China's Accession to the WTO and Impacts on Livestock Trade and Production Patterns

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Abstract

We analyze the implications of agricultural and comprehensive trade liberalization in the Chinese economy, utilizing a disaggregate CGE model incorporating developing economy features. Special attention is paid to the implications of reform for China's livestock and meat production and trade patterns.

1. Introduction

In 1950, China withdrew from the General Agreement on Tariffs and Trade (GATT). Since 1986, China has applied to rejoin the organization and its successor, the World Trade Organization (WTO). China's bid has made considerable recent progress. In late 1999, the United States reached an agreement with China to support WTO membership. The decision to support permanent normal trading relations with China passed through the US Congress in May 2000. A similar agreement has been reached with the European Union. So, barring any unforeseen political developments, China's accession to the WTO now seems likely to occur during 2001.

China's objectives in seeking reentry into the world trading system have been discussed in detail in Yang (1999). The main economic objectives are to secure its access to export markets. China believes that bilateral trade negotiation have left it open to discriminatory treatment, and also at a disadvantage when disputes arise. Hence, guaranteed MFN treatment under Article I, and access to the WTO's dispute settlement procedures are important objectives for China. On the political side, there is the desire to assert China's 'rightful' place in the world community (Yang, 1999). Another potential benefit of WTO accession (for both China and the rest of the world) is to reinforce the trend towards a market orientation of the Chinese economy.

Because of the intense interest surrounding the potential effect of trade reform in China as part of it's WTO accession, a substantial body of work estimating the likely effects of reform has developed. Computable general equilibrium (CGE) models have proved to be a particularly useful tool of analysis in this respect. Recent papers examining the potential effect of China's accession include Bach et al. (1996), Chow et al. (forthcoming), Yang (1996, 1999), Wang and Tuan (1996), Wang (1997, 1999), Mai et al. (1998), Walmsley and Hertel (2000), and Fan and Zheng (2000).

Most of the existing work has used multi-regional models with very traditional specifications (a large number use the GTAP model). In this paper we utilize a new, single economy model of China that attempts to capture the possible implications of labor market

distortions. These distortions include urban unemployment, rural-urban migration in response to wage differentials, and constraints on the mobility of labor between rural and urban activities. Within this new framework, we simulate the effect of both agricultural trade reform in line with the URAA, and comprehensive reform in line with the Sino-US agreement on Chinese accession to the WTO (using the estimates of Fan and Zheng, 2000). Thus, the primary objective of this paper is to contrast the effects of agricultural trade reform with more extensive, economy-wide reform.

Because our model incorporates significant sectoral detail (50 sectors are identified), we are able to focus some of our attention to the likely effects of the reform scenarios on trade and production patterns in livestock, meat and related industries. Although the livestock and meat sectors are not large relative to the rest of the economy, suggesting that partial equilibrium techniques may be the most appropriate tool, there are at least two reasons why general equilibrium techniques can make an important contribution to sectoral analysis of this type. First, because of the intersectoral relationships built into a CGE model, we can observe the effect of changes in the sectors of direct interest on other sectors of related interest, both up-stream and down-stream, for example, the grain and meat products sectors. Second, because of the completeness of the CGE system, we can accurately assess the effect of more general shocks (e.g., complete agricultural liberalization) on the sectors of interest.

The remainder of the paper is organized as follows. In Section 2 we describe the salient features of our CGE model (a more comprehensive description of the model and the underlying theory is contained in the two accompanying appendices). In Section 3 we outline our simulation assumptions, and present the results of our analysis. Conclusions and policy implications follow in Section 4.

2. CGE Model

Computable general equilibrium (CGE) models attempt of operationalize the abstract models of general equilibrium theory and thereby create a practical tool for policy analysis. This

is accomplished by melding real-world data on production, trade and protection, with an appropriate theoretical structure representing the behavior of economic agents within the system, and the constraints that they face. Models built along these lines have similar advantages to equilibrium theory, notably the ability to comprehensively account for economy-wide constraints and the subsequent market inter-relationships, and the ability to deal adequately with the second-best implications of policy changes. Model solutions, being expressed numerically, help us to understand orders of magnitude, and provide results that are more easily interpreted than algebraic comparative statics.

A number of useful surveys of CGE models are available, notably Decaluwé and Martens (1988), and Bandara (1991). The model utilized in this paper is a single-economy model of China, with an underlying structure based on the theoretical model presented in Appendix 1. In this section we provide a brief overview of the model and its assumptions. A more detailed description, including discussion of the equation set, is provided in Appendix 2.

3.1. Production

Each sector is represented by a neoclassical production function of the nested constant elasticity of substitution (CES) form. Intermediate goods enter each function in fixed proportions to a CES composite of primary productive factors (value-added). Constant returns to scale are assumed, each industry takes both input and output prices as given, and makes zero economic profit.

All primary factors except labor are assumed to be fully employed. Labor markets are modeled in a way that is somewhat different from other CGE models. Briefly, we assume that the urban wage is fixed, creating unemployment, and that rural labor migrates to equate the actual rural wage and the expected urban wage, i.e., the Harris-Todaro specification. However, the mobility is of labor is less than perfect, being constrained by variable migration costs. A more detailed discussion of the theory underlying this aspect model specification, and the implications for scenario analysis, is provided in Appendix 1.

3.2. Final Demand

Final demand is divided into three components, household consumption, government expenditure and investment. The quantity of government and investment consumption is treated as exogenous. The single representative household maximizes a Stone-Geary (LES) utility function. In each case, the agent in question, having chosen the optimal quantity, then chooses the optimal combination of domestic and importable goods subject to the prevailing domestic and world prices.

3.3. International Trade

As alluded to above, imports are modeled along Armington lines. This means that domestic production and imported goods are treated as imperfect substitutes, which ensures that the model can accommodate intra-industry trade, and also avoids extreme production responses to changes in the price vector. We assume that each agent in the model (each representative firm, the household, government and investor) chooses its own optimal import-domestic composite independently (the SALTER specification). The Armington composites are based on CES functions.

We do not incorporate a constant elasticity of transformation (CET) specification on the export side, that is, exports and domestic production are treated as perfect substitutes. We do, however, treat China as a large economy. This is accomplished through the use of downward sloping foreign demands for exports, which take the constant elasticity of demand (CED) form.

3.4. Closure

We close the model by fixing the current account balance in value terms, the nominal exchange rate adjusting to maintain the base year surplus. Since the quantity of investment demand is exogenous, and the balances identity *S-I=CA* must hold (where *I* represents the value

of investment expenditures), changes in household savings are the primary macroeconomic adjustment mechanism. Also, since government demands are also exogenous, and are not linked to tax revenue, we also have a situation of government deficit financing through (implicit) transfers from the domestic household. Clearly, other closure assumptions are possible.

3.5. Data and Aggregation

We have utilized the input-output, trade and protection data in the GTAP4 database (McDougall et al., 1998). The free parameters are also largely drawn from the GTAP4 database. Production elasticities are as in the database, Armington elasticities have been doubled. The income elasticities of demand are also drawn largely from the GTAP4 database, but we have updated using the work of Han and Wahl (1998) where possible. Finally, elasticities of export demand have been computed from the GTAP4 database at the initial 1995 equilibrium.

Because we are utilizing a single-economy model, we are able to work at a substantial level of commodity dissaggregation. In fact, our model separately identifies all of the 50 sectors in the GTAP4 database (see Table 1). The model fully scalable and is written independently of the data. It can be easily updated to incorporate new data as it becomes available (e.g., GTAP5).

We supplement the GTAP data with rural and urban labor force counts from the FAOSTAT database, 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. The initial urban unemployment rate of 6 percent is from Gu's (1999) estimates for 1995. The implied expected 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 Chinese economy. As there are no available estimates of the elasticity of labor migration, we use two

limiting values – low (1.0e-5) and high (100). The model is implemented as a non-linear program (levels form) in GAMS.

3.   Simulation Assumptions and Results

We consider two liberalization scenarios.   Our starting assumption is that China's accession will reduce agricultural trade barriers by the same levels as required of developing economies under the Uruguay Round Agreement on Agriculture (URAA).   This agreement required that developing economies reduce their average tariff on agricultural and food products by 24 percent. Export subsidies were to be reduced by the same margin. Domestic support was to be reduced by 13 percent, subject to de minimis provisions not requiring levels lower than 10 percent of value. Although other countries have displayed considerable ingenuity in the way that they have complied with their obligations under the URAA, in the absence of any further information on the case of China, we implement the requirements at face value and evenly across all agricultural activities.

As our alternative scenario, we consider a complete WTO accession package, involving liberalization of both agricultural and manufacturing sectors (services protection data in GTAP is currently limited, so we do not consider services reform). The tariff reductions are based on the Sino-US trade deal, as analyzed by Fan and Zheng (2000). We assume, of course, that the reductions are extended along MFN lines to all trading partners. Our two scenarios are designed to compare the effect of agricultural liberalization in isolation, with more comprehensive, economy-wide reform. The actual reductions used in the simulations are presented in Table 1.

The results of our simulations for some key economic variables are presented in Figures 1a through 1d. Consider first the net welfare results in Figure 1a. The welfare measure that we have used is the equivalent variation of the policy scenario, or the change in income at constant (pre-reform) prices that is equivalent to the proposed change, measured in US$1995 millions. Figure 2 displays some sensitivity information.

The estimated net welfare effect of acceding to the URAA agreement when labor movement is heavily constrained is a gains of just under $1.2 billion. When a high level of labor mobility is allowed the gains remain positive, but drops by nearly $300 million to approximately $0.9 billion. This result leads us to two conclusions. First, it confirms the importance of the migration elasticity parameter. As the abstract model presented in Appendix 1 indicates, when labor is immobile agricultural trade liberalization will improve the urban unemployment problem. When labor is mobile, however, agricultural trade liberalization leads to expanded migration to urban areas, and hence to expanded urban unemployment. This result is confirmed in Figure 1b, and has a significant and detrimental effect on the net welfare gains from liberalization. Second, the result also indicates that the potential allocative efficiency gains from agricultural liberalization in China are not insignificant. Even with high labor mobility, the effects of liberalization on unemployment and adverse terms-of-trade movements are not sufficient to outweigh the allocative efficiency gains of China joining the URAA commitments.

The current model only identifies one household consumption unit, so income distribution in this model is dealt with in the Ricardian tradition. Figure 1c presents the estimated effect of the liberalization scenarios on rural wages, and Figure 1d the estimated effect on the return to capital. In the case of tariff liberalization in agriculture alone, we observe declines of between one and two percent in rural wages, and marginal increases in capital incomes.

As a further depiction of the sensitivity of the model results to the value of the migration elasticity, we have constructed Figure 2, which illustrates how the three key variables (net welfare, unemployment, and rural wages) change in response to changes in the value of this parameter, for the URAA accession case. The upper diagram depicts the relationship between the welfare measure and the elasticity. Evident is that the net welfare gains from URAA accession decline rapidly as labor becomes increasingly mobile. The lower diagram depicts the percentage change in the rate of employment, and the percentage change in the rural wage (both relative to initial levels). Note that there is a clear trade-off between maximizing the extent of net welfare gains from URAA accession, and minimizing the harm inflicted on rural workers. Also, we observe a rapid decline in the rate at which the rate of urban employment improves as mobility

increases. At the critical value of $e = 0.895$, URAA accession has no effect on urban employment levels, and beyond this point the change in rural wages and the probability of employment take the same sign. With an elasticity beyond this critical point, the model behaves much like the standard HT model.

We also observe from Figure 1a that while the estimated net welfare effect of agricultural trade reform in China is not small, it is dwarfed by the positive welfare gains associated with economy-wide reform, which range from $10.7 to $11.1 billion. Why is this the case? It reflects the fact that: a) China's agricultural protection (with a few exceptions such as cane sugar) is relatively mild, and; b) the tariffs associated with the manufacturing sector are considerably higher, and the cuts associated with WTO accession more substantial (see Table 1). Furthermore, the positive impact of comprehensive liberalization shows up in significant improvements in urban unemployment, under both mobility scenarios (Figure 1b). We also observe increases of roughly two percent in rural wages, and one percent in returns to capital.

What policy implications can be drawn from these general results? The first and most important point is that, even in a model that accounts for imperfect labor mobility and urban unemployment, the net effects of URAA accession for China are estimated to be positive. Second, China's labor policy needs to be closely coordinated with its trade liberalization program. It is clear that the net benefits to China of URAA accession are maximized if controls on labor mobility are maintained to prevent a worsening of the urban unemployment problem. Third, the benefits of labor restrictions are rapidly lost as mobility increases (as Figure 2 indicates), so labor mobility controls, if implemented, should be strictly enforced. However, such a strategy also maximizes the hardship imposed by reform on the rural population. Although the estimated reductions in rural wages are small, they may be a burden that an already heavily encumbered rural population is unwilling to bear. This is particularly important in the Chinese context, because there has been concern over the extent of rural-urban income disparities (Carter, 1997; Yang and Huang, 1997), and their potential to cause political instability. Fourth, the results clearly attest to the importance of accounting for sectoral interaction when conducting trade policy analysis. Not only does comprehensive trade reform lead to much higher net welfare

gains, but it can also help to mitigate the potential for adverse effects of trade reform on agricultural wages.

Now consider the implications of reform on the grains, livestock and meat sectors. Figures 3a through 3f describe the estimated effect of reform under each liberalization scenario on output and imports of grains, livestock and meat products. The first pattern we can see from all three categories is that the elasticity of labor migration parameter, while having quite a strong effect on net welfare and factor income estimates, does not have a very strong impact on either output or import patterns. Of far more importance is the form of liberalization considered. A result that is clear but perhaps somewhat surprising is that imports of all of the agricultural products increase substantially in the comprehensive reform scenarios (roughly 4 percent for wheat, 10 percent for other grains, 35 percent for cattle, 80 percent for other animal products, 6 percent for cattle meat, and 22 percent for other meat products – see Figures 3b,d and f).

Generally, when tariffs are removed from one part of the economy, we expect output in that part of the economy to decline, and imports to subsequently expand. Resources are reallocated to previously unprotected (or less protected) sectors, which expand their output. This is the case in the livestock and meat sectors (Figures 3c and 3e). Hence, we might expect imports in these sectors to decline. The balancing factor is of course the increases in consumption that occur when income rises as a consequence of a more efficient allocation of resources (recall Figure 1a). It is this expansion of consumption that drives the significant increases in imports (although we also note that the increases in the livestock and meat categories are from a relatively low base).

This result has obvious implications for economies attempting to negotiate expanded market access in livestock and meat products when China accedes to the WTO. The tariffs on livestock recorded in GTAP4 are 4.5 and 29.6 percent for the cattle and other animal products categories, respectively. Negative tariffs apply to both meat product categories. Hence, with the exception of the other animal products category, there is little to be gained from targeting reform in these areas. Given limited negotiation resources, in may be better to target reform in other

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areas, where substantial increases in income can be assured, and wait for those increases in income to flow through to demand for agricultural products.

4. 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 China gaining access to other markets, or the effect of Chinese liberalization on other economies. In respect of the latter issue, there have now been a number studies using global general equilibrium models. Most of the gaps that remain to be filled involve China-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.

As China's accession to the WTO draws closer, it is clear that Beijing will have to carefully consider the course of its agricultural trade policy regime. Should China reaffirm the distinction between the rural and urban economies and clamp down on migration? Should they instead move towards fully liberalizing the agricultural sector, and allowing labor markets to develop? There remain conflicting objectives in the China's policy stance. They would also like to address the problem of rural-urban income divergence, but allowing labor to move into other, more profitable, activities contradicts the objective of self-sufficiency and may exacerbate urban unemployment. One possibility indicated in this paper is to utilize comprehensive reform as a stimulus to agricultural production and wages. Our simulation results indicate that this would also have a substantial positive net welfare effect, and expand imports of key agricultural products, thus mitigating a potential source of foreign trade friction.

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Table 1: Liberalization Assumptions (Percentage Reductions)

	URAA Accession			Full[3]
	Export Subsidies[1]	Domestic Support[2]	Import Tariffs	Import Tariffs
Paddy rice	24.0	13.3	24.0	24.0
Wheat	24.0	13.3	24.0	24.0
Cereal grains nec.	24.0	13.3	24.0	24.0
Vegetables, fruit, nuts	24.0	13.3	24.0	24.0
Oil seeds	24.0	13.3	24.0	24.0
Sugar cane, sugar beet	24.0	13.3	24.0	24.0
Plant-based fibers	24.0	13.3	24.0	24.0
Crops nec.	24.0	13.3	24.0	24.0
Bovine cattle, sheep and horses	24.0	13.3	24.0	24.0
Animal products nec.	24.0	13.3	24.0	24.0
Wool silk-worm cocoons	0.0	0.0	0.0	0.0
Forestry	0.0	0.0	0.0	0.0
Fishing	0.0	0.0	0.0	0.0
Coal	0.0	0.0	0.0	41.0
Oil	0.0	0.0	0.0	41.0
Gas	0.0	0.0	0.0	41.0
Minerals nec.	0.0	0.0	0.0	41.0
Bovine cattle, sheep & horse meat	24.0	13.3	24.0	24.0
Meat products nec.	24.0	13.3	24.0	24.0
Vegetable oils and fats	24.0	13.3	24.0	24.0
Dairy products	24.0	13.3	24.0	24.0
Processed rice	24.0	13.3	24.0	24.0
Sugar	24.0	13.3	24.0	24.0
Food products nec.	24.0	13.3	24.0	24.0
Beverages and tobacco products	24.0	13.3	24.0	24.0
Textiles	0.0	0.0	0.0	41.0
Wearing apparel	0.0	0.0	0.0	41.0
Leather products	0.0	0.0	0.0	41.0
Wood products	0.0	0.0	0.0	49.0
Paper products, publishing	0.0	0.0	0.0	55.0
Petroleum, coal products	0.0	0.0	0.0	41.0
Chemical, rubber, plastic products	0.0	0.0	0.0	41.0
Mineral products nec.	0.0	0.0	0.0	41.0
Ferrous metals	0.0	0.0	0.0	41.0
Metals nec.	0.0	0.0	0.0	41.0
Metal products	0.0	0.0	0.0	41.0
Motor vehicles and parts	0.0	0.0	0.0	11.0
Transport equipment nec.	0.0	0.0	0.0	11.0
Electronic equipment	0.0	0.0	0.0	41.0
Machinery and equipment nec.	0.0	0.0	0.0	41.0
Manufactures nec.	0.0	0.0	0.0	41.0

Notes:
1. Only export subsidies (and import tariffs) are eliminated. Export taxes are left in place.
2. Reductions are implemented subject to de-minimis provisions that do not require support levels below 10%.
3. Full includes URAA reform, in addition to tariff reform in other sectors. Sourced from Fan and Zheng (2000).

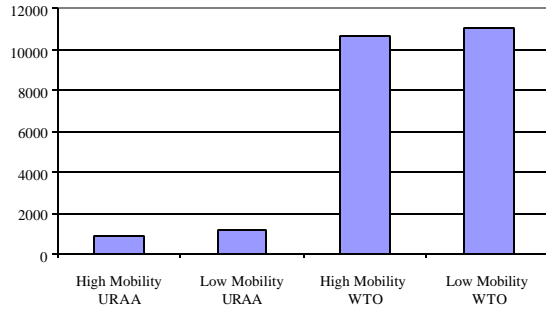**Figure 1a: Estimated Equivalent Variation (US$1995 millions)**
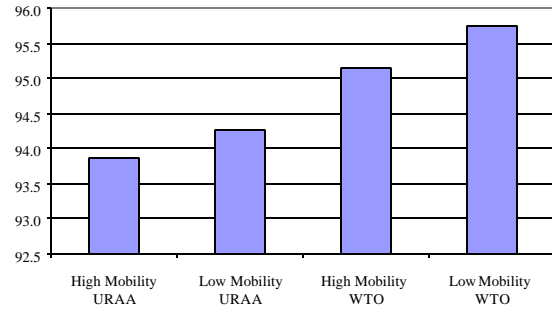

Figure 1b: Estimated Urban Employment Rate (94% base)

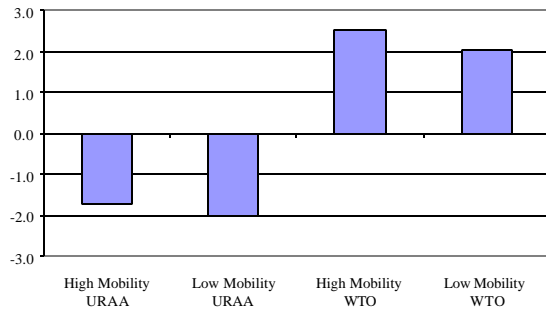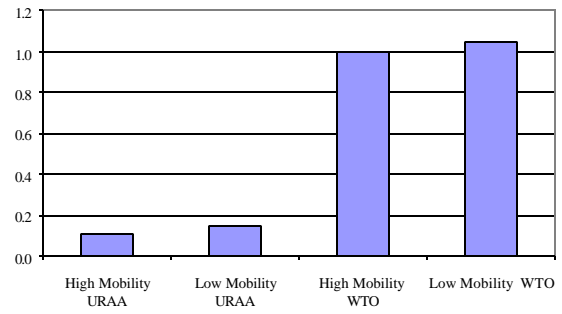**Figure 1c: Estimated Percentage Change in Rural Wage**

Figure 1d: Estimated Percentage Change in Capital Rent

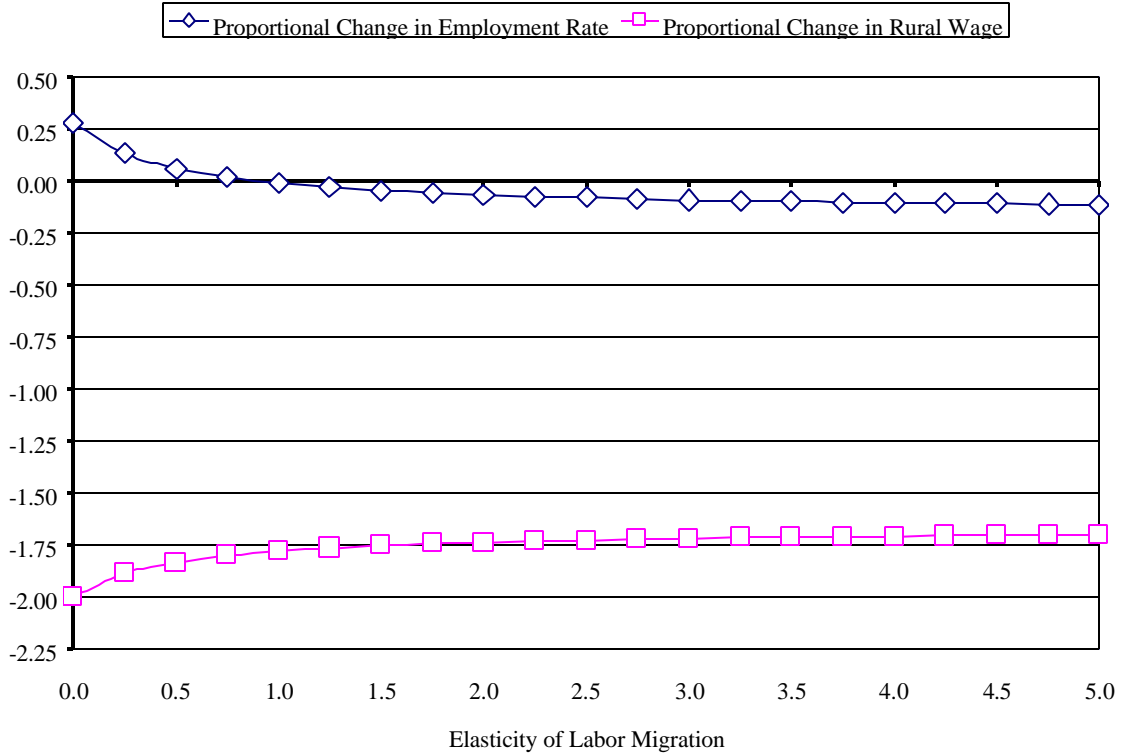**Figure 2: Sensitivity of Key Results to the Labor Mobility Parameter**

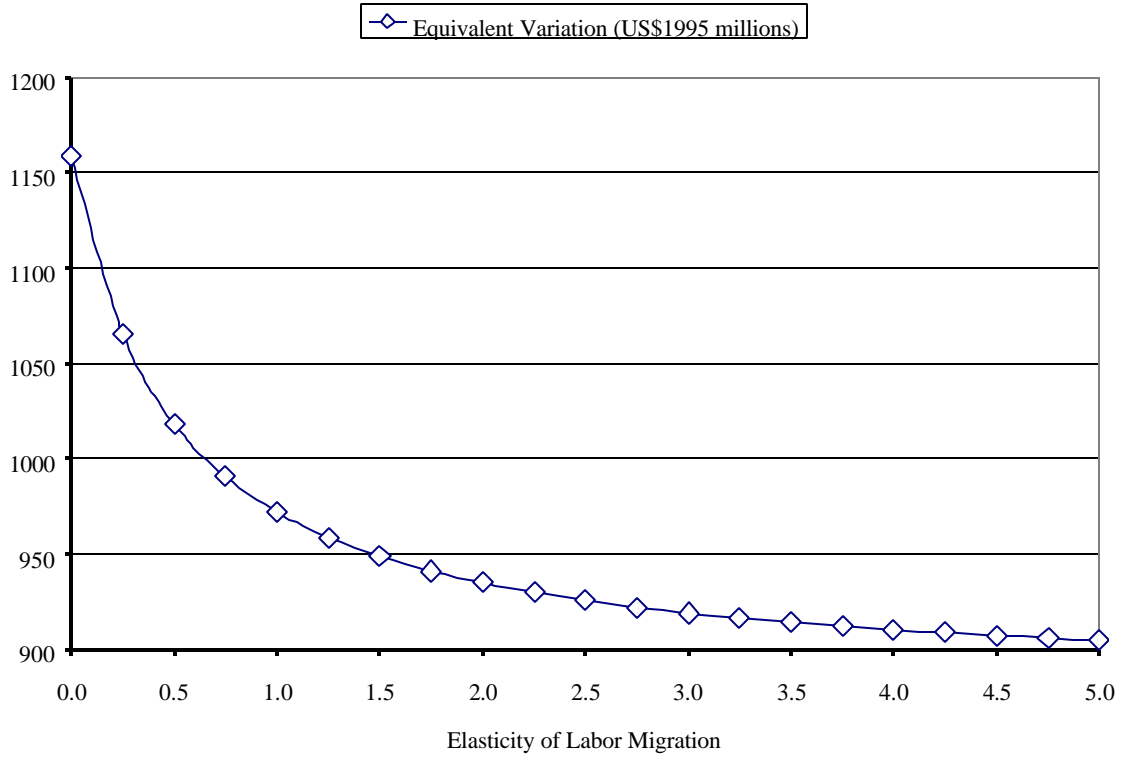◇ Equivalent Variation (US$1995 millions)

Elasticity of Labor Migration

◇ Proportional Change in Employment Rate   □ Proportional Change in Rural Wage
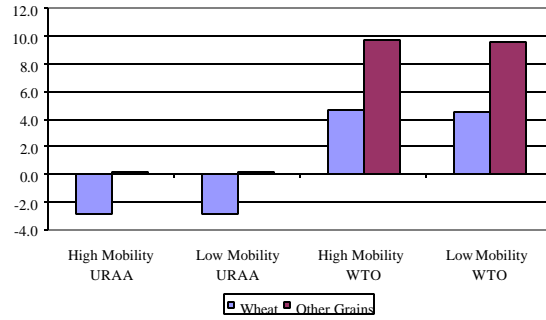
Elasticity of Labor Migration

Figure 3a: Estimated Percentage Change in Output - Grains
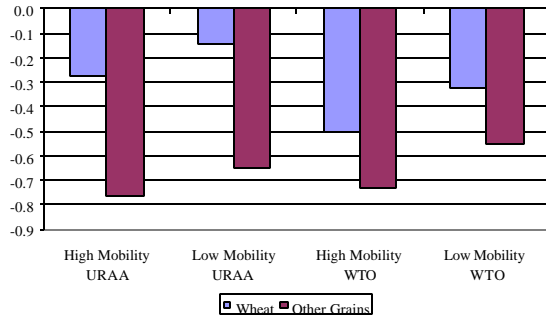
Figure 3b: Estimated Percentage Change in Imports - Grains

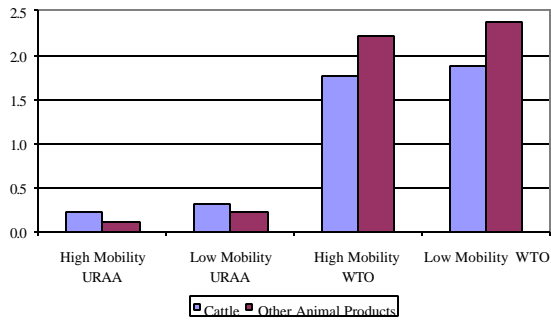**Figure 3c: Estimated Percentage Change in Output - Livestock**

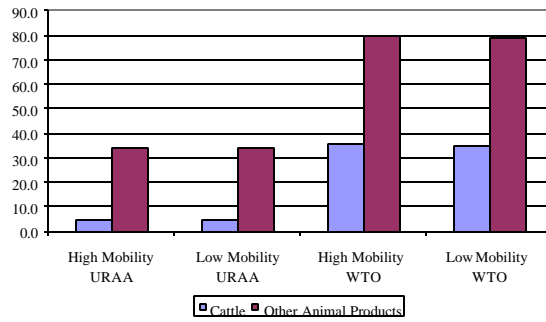**Figure 3d: Estimated Percentage Change in Imports - Livestock**

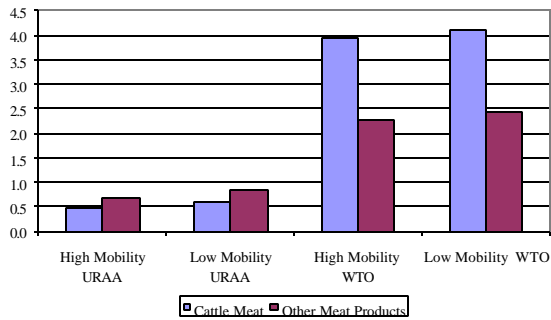**Figure 3e: Estimated Percentage Change in Output - Meat**
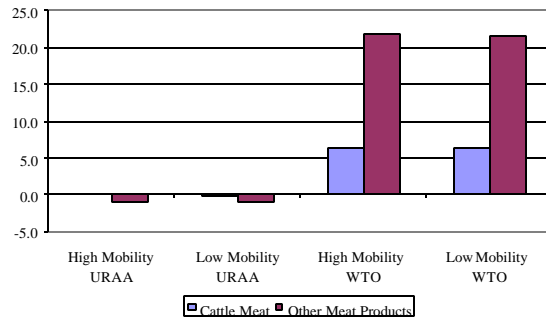

Figure 3f: Estimated Percentage Change in Imports - Meat

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Appendix 1: Theoretical Foundations

The model that we utilize in this paper was originally designed to highlight issues involved with rural labor mobility, and the consequences of trade liberalization thereof. As such, the structure is somewhat different from other CGE models. This appendix provides an overview of some of the important mechanisms underlying the model structure.

We utilize the basic structure outlined in Gilbert and Mikic (1998). Consider a small, developing economy with distinct rural and urban regions. An industrial good X is produced in the urban region, while an agricultural good Y is produced in the rural region. We assume that X is capital intensive. The production functions are linearly homogeneous, continuous and strictly concave. Labor markets in the rural region are competitive, but in the urban region the wage is institutionally rigid, resulting in unemployment. Full mobility of capital equates the rent in both regions. Perfectly competitive output markets ensure that firms make zero profit. Choosing p_Y as the numéraire, the model can be described by the following equations:

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

$$c_Y(w, r) = 1 \tag{2}$$

$$w = p\overline{w} - r \tag{3}$$

$$e = \hat{L}_U / \hat{r}. \tag{4}$$

$$a_{XL}X + pa_{YL}Y = pL \tag{5}$$

$$a_{XK}X + a_{YK}Y = K. \tag{6}$$

$$G(p_X, K, L_X, L_Y) + (p_X - p_X^*)M_X = E(p_X, u) \tag{7}$$

Given output prices and the urban wage, (1) and (2) uniquely determine factor prices. Migration occurs between the rural and urban regions until the expected urban wage is equal to the actual rural wage (3). We introduce a further differential between the rural wage and the expected urban wage, r, which is positive and may represents migration costs. The positive elasticity of labor migration can then be defined in (4). Once factor returns are known, Shepherd's lemma gives us

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the optimal input-output coefficients, which then define the factor market conditions (5) and (6). These must be solved with (3) and (4) to obtain output levels. Finally, using the GNP and expenditure functions, we have the budget constraint for the economy (7). M_X is imports of X, u is the target level of utility, a superscript * designates the fixed world relative price. The utility function is continuous, strictly quasi-concave and increasing in consumption of both goods.

We begin by deriving the equations of change for factor prices. Totally differentiating (1) and (2) holding the urban wage constant we obtain the equations of change for factor prices:

$$\hat{r} = \hat{p}_X \boldsymbol{q}_{YL}/(\boldsymbol{q}_{XK}\boldsymbol{q}_{YL}) \tag{8}$$

$$\hat{w} = -\hat{p}_X \boldsymbol{q}_{YK}/(\boldsymbol{q}_{XK}\boldsymbol{q}_{YL}) . \tag{9}$$

where $\boldsymbol{q}_{ij}$ is the cost share of factor j in industry i, and a circumflex denotes a proportional change (e.g., $\hat{w} = dw/w$). These demonstrate that the return to capital is a positive, and the return to rural labor a negative, function of the relative output price.

Now, by totally differentiating (3), (4), (5) and (6), utilizing the definition of the elasticity of substitution in each industry, $\boldsymbol{s}_i \equiv (\hat{a}_{iK} - \hat{a}_{iL})/(\hat{w}_i - \hat{r})$, and the cost minimization condition, $\boldsymbol{q}_{iL}\hat{a}_{iL} + \boldsymbol{q}_{iK}\hat{a}_{iK} = 0$, $i = X,Y$, to eliminate the proportional changes in the optimal input-output coefficients and $\boldsymbol{r}$, and then and substituting (8) and (9) into the resulting expressions we obtain:

$$\begin{bmatrix} \boldsymbol{l}_{XL} & p\boldsymbol{l}_{YL} & -\boldsymbol{l}_{XL} \\ \boldsymbol{l}_{XK} & \boldsymbol{l}_{YK} & 0 \\ -\boldsymbol{r} & 0 & (e\overline{p\boldsymbol{w}} + \boldsymbol{r}) \end{bmatrix} \begin{bmatrix} \hat{X} \\ \hat{Y} \\ \hat{p} \end{bmatrix} = \begin{bmatrix} p\hat{L} - \boldsymbol{d}_L \hat{p}_X \\ \hat{K} + \boldsymbol{d}_K \hat{p}_X \\ -\boldsymbol{d}_p \hat{p}_X \end{bmatrix} . \tag{10}$$

where:

$$\boldsymbol{d}_L \equiv \{p\boldsymbol{l}_{YL}\boldsymbol{q}_{YK}\boldsymbol{s}_Y/(\boldsymbol{q}_{XK}\boldsymbol{q}_{YL}) + \boldsymbol{l}_{XL}\boldsymbol{s}_X\}$$

$$\boldsymbol{d}_K \equiv \{\boldsymbol{l}_{YK}\boldsymbol{s}_Y/\boldsymbol{q}_{XK} + \boldsymbol{l}_{XK}\boldsymbol{q}_{XL}\boldsymbol{s}_X/(\boldsymbol{q}_{XK}\boldsymbol{q}_{YL})\}$$

$$\boldsymbol{d}_p \equiv \{ew\boldsymbol{q}_{YK}/(\boldsymbol{q}_{XK}\boldsymbol{q}_{YL}) - \boldsymbol{r}\boldsymbol{s}_X\}$$

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We can solve (10) for the equations of change for output, which will not discuss here except to note that the price-output relationships are normal for all values of e. Solving for $\hat{p}$ we have:

$$|D|\hat{p} = rp(l_{YL}\hat{K} - l_{YK}\hat{L}) - \{d_p|l| + r(l_{YK}d_L + pl_{YL}d_K)\}\hat{p}_X \tag{11}$$

where $|D| \equiv e\overline{pw}|l| - rl_{XK}pl_{YL}$. Since $|l| \equiv l_{XL}l_{YK} - pl_{YL}l_{XK} < 0$ because X is capital intensive by the Neary stability condition, $|D|$ is unambiguously negative.

From (11) with $\hat{K} = \hat{L} = 0$, substituting in the definitions of d_p, d_L and d_K, and rearranging terms we find that:

$$\hat{p}/\hat{p}_X < 0 \quad \Leftrightarrow \quad e > l_{YL}rp\{l_{XK}s_X(q_{XK}q_{YK} - 1) - s_Y l_{YK}\}/(wq_{YK}|l|) \tag{12}$$

That is to say, the conventional result (a rise in the price of X causing a fall in the rate of urban employment) holds only if the labor mobility parameter exceeds a critical value. For elasticities below this value the opposite will hold.

This raises the issue of the effects of intervention in trade. We begin by deriving a general expression of changes in social welfare. Totally differentiating (7) holding factor endowments and the urban wage constant yields:

$$dW = (p_X - p_X^*)dM_X + \overline{w}dL_X + \overline{w}pdL_Y \tag{13}$$

where $dW \equiv E_u du$. Note that the cost of moving one unit of labor out of agriculture is not only the value of the lost output, but also the migration cost. From the definition of the total urban labor force we know that $dL_X = pdL_U + L_U dp$. Substituting this into (7), simplifying and letting t be an ad-valorem tariff imposed on X, so that $p_X^*(1 + t) = p_X$, we have:

$$dW/dt = tp_X(dM_X/dt) + \overline{w}L_U(dp/dp_X)(dp_X/dt) \tag{14}$$

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Which is the basic decomposition of the welfare effect of an import tariff. The first term reflects the deadweight loss, and is negative. However, $dp_X/dt = p_X^* > 0$, and hence a sufficiently small tariff will raise social welfare if it raises the probability of employment (i.e., if $d\mathbf{p}/dp_X > 0$).

We know from (12) that if $\mathbf{e}$ falls below the critical value, the rate of urban employment will rise as the price of X rises. Hence a small positive tariff will raise net welfare if the elasticity of labor mobility is below its critical value (and hence liberalization may lower welfare).

Appendix 2: CGE Model Structure

In this appendix we set out a complete algebraic description of our CGE model. The model equations are presented in Table A1. 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 of the symbols used are contained in Table A2. The basic underlying 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 will keep our description brief.

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. 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. 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 (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. Introduction of product differentiation via this mechanism is the major departure of the model from the models of standard trade theory.

Equations (15)-(20) 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 utilized in this paper incorporates the following key features: institutionally rigid urban wages and corresponding urban unemployment, rural-urban migration in response to expected wage differentials, and an imperfectly elastic migration response. The model 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 A1). The model incorporates product differentiation, allowing it to accommodate simultaneous export and import activities in the same sector. Downward sloping export demands characterize the rest-of-world response to changes in the Chinese economy. Finally, the model incorporates a complete set of trade and output taxes to ensure accounting for the second-best implications of policy interventions. The 50 sector version of the model consists of approximately 11 thousand simultaneous equations, and is implemented and solved in levels form.

Table A1: 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:

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

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

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

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

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

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

Demand:

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

$$U = a\prod_i(C_{ig} - 1_i)^{q_i^C} \qquad\qquad g = \text{household} \tag{8}$$

$$C_{ig} = 1_i + (q_i^C/P_{ig})(NDI - \sum_j 1_j P_{jg}) \qquad\qquad g = \text{household} \tag{9}$$

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

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

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

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

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

Prices:

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

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

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

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

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

Equilibrium Conditions:

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

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

Parameters		Variables	
a_{ij}	Input-output coefficients	PM_i	Importable price
$\overline{PWM}_i$	World price of importables	PD_i	Domestic price
$\overline{END}_f$	Factor endowments	PWX_i	World price of exportables
$\overline{PF}_g$	Institutionally rigid factor returns	P_{ig}	Domestic-import aggregate price
$\overline{I}_i$	Investment	PN_i	Net prices
$\overline{G}_i$	Government expenditure	PF_f	Factor returns
$\overline{CA}$	Current account balance		
$\overline{XR}$	Exchange rate	Q_i	Gross output
		FD_i	Factor demands
tm_i	Import taxes/subsidies	ER_f	Employment rate ($=1\ f \notin g$)
tx_i	Export taxes/subsidies	UN_f	Unemployment ($=0\ f \notin g$)
ty_i	Output taxes/subsidies	$COST_f$	Cost of migration ($=0\ f \notin g$)
a_i^Q	Production function shift	U	Utility level
q_{fi}^Q	Production function share	C_{ig}	Total agent consumption
s_i^Q	Production elasticity[*]	NDI	Household income
r_i^Q	$(1/s_i^Q)-1$	M_{ig}	Imports
		D_{ig}	Domestic demand
a	Utility function shift	X_i	Exports
q_i^C	Utility function share parameter		
l_i	Subsistence consumption level		
h_i	Income elasticity of demand[*†]		
v	Frisch parameter[*†]		
a_{ig}^A	Armington shift parameter		
q_{ig}^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_g^M	Migration function shift		
e_f^M	Migration elasticity[*]		

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.