With respect to the former, to paraphrase Whalley (1985), the contribution of applied general equilibrium models is to increase the level of understanding of how institutions affect outcomes, to tell a story that is consistent with a set of stylized facts, and to provide a consistent framework for the policy debate. The results presented in this paper should be interpreted in this context. .

Our findings suggest also that, given the existence of urban unemployment and its second-best implications, that policies harmful to agriculture and other rural based industries should be approached with caution if they are likely to provoke worsening terms of trade for the rural sectors. The gains from lower natural resource prices are likely to be offset by worsening rural-urban income divergence and urban unemployment.

The other point to note that the analysis in this paper examines only removal of agricultural and food product tariffs. More comprehensive trade liberalization would also remove existing export and output barriers, taxes, and subsidies on agriculture as well other portions of the economy. It is quite possible that the net effect of complete liberalization would result in economy-wide adjustments that would substantially improve overall welfare, but that is another study.

Endnotes:

[1] We emphasize that there is no government imposed wage floor in Chile, and hence our characterization of unemployment as arising from downward inflexible wages is a simplification. Other explanations (such as search costs) are plausible. We also note that labor classified as unemployed in this model does not contribute to net social welfare, whereas the reality is that these workers are likely to be involved in the informal sector (although their marginal productivity may well be very low). For both of these reasons our model probably presents what can be interpreted as 'worst case' scenarios for unemployment.

[2] The Harris-Todaro specification of labor market equilibrium is often interpreted as implying a competitive auction in each period, with each worker having an equal chance of obtaining employment. We emphasize that, as in all models, this is a stylized description – we interpret (5) only as meaning that, once the dust has settled, any new equilibrium will have the familiar HT characteristics.

[3] Allowing each agent to independently make import decisions along Armington lines is known as the SALTER specification.

[4] The calculation of model parameters is specified in GAMS code for the Chile model. The code and the model is available from the authors upon request.

[5] It has been pointed out that the GTAP4 data (1995) on vegetable oils no longer represent the current situation in Chile. The data indicated a small domestic oil industry with small imports. Now, the domestic crushing industry has disappeared as has production of edible oil seeds being replaced by imports of edible oil.

[6] The production functions used in the model assume quasi-concavity and continuity. In a sector like sugar with only a few processing plants that require a minimum output level to remain viable the assumption of continuity becomes somewhat tenuous. In this case, reduction of production below a given threshold would result in collapse of the industry. From this point of view, our prediction of a 5% reduction in sugar production may be conservative and dependent upon a continuity assumption that may not be true. Some observers of Chilean agriculture feel that without the protection of the price band the sugar industry would collapse completely.

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Table 1: Equations of the Model

Sets:

$g:$	Agents	$u \subset i:$	Urban sectors
$i(j) \subset g:$	Sectors	$m \subset f:$	Under-employed endowments
$f:$	Endowment commodities		

Production:

$$Q_i = \{a_i^Q \big/ (1 - \sum_j a_{ji})\} (\sum_f q_{fi}^Q FD_{fi}^{-r_i^Q})^{-1/r_i^Q} \tag{1}$$

$$PF_{fi} = PN_i \{a_i^Q \big/ (1 - \sum_j a_{ij})\} (\sum_f q_{fi}^Q FD_{fi}^{-r_i^Q})^{-1/r_i^Q - 1} q_{fi}^Q FD_{fi}^{-r_i^Q - 1} \qquad PF_{mu} = \overline{PF}_{mu}, \ PF_{fi} = PF_f \quad f \notin m \tag{2}$$

$$ER_m = \sum_i FD_{mi} \big/ (\sum_i FD_{mi} + UN_m) \tag{3}$$

$$PF_{mi} = ER_m \overline{PF}_{mu} - COST_m \qquad i \notin u \tag{4}$$

$$\sum_u FD_{mu} + UN_m = a_m^M COST_m^{e_M} \tag{5}$$

$$\sum_i FD_{fi} = \overline{END}_f - UN_f \tag{6}$$

Demand:

$$NDI = \sum_i Q_i PN_i + \sum_i tm_i \overline{PWM}_i \sum_g M_{ig} \overline{XR} + \sum_i tx_i PD_i X_i - \sum_i ty_i PD_i Q_i - \sum_{ig} C_{ig} P_{ig} - \overline{CA} \cdot \overline{XR} \qquad g = \text{government, investor} \tag{7}$$

$$U = a \prod_i (C_{ig} - l_i)^{q_i^C} \qquad g = \text{household} \tag{8}$$

$$C_{ig} = l_i + (q_i^C \big/ P_{ig})(NDI - \sum_j l_j P_{jg}) \qquad g = \text{household} \tag{9}$$

$$C_{ij} = \sum_j a_{ij} Q_j \tag{10}$$

$$C_{ig} = \overline{G}_i \qquad g = \text{government} \tag{11}$$

$$C_{ig} = \overline{I}_i \qquad g = \text{investor} \tag{12}$$

$$D_{ig} = \left[a_{ig}^{A-1} \{PD_i \big/ (1 - q_{ig}^A)\}^{s_i^A} C_{ig}\right] \Big/ \left[q_{ig}^A (PM_i \big/ q_{ig}^A)^{s_i^A \cdot r_i^A} + (1 - q_{ig}^A) \{PD_i \big/ (1 - q_{ig}^A)\}^{s_i^A \cdot r_i^A}\right]^{-1/r_i^A} \tag{13}$$

$$M_{ig} = \{q_{ig}^A \big/ (1 - q_{ig}^A)\}^{s_i^A} (PD_i / PM_i)^{s_i^A} D_{ig} \tag{14}$$

Prices:

$$PM_i = \overline{PWM}_i (1 + tm_i) \overline{XR} \tag{15}$$

$$PD_i = PWX_i \overline{XR} \big/ (1 + tx_i) \tag{16}$$

$$P_{ig} = a_{ig}^{A-1} [q_{ig}^{A s_i^A} PM_i^{(1 - s_i^A)} + (1 - q_{ig}^A)^{s_i^A} PD_i^{(1 - s_i^A)}]^{1/(1 - s_i^A)} \tag{17}$$

$$PN_i = PD_i (1 + ty_i) - \sum_{j=1}^N a_{ji} P_{ji} \tag{18}$$

$$X_i = a_i^X PWX_i^{e_X} \tag{19}$$

Equilibrium Conditions:

$$Q_i = X_i + \sum_g D_{ig} \tag{20}$$

$$\sum_i \overline{PWM}_i \sum_g M_{ig} + \overline{CA} = \sum_i PWX_i X_i \tag{21}$$

Table 2: Notation

Parameters

a_{ij}	Input-output coefficients
$\overline{PWM}_i$	World price of importables
$\overline{END}_f$	Factor endowments
$\overline{PF}_g$	Institutionally rigid factor returns
$\overline{I}_i$	Investment
$\overline{G}_i$	Government expenditure
$\overline{CA}$	Current account balance
$\overline{XR}$	Exchange rate
tm_i	Import taxes/subsidies
tx_i	Export taxes/subsidies
ty_i	Output taxes/subsidies
a_i^Q	Production function shift
q_{fi}^Q	Production function share
s_i^Q	Production elasticity*
r_i^Q	$(1/s_i^Q)-1$
a	Utility function shift
q_i^C	Utility function share parameter
l_i	Subsistence consumption level
h_i	Income elasticity of demand*†
v	Frisch parameter*†
a_{iq}^A	Armington shift parameter
q_{iq}^A	Armington share
s_i^A	Armington elasticity*
r_i^A	$(1/s_i^A)-1$
a_i^X	Export demand shift
e_i^X	Export demand elasticity*
a_q^M	Migration function shift
e_f^M	Migration elasticity*

Variables

PM_i	Importable price
PD_i	Domestic price
PWX_i	World price of exportables
P_{ig}	Domestic-import aggregate price
PN_i	Net prices
PF_f	Factor returns
Q_i	Gross output
FD_i	Factor demands
ER_f	Employment rate ($=1\ f \notin g$)
UN_f	Unemployment ($=0\ f \notin g$)
$COST_f$	Cost of migration ($=0\ f \notin g$)
U	Utility level
C_{ig}	Total agent consumption
NDI	Household income
M_{ig}	Imports
D_{ig}	Domestic demand
X_i	Exports

Notes:

* These parameters are independent of the base year data ('free') and are supplied independently. Other parameters then follow by calibration.

† These parameters do not appear in the model, but are used in the calibration process of the Stone-Geary utility function (to determine the subsistence parameters). The Frisch parameter (minus the reciprocal of the marginal utility of income) scales the price elasticities.

Table 3: Chile: equivalent total tariffs for products with price bands 1990-1999

Year	Wheat (%)	Refined Sugar (%)	Coarse Soya Oil (%)
1990	53.7	6.1	25.4
1991	42.1	12.3	24.3
1992	19.7	21.5	29.0
1993	18.1	28.8	23.3
1994	15.3	12.3	6.0
1995	7.0	2.6	1.4
1996	5.3	16.5	15.2
1997	15.1	28.1	17.1
1998	47.1	49.0	6.1
1999	49.9	77.4	33.5

Source: Odepa, Ministry of Agriculture.

Table 4: Summary Statistics

Simulation	Welfare Change ($US millions)	Employment Rate (%)	Rural Wage (% of Urban)
Low Mobility			
Initial Equilibrium	-	92.57	32.5995
Pr. Band Removal	6.28	92.63	32.5935
No Ag. Tariff	-7.10	92.62	32.4339
High Mobility			
Initial Equilibrium		92.66	32.5668
Pr. Band Removal	3.03	92.67	32.5777
No Ag. Tariff	-17.73	92.56	32.4590

Table 5: Estimated Effects on Production of Key Agricultural/Food Commodities

Commodity	Initial Output Value US$ mil. x 100	Volume % Change *Low Mobility*		Volume % Change *High Mobility*	
		No Band	No Tariff	No Band	No Tariff
Paddy Rice	0.46	-3.33	-3.37	-3.34	-3.39
Wheat	9.71	-2.11	-2.44	-2.12	-2.48
Other Grains	3.67	0.40	0.66	.38	0.61
Vegetables and Fruit	34.24	0.08	0.14	.07	0.08
Oil Seeds	0.37	-3.15	-3.17	-3.16	-3.22
Sugar Cane and Beet	3.44	-3.64	-3.73	-3.65	-3.77
Plant-based Fibers	0.10	0.02	-2.08	-0.01	-2.13
Other Crops	3.02	-0.01	-0.05	-0.02	-0.11
Cattle	7.12	0.07	-0.80	0.06	-0.84
Other Agriculture	9.95	0.11	-0.29	0.10	-0.33
Raw Milk	3.52	0.26	-2.09	0.26	-2.11
Meat from Cattle	10.86	0.09	-0.98	0.07	-1.03
Other Meat Products	12.98	0.06	0.01	0.05	0.01
Vegetable Oils	0.69	-19.06	-16.29	-19.07	-16.34
Dairy Products	9.43	0.35	-2.95	0.35	-2.27
Processed Rice	.53	-7.76	-7.54	-7.77	-7.57
Sugar	4.36	-4.90	-5.07	-4.91	-5.11
Other Food Products	70.72	2.05	1.38	2.03	1.33
Beverages and Tobacco	20.72	0.26	-1.85	0.24	-1.91

Table 6: Estimated Effects on Imports of Key Agricultural/Food Commodities

Commodity	Initial Import Value US$ mil. x 100	Volume % Change *Low Mobility*		Volume % Change *High Mobility*	
		No Band	No Tariff	No Band	No Tariff
Wheat	0.25	80.97	75.37	80.98	75.42
Other Grains	0.93	2.07	-1.38	2.07	-1.38
Vegetables and Fruit	0.50	1.17	9.23	1.17	9.25
Oil Seeds	0.04	-21.69	7.08	-21.69	7.05
Sugar Cane and Beet	0.20	-17.45	-18.87	-17.44	-18.83
Plant-based Fibers	0.62	-0.27	0.62	-0.27	0.59
Other Crops	1.37	0.02	10.19	0.01	10.17
Cattle	0.009	-0.63	58.21	-0.60	58.38
Other Agriculture	0.16	-0.31	36.77	-0.29	36.87
Meat from Cattle	1.52	-0.08	13.92	-0.07	13.96
Other Meat Products	0.16	-0.38	27.31	-0.35	27.43
Vegetable Oils	1.19	13.77	12.87	13.77	12.84
Dairy Products	0.71	-1.49	53.40	-1.48	53.46
Processed Rice	0.12	24.69	22.47	24.69	22.49
Sugar	0.38	69.26	66.26	69.28	66.33
Other Food Products	2.55	-1.89	38.43	-1.89	38.44
Beverages and Tobacco	0.98	-.64	61.96	-0.62	62.07

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