

ANNEX. An Overview of the Computational Model

- A. Introduction
- B. Basic structure
- C. Taxes and policy variables
- D. Trade and transport costs
- E. The production structure
- F. The Auto Market
- G. The composite household and final demand structure
- H. Labor markets
- I. Services Barriers

A. Introduction

This appendix provides an overview of the basic structure of the global CGE model employed for assessment of Greater China accession to the WTO. The model is a standard multi-region computable general equilibrium (CGE) model. The reader is referred to Hertel (1996: <http://www.agecon.purdue.edu/gtap/model/Chap2.pdf>) for a detailed discussion of the basic algebraic model structure represented by the GEMPACK code. The capital accumulation mechanisms are described in Francois et al (1996: <http://www.agecon.purdue.edu/gtap/techpaper/tp-7.htm>). The model is implemented in GEMPACK -- a software package designed for solving large applied general equilibrium models. The model is solved as an explicit non-linear system of equations, through techniques described by Harrison and Pearson (1994). More information can be obtained at the following URL -- <http://www.monash.edu.au/policy/gempack.htm>. Social accounting data are based on Version 5 of the GTAP dataset (GTAP 2001), with an update to reflect post-Uruguay Round protection as discussed in the body of the report. The full set of model files are available upon request.

The national accounts data have been organized to 23 sectors and 25 regions. (Note that we have included some detail on the value added chain linking fibers into textiles and clothing production, to better capture the initial impact of the ATC on our base scenario.) The sectors and regions for this 23x25 aggregation of the data are detailed in A.1 below.

The data come from a number of sources. Data on production and trade are based on national accounting data linked through trade flows and drawn directly from the Global Trade Analysis Project (GTAP) version 5 dataset. (GTAP 2001). (See Reinert and Roland-Holst 1997 for a discussion of the organization of such data for CGE models). The GTAP version 5 dataset is benchmarked to 1997, and includes

detailed national input-output, trade, and final demand structures. Significant modifications have been made to the basic GTAP database. The basic social accounting and trade data are supplemented with trade policy data, including additional data on tariffs and non-tariff barriers. We have updated the dataset to better reflect actual import protection for goods and services. (The basic GTAP database includes no information at all on trade barriers for services).

B. General structure

The general conceptual structure of a regional economy in the model is represented in Figure A.1. Within each region, firms produce output, employing land, labour, and capital, and combining these with intermediate inputs. Firm output is purchased by consumers, government, the investment sector, and by other firms. Firm output can also be sold for export. Land is only employed in the agricultural sectors, while capital and labour (both skilled and unskilled) are mobile between all production sectors. Capital is fully mobile within regions. However, capital movements between regions are not modeled, but rather are held fixed in all simulations. Labour mobility is discussed below. All demand sources combine imports with domestic goods to produce a composite good, as indicated in Appendix Figure A.1. Trade elasticities are also presented in Appendix Table 2.

C. Taxes and policy variables

Taxes are included in the theory of the model at several levels. Production taxes are placed on intermediate or primary inputs, or on output. Some trade taxes are modeled at the border. Additional internal taxes can be placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Where relevant, taxes are also placed on exports, and on primary factor income. Finally, where relevant (as indicated by social accounting data) taxes are placed on final consumption, and can be applied differentially to consumption of domestic and imported goods.

Trade policy instruments are represented as import or export taxes/subsidies. This includes applied most-favored nation (mfn) tariffs, antidumping duties, countervailing duties, price undertakings, export quotas, and other trade restrictions.

The one exception is service-sector trading costs, which are discussed in the next section.

Basic data on current tariff rates come from the UNCTAD and WTO data on applied and bound tariff rates. These are integrated into the core GTAP database. These are supplemented with data from USTR and USITC on regional preference schemes in the Western Hemisphere. For agriculture, protection is based on OECD and USDA estimates of agricultural protection, as integrated into the GTAP core database. Tariff and non-tariff barrier estimates are further adjusted to reflect remaining Uruguay Round commitments, including the phase-out of remaining textile and clothing quotas under the Agreement on Textiles and Clothing (the ATC). Data on post-Uruguay Round tariffs are taken from recent estimates reported by Francois and Strutt (1999). These are taken primarily from the WTO's integrated database, with supplemental information from the World Bank's recent assessment of detailed pre- and post-Uruguay Round tariff schedules. All of this tariff information has been concorded to our model sectors. Services trade barriers are based on the estimates described below.

D. Trade and transportation costs

International trade is modeled as a process that explicitly involves trading costs, which include both trade and transportation services. These trading costs reflect the transaction costs involved in international trade, as well as the physical activity of transportation itself. Those trading costs related to international movement of goods and related logistic services are met by composite services purchased from a global trade services sector, where the composite "international trade services" activity is produced as a Cobb-Douglas composite of regional exports of trade and transport service exports. Trade-cost margins are based on reconciled f.o.b. and c.i.f. trade data, as reported in version 4 of the GTAP dataset.

A second form of trade costs is known in the literature as frictional trading costs. These are implemented in the service sector. They represent real resource costs associated with producing a service for sale in an export market instead of the domestic market. Conceptually, we have implemented a linear transformation technology between domestic and export services. This technology is represented in Appendix Figure A.2. The straight line AB indicates, given the resources necessary to produce a unit of services for the domestic market, the feasible amount that can instead be produced for export using those same resources. If there are not frictional barriers to

trade in services, this line has slope -1. This free-trade case is represented by the line AC. As we reduce trading costs, the linear transformation line converges on the free trade line, as indicated in the figure.

E. Production structure

The basic structure of production is depicted in Appendix Figure A.3. Intermediate inputs are combined, and this composite intermediate is in turn combined in fixed proportions with value added. This yields sectoral output Z. The value-added substitution elasticities (between capital and labor) are presented in Appendix Table A.1.

F. The Auto Market

The automobile sector is modeled as two distinct activities. The first involves intermediate parts. The second involves final assembly of automobiles. The final assembly of automobiles, using traded and domestic intermediates, is modeled as involving cost-price markups dictated by inefficiencies and regulated prices. These cost-price markups lead to an internal price for automobiles reflected in the current 80% to 100% import tariffs. At the same time, it must be recognized that the Chinese automobile sector currently has far too many plants relative to the number of automobiles produced. For this reason, we can expect some cost economies in the domestic industry as consolidation leads to an expansion of production at the plant level. This is modeled as a scale/efficiency effect, calibrated from engineering-based scale elasticities, and based on the difference between the current level output per plant (both for the largest plants, and for the residual industry) in comparison to average output per plant in the North American market. It is assumed that the output per plant approaches minimum efficient scale following WTO accession and internal market liberalization.

G. The composite household and final demand structure

Final demand is determined by an upper-tier Cobb-Douglas preference function, which allocates income in fixed shares to current consumption, investment, and government services. This yields a fixed savings rate. Government services are produced by a Leontief technology, with household/government transfers being endogenous. The lower-tier nest for current consumption is also specified as a Cobb-Douglas. The

regional capital markets adjust so that changes in savings match changes in regional investment expenditures. (Note that the Cobb-Douglas demand function is a special case of the CDE demand function employed in the model code. It is implemented through GEMPACK parameter files.)

H. Labour markets

Our default closure involves modeling labour markets as clearing with flexible wages. However, in implementation the mobility of labour between sectors is slightly "sluggish" in the sense that there is not a perfectly linear transform technology for movement of labour between sectors. This represents the assumption that for institutional reasons (and because some skills are sector specific), labour is not fully flexible in its application across sectors. We view this as a reasonable representation of labour markets. To the extent that wage rigidities are important, the direction of aggregate employment effects may be inferred from wage effects. (Hertel 1996 refers to this as "sluggish" factor movements). Theoretical discussion of factor mobility, along the lines developed in Hertel and employed here, can be found in Casas (1984). It should be noted that in practice the transformation elasticities are set very high (-25.0) but not infinitely so. This effectively allows for "essentially" full mobility. (It also speeds up finding numeric solutions without changing the substantive results.) Values for these parameters can be found in Appendix Table A.1, which provides a summary of several relevant elasticities.

I. Services Barriers

The basic methodology involves the estimation of sector-specific gravity equations vis-à-vis global trade levels. Basically, we take GTAP bilateral trade data, and fit it to a simple gravity model of total imports by country. In this case, these equations have been estimated at the level of aggregation corresponding to the model sectors.

The gravity equations are estimated using ordinary least squares with the following variables:

$$(1) \quad X_i = a_1 \cdot \ln(POP_i) + a_2 \cdot \ln(PCGDP)_i + a_3 \cdot \ln(PCGDP)_i^2 + e_i$$

where X_i represents imports from the world, POP represents population, and $PCGDP$ per-capita income in the importing country.

In the regressions, we break out Hong Kong as a free trade "benchmark" in the regressions. Deviations from predicted imports, relative to this free trade benchmark, are taken as an indication of barriers to trade. These tariff equivalent rates are then backed out from a constant elasticity import demand function as follows:

$$(2) \quad \frac{T_1}{T_0} = \left[\frac{M_1}{M_0} \right]^{\frac{1}{e}}$$

Here, T_1 is the power of the tariff equivalent $(1+t_1)$ such that in free trade $T_0=1$, and $[M_1/M_0]$ is the ratio of actual to predicted imports (normalized relative to the free trade benchmark ratio for Hong Kong, as discussed above). This is a reduced form, where actual prices and constant terms drop out because we take ratios. The term e is the demand elasticity (with values as suggested by the relevant trade substitution elasticities in Table A.2).

Relevant estimates of tariff equivalents for the model sectors and regions are reported in Table A.3.

Table A.1

The Sectoring Scheme of the Model

Model Regions		Model Sectors	
<u>abbreviations</u>	<u>description</u>	<u>abbreviations</u>	<u>description</u>
Australia	Australia	Wool	Wool
NewZealand	New Zealand	NatFibers	Natural fibers (cotton etc.)
China	Mainland China	PrimFood	Primary food production
HongKong	Hong Kong	OthPrimary	Other primary production
Japan	Japan	Sugar	Sugar
Korea	Korea	ProcFood	Processed food, tobacco, and beverages
Taiwan	Chinese Taipei (Taiwan)	Textiles	Textiles
ASEAN5	ASEAN5 member states 1/	Clothing	Wearing apparel
Vietnam	Vietnam	Leather	Leather products
Bangladesh	Bangladesh	ChemRef	Chemicals, refinery products, rubber, plastics
India	India	Steel	Steel refinery products
SouthAsia	South Asia	Nfmetals	Non-ferrous metal products
Canada	Canada	MotorVehs	Motor vehicles and parts
Mexico	Mexico	Electronics	Electronic machinery and equipment
USA	United States of America	OthrMach	Other machinery and equipment
CBI	Caribbean Basin Initiative countries	MnfcsNEC	Other manufactured goods
ATP	Andean Trade Pact countries	Trade	Wholesale and retail trade services
Brazil	Brazil	Transport	Transportation services (land, water, air)
MERCOSUR	MERCOSUR 2/	Communic	Communications services
Chile	Chile	Construction	Construction
OtherLatAm	Other Latin America	FIRE	Finance, insurance, and real estate services
EuropUnion	European Union	CommServ	Other commercial services
Turkey	Turkey	OtherServ	Other services (public, health, etc.)
AfricaME	Africa and the Middle East		
ROW	Rest of World		

1/ ASEAN5 includes Phillipines, Thailand, Indonesia, Singapore, and Malaysia

2/ MERCOSUR includes Argentina, Paraguay, Uruguay. Brazil is represented separately

Table A.2 – Model parameters

<i>description</i>	elasticity of substitution in value added	Armington elasticity
Wool	0.24	4.4
Natural fibers (cotton etc.)	0.24	4.4
Primary food production	0.23	4.61
Other primary production	0.2	5.6
Sugar	0.63	4.4
Processed food, tobacco, and beverages	1.12	4.72
Textiles	1.26	4.4
Wearing apparel	1.26	8.8
Leather products	1.26	8.8
Chemicals, refinery products, rubber, plastics	1.26	3.8
Steel refinery products	1.26	5.6
Non-ferrous metal products	1.26	5.6
Motor vehicles and parts	1.26	10.4
Electronic machinery and equipment	1.26	5.6
Other machinery and equipment	1.26	6.25
Other manufactured goods	1.26	5.16
Wholesale and retail trade services	1.68	3.8
Transportation services (land, water, air)	1.68	3.8
Communications services	1.26	3.8
Construction	1.4	3.8
Finance, insurance, and real estate services	1.26	3.8
Other commercial services	1.26	3.8
Other services (public, health, etc.)	1.26	4.06

Table A.3

Pre- and Post-Accession Protection by Sector (tariff or tariff equivalent)						
	Mainland China			Chinese Taipei		
merchandise	GTAP base rates	Accession rates	New bound rates	GTAP base rates	Accession rates	New bound rates
Wool	14.76	42.00	38.00	0.00	0.00	0.00
Natural fibers (cotton etc.)	3.14	17.38	13.58	0.00	6.02	4.88
Primary food production	58.80	58.13	46.83	8.48	1.49	1.42
Other primary production	0.48	6.94	5.08	4.72	1.85	1.62
Sugar	29.49	30.00	20.00	22.05	14.00	14.00
Processed food, tobacco, and beverages	37.65	40.66	23.18	26.17	8.19	6.67
Textiles	25.09	25.43	10.21	6.13	2.58	2.28
Wearing apparel	31.75	32.80	16.05	12.80	4.84	4.22
Leather products	12.10	20.94	17.02	3.99	1.50	1.31
Chemicals, refinery products, rubber, plastics	12.62	14.85	7.17	3.75	1.92	1.43
Steel refinery products	9.68	8.92	5.10	5.12	1.79	0.16
Non-ferrous metal products	7.83	8.20	5.52	1.70	1.28	0.68
Motor vehicles and parts	34.42	38.65	15.41	23.89	10.65	5.47
Electronic machinery and equipment	11.93	16.90	9.62	2.93	3.29	2.07
Other machinery and equipment	12.83	15.37	10.14	4.57	1.92	1.26
Other manufactured goods	14.51	21.99	16.29	4.94	2.01	1.49
services	Base Protection		New Protection	Base Protection		New Protection
Wholesale and retail trade services	0.00	*	0.00	0.00	*	0.00
Transportation services (land, water, air)	3.97	*	1.99	3.38	*	1.69
Communications services	9.18	*	4.59	4.41	*	2.21
Construction	13.68	*	6.84	11.76	*	5.88
Finance, insurance, and real estate services	8.08	*	4.04	3.71	*	1.86
Other commercial services	47.92	*	23.96	8.37	*	4.19
Other services (public, health, etc.)	25.74	*	12.87	14.17	*	7.09

Figure A.1 — Armington Aggregation Nest

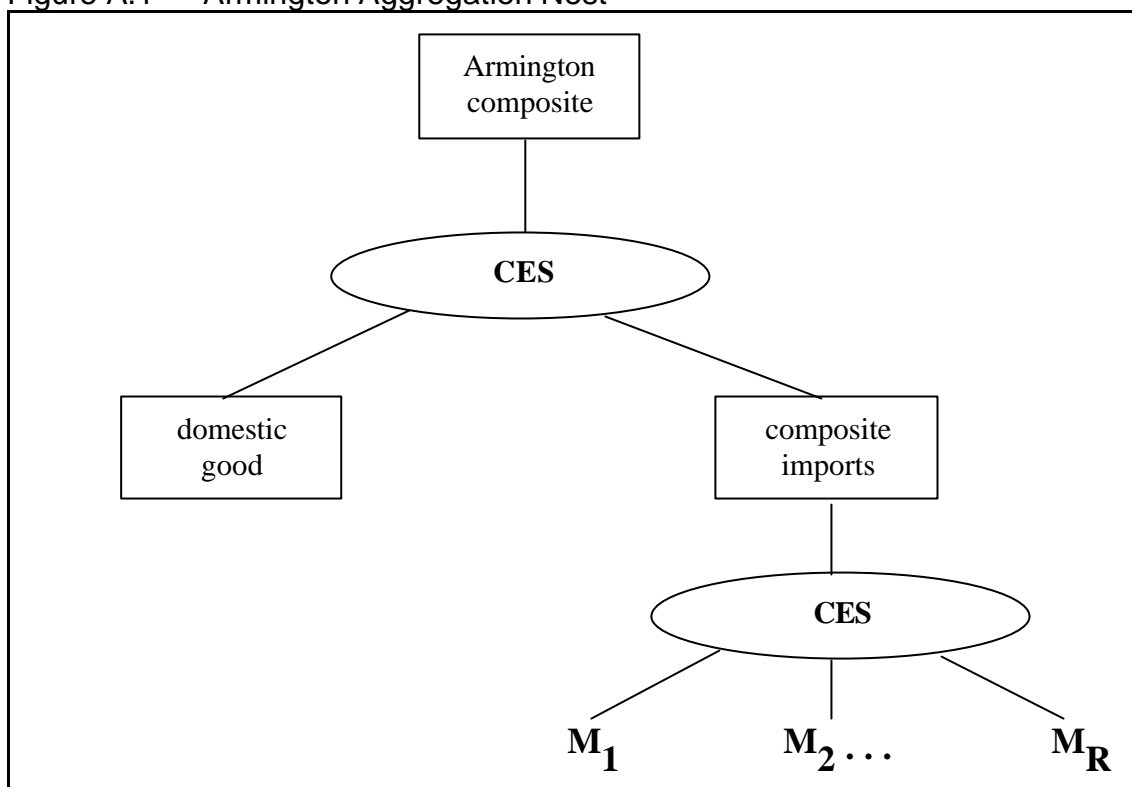


Figure A.2 -- Trading Costs in the Service Sector

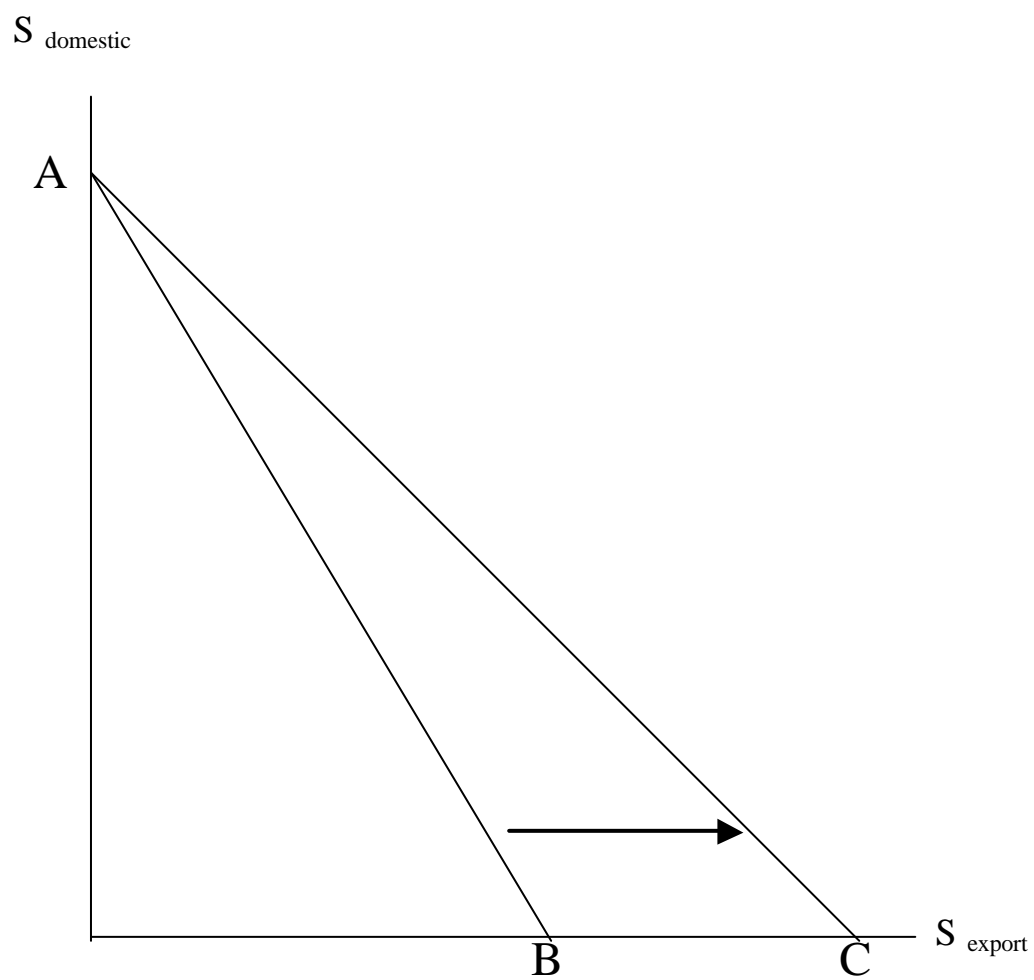
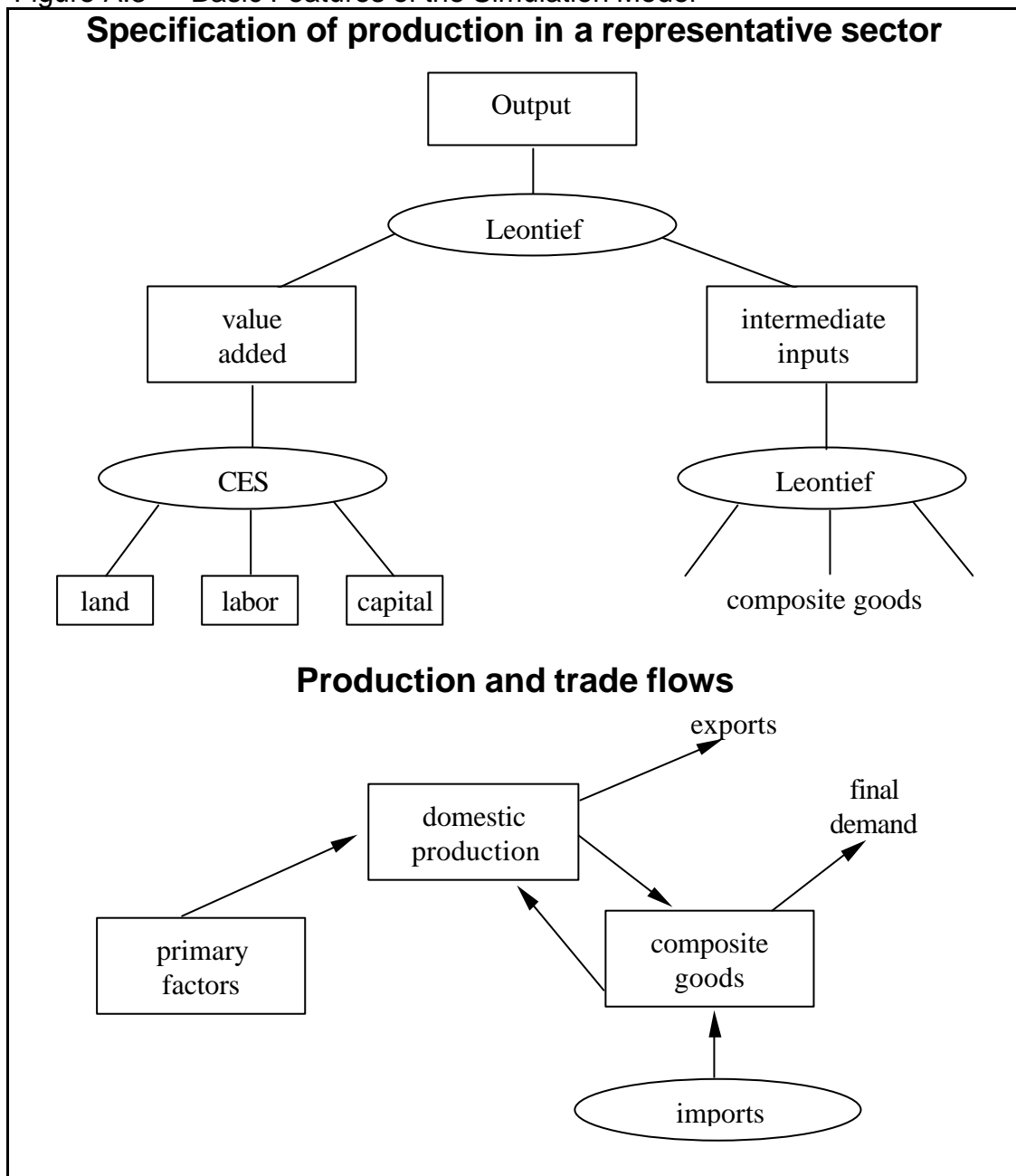


Figure A.3 — Basic Features of the Simulation Model



REFERENCES

- Baldwin, R.E. and J.F. Francois (1999), *Applied Issues in Dynamic Commercial Policy Analysis*, Cambridge: Cambridge University Press.
- Baldwin, R.E. and J. Francois, "Is it time for a TRAMP? Quantitative perspectives on transatlantic liberalization," in O.G.Mayer and H-E Scharrer, eds., *Transatlantic Relations in a Global Economy*, Hamburg: Nomos Verlagsgesellschaft, ISBN: 3-7890-5935-8, 1999, pp. 69-77.
- Commission of the European Communities (1988), *The Cost of Non-Europe*, Brussels.
- Economic Planning Agency (1997), "Economic Effects of Selected Trade Facilitation Measures in APEC Manila Action Plan," mimeo prepared for APEC secretariat, Japan.
- Francois, J.F. and C.R. Shiells, *Modelling Trade Policy: Applied General Equilibrium Assessments of North American Free Trade*. Cambridge University Press: Cambridge, (1994). coedited.
- Francois, J.F., B.J. McDonald, and H. Nordstrom, "A User's Guide to Uruguay Round Assessments," Centre for Economic Policy Research discussion paper, 1996.
- Francois, J.F., B. McDonald and H. Nordstrom (1996b), "Trade liberalization and the capital stock in the GTAP model," GTAP consortium technical paper.
- Francois, J.F. and A. Strutt (1999), "Post Uruguay Round Tariff Vectors For GTAP Version 4," Erasmus University manuscript.
- Francois, J.F. (2000) "Assessing the results of general equilibrium studies of multilateral trade negotiations," UNCTAD/ITCD/TAB/4, UNCTAD Policy Issues in International Trade and Commodities Study Series, UNCTAD:Geneva, October.
- Industry Commission (1995), "The Impact of APEC's Free Trade Commitment," IC95, Australia: Canberra.
- McDougall, R., ed. (2001). *The GTAP database -- version 5*, Global Trade Analysis Center: Purdue University.
- Reinert, K.A. and D.W. Roland-Holst (1997), "Social Accounting Matrices," in
- Francois, J.F. and K.A. Reinert, eds. (1997), *Applied methods for trade policy analysis: a handbook*, Cambridge University Press: New York.
- Francois, J.F. and D. Spinanger (2001), "Greater China's Accession to the WTO: Implications for International Trade/Production and for Hong Kong," paper prepared for the Hong Kong Trade Development Council, December.

Smith, M.A.M (1977), "Capital Accumulation in the Open Two-Sector Economy," *The Economic Journal* 87 (June), 273-282.

Smith, M.A.M. (1976), "Trade, Growth, and Consumption in Alternative Models of Capital Accumulation," *Journal of International Economics* 6, (November), 385-388.

Srinivasan, T.N. and J.N. Bhagwait (1980), "Trade and Welfare in a Steady-State," Chapter 12 in J.S. Chipman and C.P Kindelberger, eds., *Flexible Exchange Rates and the Balance of Payments*, North-Holland Publishing.

United Nations Committee on Trade and Development (1994), "Columbus Ministerial Declaration on Trade Efficiency."