9

Multi-Region General Equilibrium Modeling

Thomas W. Hertel, Elena Ianchovichina, and Bradley J. McDonald

I Introduction

This chapter is about the issues that modellers confront in deciding whether to apply single-region or multi-region general equilibrium models and, when multi-region models are used, the inherent differences in data and modeling methods that modellers face. The chapter provides an overview of the key data and conceptual issues involved in moving from single-region to multi-region models, such as the organization of trade and protection data, assumptions about product differentiation, and implications of alternative macroeconomic model closures.

The single-region and multi-region approaches are directly compared for a particular example involving the Uruguay Round. During the course of these negotiations, many countries sought quantitative guidance on the likely impact of the agreement on their economies. Because of limited data and modeling capacity, most of these countries conducted this analysis by using either single-region applied general equilibrium (AGE) models or multi-region partial equilibrium models. In our example, we ask the question, How much additional analytical insight would have been gained by having access to a multi-region model? The answer obviously depends on the country in question. We focus our analysis on Korea, which permits us to draw some tentative conclusions about the value added from multi-region AGE models.

II Conceptual Issues in Multi-Region AGE Models

International trade is the key inter-regional link in multi-region AGE models, even when these models are not explicitly oriented toward trade issues. "Current account" relations between regions overshadow their counterpart "capital account" relations partly because of the issues being studied, but also because the numerical modeling of financial and asset-related international flows is less well-developed.[1] Data on bilateral flows of merchandise trade are also easier to obtain than similar data for capital flows. Finally, many of the existing models were developed to support multi-lateral trade negotiations, which in the past have largely focused on merchandise trade. Within the current account, regional exports and imports of goods (and often services) are usually the only categories considered explicitly. International transfers and flows of investment income, the other components of the current account, rarely receive careful attention, although their values must be present somewhere in the underlying social accounting matrix. Clearly, this is an important area for future research.

II.1 Product Differentiation

Modeling merchandise and services trade in multi-region models involves most of the same choices that one confronts in single-region modeling, plus some additional complications. Perhaps the most important assumptions pertain to the structure of final and intermediate demands for products sourced from the various regions of the model. Are competing products from the various regions assumed to be identical, or are they instead differentiated by their region of origin? If they are assumed to be identical, this aspect of the model is straightforward: Net exports of the product are equal to the excess of production over total domestic use of the product. Any intra-industry trade that exists is "netted out," reducing the apparent importance of trade to the region. Intra-industry trade may be reduced by increasing the sectoral detail of a model, but the detail needed to reduce it to inconsequential levels is unlikely to be achieved in multi-region models.[2] Net trade models can also be hypersensitive to changes in transportation cost and trade policy wedges. Finally, they run the risk of extreme specialization when sector-specific factors of production are not present in the model.

1 In AGE modeling, capital account issues are normally considered to be questions of model closure, a topic discussed later. For recent efforts in this area, see Goulder and Eichengreen (1992).

2 The size of a model increases rapidly with the number of regions, especially in the presence of bilateral trade flows, and sectoral detail is computationally and otherwise more expensive in multi-region models. Furthermore, differences in data coverage across countries makes it difficult to develop comparable social accounting data for a narrowly defined industry in more than one country: Industry definitions for input–output tables are not harmonized across countries, while merchandise trade categories of the Harmonized System (HS) are harmonized only to six digits.

II.2 Endogenous Versus Exogenous Differentiation

Once one introduces the idea of product differentiation, the immediate question that arises is, Why are the products differentiated? The traditional approach to modeling product differentiation, due to Armington (1969), is to assume that it is related to exogenous considerations that somehow are linked to the country of origin. For example, as a result of variation in climate and soils, Canadian wheat tends to be differentiated from U.S. wheat. Alternatively, it is sometimes argued that while particular products such as soft wheat are nearly identical regardless of source, the aggregation of soft wheat and hard wheat into a single product, "wheat," means that the composition of wheat produced in different regions varies. One can capture these phenomena by introducing imperfect substitutability among wheat from different sources. Whatever the source of this differentiation, the key assumption in the Armington approach is that it is *exogenous* to the model.[3]

An alternative approach to product differentiation in models of international trade is based on the work of Spence (1976), and of Dixit and Stiglitz (1977), in which products are differentiated by firm. In this case firms incur fixed or overhead costs, such as research and development and product marketing, when producing differentiated goods. In its pure form, firm-level differentiation means that an automobile manufactured by Honda is modeled as being different from one manufactured by Mercedes-Benz, regardless of origin. This *endogenous* differentiation has important implications for the structure of costs and the consequences of trade liberalization. In particular, it is customary to treat the resources associated with differentiation as fixed costs. Coupled with constant returns to scale in production (i.e., fixed marginal costs), this gives rise to declining average total costs. Therefore, any shock that causes individual firms (as opposed to the industry) to increase their output results in positive *scale effects* for the economy, as fixed costs are spread over more units.

Working in the other direction is the *varietal effect* associated with the number of differentiated products on offer. Clearly, firms would not engage in product differentiation if consumers, in aggregate, preferred a single variety, or if variety itself were not somehow valued. In this case, there would be no incentive to deviate from a single variety. Therefore, the pres-

3 There is no particular reason why all products and/or all regions need to have the same Armington structure. For example, in the RUNS model (Goldin, Knudsen and van der Mensbrugghe, 1993), trade in industrial products was described by two-stage CES Armington functions. Agricultural products, on the other hand, were not assumed to be differentiated by region of origin and trade in these products was on a net trade basis.

ence of differentiated products implies either heterogeneity among consumers or a demand for variety among at least some consumers. When additional products are added to the marketplace, thereby incurring fixed costs and diluting the sales of existing firms, there is an offsetting gain due to increased variety. In particular, the new products permit individual consumers either to obtain a better match between their preferred variety and those extant in the marketplace or to obtain increased variety in consumption.[4]

Applied models of trade based on consumer-level product differentiation build on theoretical work by Helpman (1981), Krugman (1979, 1980), and Lancaster (1980). An alternative interpretation involves differentiation of intermediate products. In particular, this approach builds on Ethier's (1979, 1982) work on international scale economies related to increased specialization of intermediate goods.[5] Regardless of the particular approach, equilibrium in a setting with firm-level product differentiation generally requires firms to exercise some market power, marking up their price over marginal cost in order to cover the fixed costs of product differentiation. The degree of market power obtained will depend on the number of firms and the heterogeneity of consumers. In particular, as emphasized by Anderson, DePalma, and Thisse (1992), greater heterogeneity implies a smaller elasticity of substitution in the aggregate utility function and thus larger markups. If entry and exit are permitted, the extra revenues obtained via this markup will be precisely exhausted on fixed costs in the zero profits equilibrium.

There is now an extensive body of theoretical literature exploring the properties of trade policy in the presence of endogenous product differentiation (e.g., Krugman, 1979; Helpman and Krugman, 1989; Venables, 1987; Brown, 1991; Francois, 1992, 1994; Hertel, 1994). There is also an emerging body of literature based on empirical analysis using global trade models under different specifications (e.g., Francois et al., 1995; Harrison et al., 1995; Hertel and Lanclos, 1994). Alternative approaches to modeling firm-level differentiation are examined by Francois and Roland-Holst in Chapter 11 of this volume. The introduction of imperfect competition gives rise to several additional mechanisms through which trade policy can influence the economy. Since these models require more data about industry structure, they are also more difficult to implement empirically in the context of a global model. For these reasons, we will restrict our attention in the remainder of this chapter to the Armington, perfect competition specification. This

4 See Helpman and Krugman (1985, Chapter 6), for a technical discussion of the love-of-variety and preferred variety approaches.

5 For example, see the technical annex of Francois et al. (1995).

provides a good starting point for the individual interested in multi-region AGE analysis.

II.3 Focus on the Armington Specification

When applied to single-region models, the product-differentiation-by-region-of-origin assumption is implemented by defining a composite product, $C_i=f(D_i, M_i)$ ($i \in I$, where I is the set of all tradeable products), that is an aggregation of domestically produced quantities of product i, D_i, and imported quantities, M_i. This is the end of the story for single-region models, which are not required to distinguish among import sources.[6] In contrast, multi-region models must take this notion a step further and distinguish M_{ir} (imports of i sourced from region r) from M_{is} (imports of i sourced from region s): $C_i=g(D_i, M_{ir}, M_{is}, \ldots)$.[7] Exactly how the Armington distinction is made varies in two key ways: the functional form chosen for the aggregator function, $g(\cdot)$, and whether the Armington aggregation is specific to each agent within a region or instead is simply performed at the border. The approaches used in various model applications are summarized in Table 9.1. We now turn to a discussion of each of these points, in turn.

In specifying import demand, either a single constant elasticity of substitution (CES) aggregator function or a nested CES Armington structure is often employed.[8] Under the nested approach, the composite good C_i is assumed to be a function of the domestic good and a composite of imports sourced from the other regions in the model:

$$C_i = g\left[D_i, h\left(M_{ir}, M_{is}, \ldots\right)\right] \tag{9.1}$$

where both the function g (the "top level" nest) and the function h (the "bottom level" nest) are CES functions. This formulation places two main restrictions on the structure of international trade. First, imports are made *separable* from the domestic good: Relative price changes among imports do not affect the quantity demanded of the domestic good, and a change in the price of the domestic good does not affect the relative quantities demanded

6 See Dervis, de Melo and Robinson (1982).
7 This notation is meant to indicate that regions r and s are two of an unspecified number of regions in the model other than the importing region under examination here.
8 See, for example, Shoven and Whalley (1992). For econometric evidence regarding the validity of this approach, see Winters (1984). Alternatives to the CES functional form include the almost ideal demand system (AIDS) of Deaton and Muellbauer (1980). In the context of agricultural commodities, Alston et al. (1990) have found that the elasticity of substitution between imports and domestic competing goods in the United States was substantially higher from AIDS estimation than from a CES-based estimation. Burfisher et al. (1994) work with a multi-region general equilibrium trade model which employs the AIDS import demand formulation.

Table 9.1. *Armington structure in selected multi-region CGE model applications*

Model Application	*No. of Stages*	*Functional Form*	*Location of Armington Aggregation*	*Export-side Armington ?*	*Comments*
Francois, McDonald and Nordström (1995)	One	CES	At the Border	No	
Jomini, *et al* (1991)	Two	CES	User Specific	No	Disaggregate imports sourced by agent
Lewis, Robinson and Wang (1995)	One	AIDS	At the Border	Yes	
Michigan Model (Deardorff and Stern, 1986)	One	CES	At the Border	Yes	
Roland-Holst, Reinert and Shiells	One	CES	At the Border	Yes	
RUNS Model (Goldin, Knudsen and van der Mensbrugghe, 1993)	Two	CES	At the Border	Yes	Agricultural products are not differentiated by region of origin
Standard GTAP Model (Hertel and Tsigas, 1995)	Two	CES	User specific	No	Composite imports sourced by agent
Whalley (1985), Seven-region model	Two	CES/LES	At the border	No	
Whalley (1985), Four-region model	One	CES/LES	User-Specific	No	Number of agents varies across regions

of the various imported goods.[9] Second, the particular assumption of g and h as CES functions implies not only that the elasticities of substitution at these two levels are constant, but that the elasticity of substitution at the lower level is equal for each pair of imports.[10] Under the non-nested specification, the substitution elasticities are implicitly identical at both levels.

9 As shown by Perroni and Rutherford (1995), it is possible to introduce more complex CES nesting structures in order to allow for nonseparability. The motivation behind their non-separable CES (NCES) form is primarily to allow flexibility in the representation of production technology rather than the international trade structure.

10 A special case of the nested CES Armington structure is that in which the elasticity of substitution among imports (the lower nest) is equal to that between imports and the domestic good (the upper nest). By restricting the elasticity of substitution to be equal among each pair of goods entering the aggregation, the Armington structure can be represented in a single stage function, $C_i=g(D_i, M_{ir}, M_{is}, \ldots)$, where g is a CES function. Of course, if the elasticity of substitution in the lower nest becomes smaller than that in the upper nest, then gross complementarity among imports becomes a possibility. That is, a reduction in one import's price could lead to an increase in the demand for *all* imports.

Modellers have tended to accept these restrictions because the empirical information necessary to exploit a less-restrictive structure is not typically available and because this structure has the virtues of analytical simplicity and computational ease.[11]

Largely on the basis of results of sensitivity analyses of models to changes in the substitution elasticities (σ^D in the top level nest and σ^M in the bottom nest) in CES-based Armington functions, modellers have come to appreciate the extent to which these parameters influenced the model results, particularly because the parameters largely determine terms of trade effects in the two-nest specification. The magnitude of terms of trade effects in Armington AGE models is often considered to be "excessive." These issues have been studied analytically by Brown (1987), who has concluded the following:

1 Terms of trade effects are reduced as σ^M approaches ∞.
2 As σ^D increases in the region making a tariff change, the terms of trade effects of the change are increased. However, as σ^D increases in the other regions, the terms of trade effects of the same tariff change are diminished. Increasing σ^D in all regions has an ambiguous influence on the magnitude of terms of trade effects.

Experience with sensitivity analysis by economists working with multi-region models suggests that the magnitude of the terms of trade effects noted by Brown in fact vary substantially with the substitution elasticities. This is especially troublesome, since there remains considerable uncertainty about the appropriate values of these elasticities.[12] Francois (1996) notes that the body of the Armington-based CGE literature steadfastly suggests gains to all participating countries in practically all regional trading arrangements, in contrast to economic theory on trade diversion. He argues that this may be an artifact of the Armington parameters. In this regard, it is important to conduct systematic sensitivity analysis on these and other parameters. Preckel et al. (1993) have proposed a method of sampling based on Gaussian quadrature that is particularly useful in large-scale, multi-region models where repeated solutions can be very time-consuming.

Of course the ultimate solution to the problem of parametric uncertainty rests in sound econometric work. However, the empirical estimation of Armington elasticities presents several challenges. For example, the product definition used in the estimation may be more narrow, or more broad, than

11 The analytical properties of the CES function are summarized in Table 4.9 of Shoven and Whalley (1992).
12 See Shiells and Reinert (1993).

the product definition used in the model; the same problem exists with regard to regional aggregation as well as product aggregation.[13] Another issue is the appropriate time frame for econometric estimation. The use of (appropriately adjusted) quarterly data may be necessary to gain a sufficient sized data set but, for reasons similar to those underlying the "J-curve," quarterly data may generate very inelastic estimates.

Brown's second point indicates the likely importance of region-specific estimates of the top nest substitution elasticity in determining the magnitude of terms of trade effects. Effects will be smaller if this elasticity is small in the region that changes tariffs, but larger if this elasticity is small in other regions. Relative sizes of upper nest elasticities thus help determine the magnitude of terms of trade effects. Nevertheless, when the nested CES Armington approach is used in multi-region models, the substitution elasticities used for a particular product usually are common to all regions in the model. While thorough econometric estimation of these elasticities has been performed by some modeling teams (see Roland-Holst et al., 1994; and the brief discussion in Chapter 1 of this volume), these estimates have typically been for only one region of a multi-region model.

II.4 Import Sourcing by Agent

Regardless of the type of Armington structure used, there are two alternatives in locating the structure within the model. The more common alternative is to use just one Armington function for each good in each region. We refer to this approach as applying the Armington aggregation "at the border." The other alternative is to specify one Armington function for each agent "consuming" each good in each region. We refer to this approach as using user-specific Armington functions. Here the modeller may choose to track *differentiated* imports to the users (more demanding) or, alternatively, to track *aggregated* imports to users.

User-specific Armington functions imply a substantial increase in model size compared to aggregation at the border. The number of potential users equals the number of sectors (which is usually equal to the number of goods) plus the number of final demand agents (typically consumers, government, and investment). This requires $(G+3)\cdot G\cdot R$ Armington functions, one for each good G used in each productive sector in each region R, one for each good privately consumed in each region, one for each good purchased by

13 Research into appropriate methods of aggregating econometric estimates obtained for detailed product specifications into the broader product categories common in multi-region AGE models may be very fruitful.

government in each region, and one for investment demand. If *differentiated* imports are tracked to users (e.g., Jomini et al., 1991), data are required on the sourcing of intermediate and final inputs for each user in each region. Such detailed data are not available from the input–output accounts. This has led to a third alternative, a compromise between full-blown sourcing of imports by agent and complete Armington aggregation at the border. Here, *disaggregate* imports are sourced at the border, but *composite* imports are tracked to the individual agents (Hertel and Tsigas, 1996). This matches the level of detail available in some national social accounting matrices, since breakdown of intermediate and final demands according to domestic and imported origins is a common practice in national input–output accounting (e.g., Hambley, 1992).

II.5 Macroeconomic Closure

One of the more contentious aspects of comparative static AGE models is the question of *macroeconomic closure*, a term first coined by Sen (1963) and later applied to AGE modeling by Taylor and Lysy (1979). Dewatripont and Michel (1987) note that there are four popular solutions to the fundamental indeterminacy of investment determination in comparative static models. The first three are non-neoclassical closures in which investment is simply fixed and another source of adjustment is permitted. In the fourth closure investment is permitted to adjust. However, rather than including an independent investment relationship, it simply accommodates any change in savings. Contemporary comparative static multi-region trade models often employ some form of this last closure rule, although variants of the other three are also sometimes adopted as special cases.[14]

In addition to adopting a closure rule with respect to investment, it is also necessary to come to grips with potential changes in the current account. Many multi-region trade models have evolved as a set of single-region models that are linked via bilateral merchandise trade flows (e.g., early versions of the SALTER model, which evolved from the ORANI model of Australia). These models have no *global closure* with respect to savings and investment, but instead impose the macroeconomic closure at the regional level. Here it is common to force domestic savings and investment to move in tandem, by fixing the current account balance. To understand this, it is

14 A collection of structuralist single-region AGE models, along with an analytical overview of the features of such models, is found in Taylor (1990). See Chapter 12 of this volume for dynamic extensions of these basic closure options.

useful to recall the following accounting identity, which follows from equating national expenditure from the sources and uses sides:

$$S - I + (T - G) \equiv X + R - M \tag{9.2}$$

which states that the private sector savings minus investment plus the government budget surplus is identically equal to the current account surplus, where R is international transfer receipts.[15] By fixing the right-hand side of identity (9.2) one also fixes the difference between national savings (including government savings) and investment.

If global savings equals global investment in the initial equilibrium, then the summation over the left-hand side of (9.2) equals zero and the sum of all current account balances (including transfer receipts) must initially be zero (provided *c.i.f./f.o.b.* margins are accounted for in national exports). Furthermore, by fixing the right-hand side of (9.2) on a regional basis, each region's share of savings in the global pool of net savings is fixed. In this way, equality of global savings and investment in the new equilibrium is also assured, in spite of the fact that there is no "global bank" to intermediate formally between savings and investment on a global basis. However, since investment is forced to adjust in line with regional changes in savings, this approach clearly falls within the "neoclassical" closure, as identified by Dewatripont and Michel.

The exogeneity of the current account balance embodies the notion that this balance is a macroeconomic, rather than microeconomic, phenomenon. To a great extent, the causality in identity (9.2) runs from the left side to the right side. It also facilitates analysis by forcing all adjustment to external imbalance entirely onto the current account. If savings does not enter the regional utility function, this is also the right approach to welfare analysis because an arbitrary shift away from savings towards current consumption would otherwise permit an increase in utility to be attained, even in the absence of improvements in efficiency or regional terms of trade.

For some types of experiments, however, modellers may wish to endogenize the balances on the left and right sides of identity (9.2). Some trade policy reforms may, for example, raise returns to capital or lower the price of imported capital goods (see Goulder and Eichengreen, 1992, and Chapters 12 and 13 of this volume). In this case, we would expect an increase in regional investment and, *ceteris paribus*, a deterioration in the current account. In other cases one might wish to explore the implications of, for example, an *exogenous* increase in foreign direct investment, which would

15 See, for example, Dornbusch (1980).

also dictate a deterioration in the current account. Once the left-hand side of (9.2) is permitted to adjust, we need a vehicle for ensuring that the global demand for savings equals the global demand for investment in the post-solution equilibrium. This can be ensured through the use of a "global bank" to assemble savings and disburse investment, an approach adopted in the Global Trade Analysis Project (GTAP) model (Hertel and Tsigas, 1996).

For the purpose of illustration, we work in this chapter with the GTAP model. The GTAP model treats savings and investment in an analogous manner to all other goods and services in the model. In particular, savings enters a regional Cobb–Douglas utility function, along with composite private consumption and aggregate government purchases. This reflects an implicit assumption of fixed savings rates. Fixing the savings rate prevents an arbitrary shift of savings in favor of current consumption from generating apparent increases in utility. The resulting behavioral equations are also compatible with a multi-period optimization problem, in which current period savings result in future consumption (Howe, 1975). Thus, from a consumption point of view, savings is treated analogously with other goods in the GTAP model. However, since bilateral information on savings flows is not available, we do not employ an Armington-type specification here. Rather, regional savings are gathered by the global banking sector and treated as a homogeneous good, which serves as numéraire in the model.

The global bank in the GTAP model uses savings to assemble a portfolio of regional investment goods. The size of this portfolio adjusts to accommodate changes in global savings. Therefore, the *global closure* in this model is neoclassical. However, on a regional basis, some adjustment in the portfolio is permitted, thereby adding another dimension to the determination of investment in the model. In particular, the global bank equates *expected* rates of return on investment across regions. This approach breaks the link between domestic investment levels and domestic savings rates, allowing welfare analysis in a static setting that involves shifts in capital flows. Any change in net capital flows is directly linked to a change in investment. This rules out direct linkages between an arbitrary shift in capital flows (foreign savings) and apparent shifts in utility due to shifting budget constraints.

Expected rates of return are an increasing function of current returns and a decreasing function of current period investment, following a specification originally proposed by Dixon et al. (1982):

$$RORE(r) = RORC(r)\left[\frac{KE(r)}{KB(r)}\right]^{-RORFLEX(r)} \quad (9.3)$$

Thus investors behave as if they expect a region's rate-of-return in the next period (*RORE*(*r*)) to decline with positive additions to the capital stock (*KE*(*r*)). The rate at which this decline is expected to take place depends on the flexibility parameter *RORFLEX*(*r*)>0. Therefore, the elasticity of *RORE*(*r*) with respect to *KE*(*r*) is equal to –*RORFLEX*(*r*). A small value for *RORFLEX*(*r*), say *RORFLEX*(*r*)=0.5, implies that a 1 percent increase in *KE*(*r*) is expected to reduce the rate of return on capital by 0.5 percent. For example, if the current rate of return were 10 percent, the expected rate of return on a net investment equal to 1 percent of *KE*(*r*) would be 9.95 percent, i.e., little change. In this case, the supply of new investment is *very* sensitive to the expected rate of return. In order to maintain equal changes in *RORE* across regions, the model will produce large changes in regional investment.

However, a large value for *RORFLEX*(*r*), say *RORFLEX*(*r*)=50, implies that a 1 percent increase in *KE*(*r*) is expected to cut the rate of return on capital in half. In this case the supply of new capital goods is not very sensitive to changes in the expected rate of return. Therefore, equal changes in *RORE* across regions can be accommodated with small changes in regional investment. In other words, if the user believes that the experiment under consideration will not have a great impact on regional investment (or wishes to abstract from such effects) large values of *RORFLEX*(*r*) are chosen.

II.6 International Factor Mobility

In a multi-period model, international investment flows in the current period will be accompanied by reverse flows in international factor payments in future periods. However, in a comparative static model (like that considered here), new investment does not come on line, so this aspect need not be considered. However, any global data set must contain (albeit implicitly) such income flows that result from historical transboundary investment. These factor service flows are an important part of the international economy, particularly in the case of certain closely linked countries. For example, increased factor payments in the United States will benefit investors in Canada, and vice versa. Foreign ownership claims on capital income are represented in the models of Whalley (1985) and have been emphasized by researchers such as Markusen and Wigle (1989), who take explicit account of cross-ownership of factors in their analysis of a Canada–United States Free Trade Agreement.[16] Unfortunately, data on bilateral factor service flows are limited and so most global trade models have abstracted from this issue. An exception is provided by recent innovations to the SALTER model (McDougall, 1993).

III Data Issues in Multi-Region AGE Modeling

III.1 MFN Tariffs and the Compositional Effects of Aggregation

When working with single-region models, one faces the question of how to aggregate most favored nation (MFN) tariffs.[17] One approach often used is the weighting of tariffs by import value. With hundreds or perhaps thousands of individual lines in the tariff schedule being combined into one model sector, the compositional effects that can be captured by import weighting are potentially of great importance. It is often noted, though, that weighting by import value can lead to a downward bias in tariff aggregations. Higher tariffs lead to smaller (tariff-exclusive) import values, since imports are themselves a decreasing function of tariffs.[18] This is sometimes used as an argument in favor of another often-used approach, the simple averaging of tariffs, which in effect assumes the identical weight for each tariff line, regardless of its importance in trade. It also sometimes goes unrecognized that, for political economy reasons, past tariff reductions may have been deepest on those items that were more lightly imported. This implies that higher tariffs may remain on items of greater importance to trade and argues against the use of simple averaging.[19]

Uneven tariffs are more distorting than a uniform tariff with the same mean. Regardless of the weighting method used, the averaging process may incorporate tariff variance. This will be particularly desirable when dealing with policies that lead to very uneven protection, either across tariff lines

16 International labor mobility may also be important in certain applications. One approach is that of Burfisher et al. (1994). This area of research, however, remains underdeveloped.
17 Further discussion of this issue is contained in Chapter 2 in this volume.
18 By weighting tariffs with the duty-inclusive value of imports, some of this bias might be offset. Ultimately the degree of bias will depend on the price elasticity of import demand.
19 An additional argument in favor of import weighted averaging in the context of AGE modeling is that this method gives an accurate accounting of the tariff revenue. The importance of this accuracy will depend on several factors, including the presence of certain model features (are government revenue sources distinguished?), the size of tariff revenue collections relative to total government revenue or to GDP, and the value of imports that enter the country under other than MFN tariffs (for example, under preferential tariff arrangements).

Table 9.2. *Results of alternative tariff averaging methods*

GTAP Region and GTAP Product Name	*Simple Average*	*Trade-Weighted Average*	*Bilateral Trade-Weighted Average*	
			Low	*High*
	Per cent			
Indonesia, non-grain crops	17.1	3.9	0.0	24.1
United States, beverages and tobacco	8.0	4.3	0.8	15.8
Australia, textiles	25.4	13.2	4.2	29.4
New Zealand, chemicals, rubber and plastics	14.0	19.8	5.0	36.0

Source: Calculations reported in Gehlhar, et al. (1996) based on tariff data from the GATT Integrated Data Base.

(within a model sector) or across import sources. Magee (1972) proposed an averaging method that incorporates tariff variance. This method was applied in calculations of average anti-dumping duties for the 1994 GTAP database (Gehlhar et al., 1996).

Multi-region modeling adds yet another dimension to the debate over tariff averaging methods. The composition of the imports of a product from one source differs from the composition of imports of the same product from another source. By using the Armington assumption of product differentiation by region of origin, one recognizes this compositional effect in trade flows. It is reasonable to extend this recognition to tariffs as well and to use *bilateral* import-weighted tariffs, with the result that each of the model's bilateral trade flows (potentially $G \cdot R \cdot (R-1)$ of them) has an associated MFN tariff rate.

This is the method by which tariff rates are calculated for the 1994 and subsequent releases of the GTAP database (Gehlhar et al., 1996), a standard data source for multi-region modeling, and one which we work with in this chapter. For calculating the tariff data, data on bilateral imports and applied MFN tariffs were collected at the tariff-line level, where the number of tariff lines exceeded 12,000 for some regions. Results from this exercise indicate that, in many cases, compositional effects lead to tariff averages that vary substantially by source region, sometimes by multiples of 2 or 3. Gehlhar et al. (1996) report four examples, which are summarized in Table 9.2. The first row in this table shows that the simple average of all tariffs on non-grain crops imported into Indonesia is equal to 17.1 percent. This contrasts sharply with the trade-weighted average tariff on this group of products, which is only 3.9 percent, indicating that some of the highest tariffs are on lightly traded products. Also worthy of note is the variation in bilateral tariff rates which results from the differing composition of imports from different sources. These range from a zero bilateral tariff on imports to a 24.4 percent tariff. In sum, applying a simple average tariff to all imports hides a good deal of variation in effective tariff rates by source.[20]

III.2 Discriminatory Tariffs

In reality, much of global movement in merchandise goods does not take place under MFN tariffs. Price-based trade policies other than MFN tariffs include preferential tariffs, minimum import prices, anti-dumping duties and countervailing (anti-subsidy) duties. These policies, typically applied bilater-

20 When bilateral weighting is used in the development of the base tariff rates, the same process can be applied to aggregate tariff reductions.

ally, present special challenges in the setting of a multi-region model that may be "aggregated away" in single-region modeling. To date, however, there has been little progress toward a comprehensive treatment of such policies.

In the category of preferential tariffs we include tariff rates applied under regional trade agreements and tariff preferences for developing countries under the Generalized System of Preferences. Because the spread of regional trade agreements is quite recent, these preferential tariffs have not yet been incorporated into the benchmark data for multi-region AGE models. Many models built for the analysis of actual or proposed preferential trade agreements or tariff preferences do introduce preferential rates as the key component of counterfactual simulations (see, for example, particular chapters in Francois and Shiells, 1994; Hertel, 1996). To the extent they existed in the base period of the model from which trade data are taken, however, preferences have rarely, if ever, been recorded in the base data of multi-region AGE models.[21]

Anti-dumping and countervailing duties (AD/CVD) are other important policy instruments that discriminate among import sources.[22] Anti-dumping duties, by far the more prevalent of the two, are common in most major trading countries, with the exception of Japan. As of December 1994, the United States had 277 final anti-dumping duty orders in effect, each order country- and product-specific.[23] In late 1994, the European Union applied final anti-dumping duty orders on some 115 country and product combinations and had 51 price undertakings in effect.[24] In both these major traders, anti-dumping duty margins typically are in the range of 20 to 40 percent – many times the rates of MFN tariffs – and sometimes exceed 100 percent. AD/CVD actions have not yet been fully incorporated into multi-region model databases. To our knowledge, the first step in this direction is the 1994 release of the GTAP database, which incorporates, on a bilateral basis, aggregated anti-dumping duties and price undertakings of the United States, European Union, and Canada (Gehlhar et al., 1996).

The extent to which the neglect of discriminatory policies in multi-region models will distort results is not known, but it can be expected to depend on

21 Some 40 agreements were notified to the GATT between 1989 and 1994.

22 An excellent overview and several case studies are provided in Finger (1993). Staiger and Wollak (1994) establish empirically that anti-dumping actions restrict trade for other reasons in addition to the final orders that may be applied.

23 U.S. Department of Commerce (1994). In addition, according to this report, there were twelve suspension agreements in effect that resulted from anti-dumping actions, and ninety-seven countervailing duty (final) orders in effect. The country and product coverage of anti-dumping and countervailing orders often overlap.

24 Anti-dumping and countervailing duty actions of the European Union are reported in the *Official Journal*, available on CD-ROM.

several factors. One example with the potential to distort results is when preferential tariffs are in place but are neglected in the benchmark data, and counterfactual simulations are run in which MFN tariffs are reduced. In fact, we might expect a reduction in exports by preference-receiving countries as their margin of preference is eroded. If the preferential tariffs are not reflected in the benchmark data, however, the model results can be expected to show an increase in exports by the preference-receiving countries, as well as other exporters.

The neglect of bilateral policies will also lead to what we term "dirty calibration." An example is when imports are influenced by anti-dumping duties, but these duties are neglected in the benchmark protection data and in the calibration process. The calibrated share parameter in the Armington function will then be understated. Because the benchmark equilibrium is inaccurately recorded, dirty calibration will distort the results of all counterfactuals, although the magnitude of such effects has not been studied.[25]

III.3 Non-Tariff Barriers to Trade

Non-tariff trade barriers (NTBs) are, in many cases, administered bilaterally and therefore present many of the same modeling and data challenges discussed in the section on discriminatory tariffs. As with single-region models, however, incorporating NTBs into multi-region AGE models requires additional information on the price-based measure equivalent to the NTB. Typically, these equivalent measures are import tariffs when the NTB is a restraint on imports, and export taxes when the NTB is a restraint on exports. A discussion of NTB measurement issues is provided in Chapter 2.

III.4 International Transportation Margins

One feature of international trade that has been largely neglected in multi-region AGE models is the presence of international transport costs. The difficulty has been one of data availability, since these margins vary by route and commodity and are not directly observed in the international trade data. However, Tsigas et al. (1992) show how these margins may be estimated from pooled times series/cross section bilateral trade data. Indeed, the estimation of these margins is a critical step in the process of reconciling re-

25 As pointed out in Chapter 5, the neglect of underlying distortions also can lead to the systematic and substantial underestimation of the welfare benefits attributable to the removal of a particular distortion. The welfare impact of a tariff reduction from 50 percent to 40 percent will exceed that of the elimination of a 10 percent tariff, given the same initial trade values.

ported (*c.i.f.*) imports and (*f.o.b.*) exports. This concept is further refined in Gehlhar et al. (1996), where a trade margins function depending on distance, volume and an input price index is explicitly estimated. The resulting margins are incorporated in the GTAP database. As modeled here, they result in incomplete transmission of *f.o.b.* price changes into *c.i.f.* changes. Furthermore, they open the opportunity for users to explore the implications of changes in technology, policy and market structure that might alter these transport margins.

IV Multi-Region and Single Region Analysis Compared: Korea and the Uruguay Round

We now turn to the analysis of a specific problem in trade policy, namely, the impact of the Uruguay Round Agreement reached under the auspices of the GATT. We approach this problem from the point of view of an individual country and ask how multi-region analysis adds to their understanding of the agreement and its impact on them.

IV.1 Motivation

During the course of the Uruguay Round negotiations, virtually every country involved found itself faced with the question, What will be the impact of this agreement on our national economy? As a result of improvements in software and computing capabilities, as well as a fairly broad base of international expertise, many countries had access to some sort of economywide analysis, often using applied general equilibrium models. However, very few had access to applicable results from a global AGE model. How much more information would they have been able to obtain from such a model? Is it worth the effort associated with acquiring the necessary expertise?

This question is impossible to answer in the abstract. One's conclusion will depend on the relative size of an individual country's offers, as compared to that of its trading partners. It also depends on their size in the various international markets of interest. An extreme case is provided by Taiwan, a country which is not currently a member of the GATT and therefore not directly affected by the agreement. A single-region analysis of the Uruguay Round is not helpful for Taiwan, since all of the "action" occurs in other regions. Yet given its heavy reliance on trade, the welfare of Taiwan clearly depends on what happens to border measures in its partner regions. Without a multi-region model, there is little to say about this issue, other than to take

Table 9.3. *Average pre– and post–Uruguay Round protection levels, by importing region*

Importing Region	*Pre-Round[a] Tariff (%)*		*Post-Round[a] Tariff (%)*		*Average Import[b] Price Cuts (%)*	
	Food	*Mnfcs*	*Food*	*Mnfcs*	*Food*	*Mnfcs*
US & Canada (USC)	11.7	4.3	11.0	2.8	-0.6	-1.4
European Union (EU)	26.5	6.5	26.0	3.9	-0.3	-2.4
Japan (JPN)	87.8	4.9	56.1	2.1	-8.1	-2.7
Korea (KOR)	99.5	16.1	41.1	8.2	-17.9	-6.8
Taiwan (TWN)	0.0[c]	0.0[c]	0.0[c]	0.0[c]	0.0[c]	0.0[c]
Hong Kong(HKG)	0.0[c]	0.0[c]	0.0[c]	0.0[c]	0.0[c]	0.0[c]
China (CHI)	0.0[c]	0.0[c]	0.0[c]	0.0[c]	0.0[c]	0.0[c]
Indonesia (IND)	21.9	14.2	15.5	13.5	-4.2	-0.6
Malaysia (MYS)	87.9	11.0	34.3	7.7	-14.9	-2.9
Philippines (PHL)	86.9	23.9	33.4	21.5	-15.3	-1.8
Thailand (THA)	59.8	36.2	34.5	27.6	-10.8	-5.9
Latin America (LTN)	2.3	17.1	1.5	14.9	-0.5	-1.6
Sub-Saharan Africa (SSA)	15.6	9.5	12.4	9.4	-1.7	-0.1
South Asia (SAS)	-3.5	51.9	-4.3	37.1	-0.7	-9.4
Rest of World (ROW)	15.7	10.6	14.1	9.1	-1.2	-1.3

[a] Source: Hertel et al. (1995). See also Hathaway and Ingco for details on farm and food protection. Nonfood protection levels are based on information from the GATT's Integrated Data Base.
[b] Change in tariff rate divided by the power of the initial tariff rate. This is the average of the disaggregate price cuts, and therefore differs from the price cut computed from the average tariffs.
[c] Taiwan, Hong Kong, and China are not covered by the Integrated Data Base from which these data are derived.

partial results from other analyses and try to relate them to variables in a national model.

The case of Korea is rather different, and for that reason more interesting for purposes of this chapter. Because Korea's offer under the Uruguay Round made deeper cuts in protection than was generally true on average, we expect that a disproportionate amount of the "action" will occur in the domestic economy. What does multi-region analysis contribute in this case? How closely are predictions from the two approaches correlated? What

Table 9.4. *Value of Uruguay Round cuts in import tax on commodities imported to Korea in millions of U.S. dollars (percentage change in power of the import tax in italics)*

	JPN	*OAS*[c]	*NAM*	*EAZ*	*ROW*	*TOTAL*
crops	-2	-1537	-1559	-501	-187	-3786
	-1[b]	*-24*	*-24*	*-35*	*-10*	
othagr	-5	-73	-253	-113	-36	-480
	-15	*-15*	*-16*	*-13*	*-16*	
extract	-86	-42	-155	-67	-47	-397
	-7	*-1*	*-4*	*-3*	*0*	
food	-5	-51	-227	-247	-4	-534
	-3	*-4*	*-20*	*-21*	*-1*	
textiles	-38	-26	-8	-22	-24	-118
	-4	*-2*	*-3*	*-5*	*-5*	
apparel	-2	-3	-1	-3	-1	-10
	-5	*-2*	*-10*	*-3*	*-5*	
crp	-315	-59	-268	-202	-68	-912
	-9	*-6*	*-9*	*-9*	*-8*	
metals	-298	-36	-78	-120	-125	-657
	-11	*-4*	*-4*	*-7*	*-6*	
trnseq	-39	-2	-8	-10	-6	-65
	-6	*-1*	*0*	*-2*	*-1*	
macheq	-1001	-396	-821	-331	-87	-2636
	-7	*-11*	*-9*	*-6*	*-6*	
othmnfc	-59	-28	-57	-50	-12	-206
	-6	*-6*	*-9*	*-8*	*-8*	
svces	0	0	0	0	0	0
	0	*0*	*0*	*0*	*0*	
Total	-1850	-2253	-3435	-1666	-597	-9801

[a] Source: Hertel et al. (1995). See also Hathaway and Ingco for details on farm and food protection. Nonfood cuts are based on the GATT's Integrated Data Base.
[b] Change in tariff rate divided by the power of the initial tariff rate. This is the average of the disaggregate price outs, and therefore differs from the price cut computed from the average tariffs.
[c] Taiwan, Hong Kong, and China are not covered by the Integrated Data Base.

explains the sources of discrepancy? We investigate these questions in the subsequent sections.

IV.2 Korea and the Uruguay Round

Table 9.3, taken from Hertel et al. (1995), shows the pre– and post–Uruguay Round levels of protection for non-food manufacturing and farm and food products under the Round. Note that Korean protection prior to the Round

Table 9.5. *Value of the Uruguay Round cuts in the import tax on commodities exported from Korea (percentage change in the power of the import tax in italics)*

	JPN	*OAS*	*NAM*	*EAZ*	*ROW*	*TOTAL*
crops	-13	-2	0	0	0	-15
	-2	*-1*	*0*	*0*	*-1*	
othagr	0	-1	0	0	0	-1
	0	*-4*	*0*	*0*	*-1*	
extract	-31	-14	-9	-11	-12	-77
	-1	*-1*	*-2*	*-4*	*-2*	
food	-79	-3	0	0	0	-82
	-10	*-1*	*0*	*0*	*0*	
textiles	-9	-147	-29	-44	-33	-262
	-1	*-3*	*-3*	*-6*	*-1*	
apparel	-84	-1	-51	-28	-11	-175
	-4	*-1*	*-2*	*-2*	*-2*	
crp	-22	-19	-12	-25	-59	-137
	-2	*-1*	*-1*	*-2*	*-4*	
metals	-88	-3	-45	-48	-47	-231
	-4	*0*	*-3*	*-5*	*-4*	
trnseq	-6	0	-14	-5	-19	-44
	-3	*0*	*-1*	*0*	*0*	
macheq	-73	-78	-169	-104	-112	-536
	-3	*-1*	*-2*	*-2*	*-2*	
othmnfc	-38	-12	-112	-86	-44	-296
	-2	*-1*	*-2*	*-3*	*-3*	
svces	0	0	0	0	0	0
	0	*0*	*0*	*0*	*0*	
Total	-443	-280	-441	-351	-337	-1852

[a] Source: Hertel et al. (1995). Hathaway and Ingco for details on farm and food protection. Nonfood cuts are based on the GATT's Integrated Data Base.
[b] Change in tariff rate divided by the power of the initial tariff rate. This is the average of the disaggregate price cuts, and therefore differs from the price cut computed from the average tariffs.
[c] Taiwan, Hong Kong, and China are not covered by the Integrated Data Base.

was quite high, especially for farm and food products, where the average tariff equivalent was almost 100 percent. Even in non-food manufacturing, the average tariff rate was relatively high (16 percent) compared with that of OECD countries and some other Asian economies. The cuts agreed to by Korea under the Round reduce the average tariff on food products (using pre-Round trade flows to weight the tariffs) to 40 percent and that on non-food manufactures by half. The resulting average price cuts, at constant *c.i.f.* prices, amount to 18 percent and 7 percent, respectively.

These cuts in protection can also be broken out by commodity and source, as is done in Table 9.4, which shows the value of cuts offered by Korea under the Round, in 1992 US$. These cuts represent the simple product of the reduction in *ad valorem* equivalent tariff, multiplied by 1992 imports (*c.i.f.* basis). Fully half of the total cuts ($9.8 billion) are in farm and food products (crops, other agriculture and food). A single-region analysis of the Korea cuts would be based on the row totals in this table. By expanding to a multi-region context, these cuts may be sourced by region. When broken out in this way, we see that U.S. and Canadian (NAM) exports are associated with the largest cuts ($3.4 billion).

If we were conducting a one-region analysis of cuts in protection under the Uruguay Round, this is where we would have to stop. There would be no vehicle for organizing the information on other regions' cuts and simulating them endogenously in the model. While these cuts are proportionately smaller than those in Korea, they are still significant in the case of some products. Table 9.5 displays the value of other regions' tariff cuts on products exported by Korea. These cuts are valued (on the basis of pre-Round trade) at almost $2 billion, with about one-fourth of this in machinery and equipment exports. When separated by destination, the value of cuts in Japan and the United States is largest – both are about $440 million.

IV.3 Non-Tariff Barriers Reduced in the Uruguay Round

Up to this point, we have only discussed cuts in import tariffs and the newly established tariff equivalents for farm and food products. However, the Uruguay Round also addressed two other areas relevant to this quantitative analysis. First, countries agreed to cut agricultural export subsidies by 36 percent. The major impact of this for Korea, at this level of aggregation, is an 11 percent increase in the *f.o.b.* price (assuming constant market prices) of crops exported from the EU to Korea. There is also a small increase in the U.S. price of crops sold to Korea. All other changes are negligible.

More significant is the agreement to accelerate quota growth associated with textiles and wearing apparel exports under the Agreement on Textiles and Clothing, eventually abolishing them altogether in 2005. As one of the relatively "older" exporters under this arrangement, Korea exports a relatively large share of its products to the restricted markets. Table 9.6 reports the estimated quota rents on textiles and wearing apparel sales exported from Korea, Other Asia, and the rest of the world (ROW) to those regions containing restricted importers. The quotas on Korea are less binding than the quotas on Other Asian exporters across the board, indicating that

Table 9.6. *Quota rents associated with the MFA ($1,992 million, proportion of exporter's market price in parentheses)*

	Destination			
	Textiles		Wearing Apparel	
Source	NAM	EAZ	NAM	EAZ
KOR	65.5 (0.10)	45.7 (0.08)	388.9 (0.123	165.7 (0.19)
OAS	266.3 (0.13)	384.1 (0.14)	3,344.1 (0.28)	2,246.6 (0.25)
ROW	235.9 (0.11)	873.0 (0.10)	1,665.8 (0.23)	1,805.9 (0.12)

Source: Hertel et al. (1995).

Korea's comparative advantage has been moving away from this type of export in recent years (Yongzheng et al., 1996).

IV.4 Overview of the Korean Economy

Before turning to the results of the Uruguay Round experiment, it is useful to provide a brief overview of the Korean economy. Table 9.7 provides some summary statistics for Korea as well as several other aggregated regions which are represented in the multi-region data base used later. The top set of entries reports the regional shares in global gross domestic product (GDP). From this it can be seen that the Korean economy is small relative to the world economy, and relative to some of its major trading partners. This means that the feedback effects from changes in the Korean economy, through other economies and back to Korea, are likely to be small. Therefore, a small-open economy representation is likely appropriate for analysis of *Korea-specific* shocks.

The next block of entries in Table 9.7 refers to the composition of final demand, by region. From this, it can be seen that the share of private household consumption in GDP is relatively small in Korea. This is due in large part to the dominant role of investment. Japan has a similar profile of final demand, with slightly lower investment and higher private consumption. North America stands out with 68 percent of GDP expended by private households, and investment equal to only 14 percent of this aggregate.

The final block of entries in Table 9.7 refers to the structure of production in each of these regions. Here, the entries refer to the share of economywide

Table 9.7. *Composition of Korean economy and other regions compared*

	KOR	*JPN*	*OAS*	*NAM*	*EAZ*	*ROW*
Share of Global GDP (percent)	1.09	14.50	4.5	30.35	29.89	19.62
			Composition of Final Demand (Share of GDP)			
Consumption	0.53	0.57	0.57	0.68	0.62	0.66
Investment	0.36	0.31	0.29	0.14	0.20	0.20
Government	0.11	0.10	0.13	0.19	0.19	0.15
Exports	0.33	0.11	0.47	0.11	0.11[a]	0.20
Imports	-0.33	-0.09	-0.46	-0.12	-0.12[a]	-0.21
Total	1.0	1.0	1.0	1.0	1.0	1.0
			Structure of Production (Share of Value-added)			
Food & AGR	0.13	0.05	0.22	0.04	0.08	0.13
N Resources	0.08	0.06	0.14	0.09	0.09	0.13
Textile & APP	0.02	0.01	0.03	0.01	0.01	0.02
O. Manuf	0.18	0.19	0.14	0.12	0.12	0.12
Svces	0.59	0.69	0.47	0.74	0.70	0.60
Total	1.0	1.0	1.0	1.0	1.0	1.0

[a] Excludes intra-EU trade

value added employed in various groupings of sectors. The services sector (including wholesale/retail and transport margins for all consumer goods) is dominant in all of these economies, with the highest share appearing in the United States and Canada (NAM), where it reaches 74 percent. Korea and ROW have a smaller, but still dominant share in this sector (about 60 percent), and Other Asia has only 47 percent of value added in the services and margins activities. Also worthy of note are the relatively small shares of value added devoted to textiles and wearing apparel production. Finally, the share of value added in agriculture and food processing varies considerably across economies. In Korea, this equals 13 percent, which is comparable to Other Asia and ROW. However, in the more industrialized economies, this share is much smaller.

In addition to patterns of final demand and value added, it is important to consider the patterns of import use and export intensity in the Korean economy. Table 9.8 reports the share of imports in composite demand, by commodity and use. The information in this table is based on the 1985 input–

Table 9.8. *Share of imports in composite demand at market prices, by use*

	Intermediate Uses												Final Demands			Total Uses
	crops	*othagr*	*extract*	*food*	*textiles*	*apparel*	*crp*	*metals*	*trnseq*	*macheq*	*othmnfc*	*svces*	*Inv*	*Priv*	*Gov*	
crops	0.06	0.00	0.51	0.40	0.99	0.50	0.99	0.52	0.76	0.67	0.81	0.00	0.01	0.07	0.14	0.41
othagr	0.13	0.84	0.63	0.11	1.00	0.99	0.44	0.79	0.90	0.12	0.64	0.18	0.93	0.40	0.83	0.32
extract	0.00	0.00	0.51	0.21	0.01	0.03	0.48	0.40	0.20	0.26	0.21	0.10	0.01	0.06	0.08	0.28
food	0.00	0.00	0.10	0.26	0.04	0.88	0.58	0.00	0.10	0.03	0.47	0.03	0.26	0.02	0.08	0.07
textiles	0.03	0.01	0.18	0.04	0.17	0.27	0.14	0.05	0.11	0.11	0.06	0.02	0.14	0.04	0.21	0.17
apparel	0.05	0.01	0.18	0.01	0.01	0.79	0.49	0.01	0.38	0.01	0.23	0.01	0.30	0.06	0.60	0.06
crp	0.05	0.00	0.24	0.15	0.14	0.17	0.39	0.18	0.31	0.23	0.23	0.07	0.08	0.03	0.09	0.22
metals	0.19	0.04	0.10	0.08	0.11	0.25	0.09	0.21	0.23	0.24	0.14	0.07	0.23	0.19	0.07	0.18
trnseq	0.00	0.00	0.09	0.00	0.00	0.00	0.01	0.04	0.42	0.19	0.16	0.34	0.17	0.01	0.15	0.22
macheq	0.02	0.02	0.32	0.18	0.40	0.15	0.46	0.45	0.36	0.54	0.28	0.33	0.55	0.15	0.14	0.47
othmnfc	0.09	0.01	0.08	0.41	0.57	0.54	0.24	0.23	0.39	0.67	0.27	0.41	0.23	0.44	0.65	0.36
svces	0.01	0.01	0.05	0.03	0.02	0.06	0.06	0.02	0.04	0.05	0.04	0.13	0.01	0.03	0.00	0.04
all goods	0.04	0.04	0.39	0.27	0.38	0.27	0.36	0.21	0.27	0.36	0.23	0.13	0.17	0.04	0.00	0.18

Source: GTAP data base, modified to include pre-Uruguay Round protection links.

output table (provided by the Bank of Korea), updated to 1992 macroeconomic and trade data. It is clear that the intensity of imports of any given commodity varies widely by use. For example, the last column of Table 9.8 shows that 22 percent (value-based share) of all chemical, rubber and plastic (CRP) products used in Korea are imported. However, only 3 percent of private household purchases of CRP products are sourced from abroad, while 39 percent of the own-intermediate inputs used by the chemical, rubber and plastics sector are purchased from overseas. This means that a tariff reduction in this sector will have little direct effect on consumer prices. The first-round effect will be predominantly through lower input costs to firms. Furthermore, the intensive use of imported CRP intermediates by the CRP sector itself will somewhat blunt the effect of competition from more competitive imports.

The last row in Table 9.8 reports the average variation in import intensity by use. Here it can be seen that, on average, the firms use imports relatively more than do households. Indeed, the average import intensity of private household consumption is only 4 percent. This stands in sharp contrast to many of the productive sectors, where average import intensities across all intermediate purchases are between 35 and 40 percent in the cases of extractive industries, textiles, chemicals, rubber, and plastics and machinery and equipment. Even investment goods are more heavily imported, with an average intensity of 17 percent. This means that the first round effects of tariff cuts are more likely to be evidenced in terms of reduced costs. Of course, all of this information is lost in the bulk of the multi-region AGE studies, where imports are blended at the border. In this case the implicit intensity in all uses is equal and the value is given by the entries in the final column of Table 9.8.

The strong effect of tariff cuts on firms' variable costs becomes doubly important in models of endogenous product differentiation and entry/exit. This is because the tariff cuts reduce average variable costs relative to the fixed cost of product differentiation. In order to maintain a zero profits equilibrium in the presence of declining average total costs, output per firm must increase. Hertel and Lanclos find that this mechanism gives rise to strong scale effects, which serve to benefit the liberalizing economy substantially.

Table 9.9 reports the size and disposition of estimated 1992 exports from Korea.[26] Korea is shown to be a net exporter of textiles and apparel, transport equipment, other manufactures and services. These are also the sectors

26 See Gehlhar et al. (1996) for a discussion of the procedures for estimating these bilateral flows.

Table 9.9. *Korean exports, by commodity (f.o.b. values)*

Commodity	*Net Exports*	*Gross Exports*	*jpn*	*oas*	*nam*	*eaz*	*row*	*Exports/ Output*
crops	-2967	498	315	138	13	18	14	0.02
othagr	-1524	55	27	15	2	6	5	0.01
extract	-17911	4194	1911	1285	378	208	412	0.06
food	-1547	1109	514	184	133	160	117	0.02
textiles	5371	8284	571	3895	733	649	2435	0.33
apparel	5127	5391	1741	138	2079	1048	385	0.50
crp	-2979	6159	738	2844	763	768	1047	0.14
metals	-1030	7167	1736	2577	1208	776	869	0.15
trnseq	5381	9148	228	709	2061	1334	4817	0.38
macheq	-5876	22616	1983	6172	7304	3733	3425	0.37
othmnfc	9668	12040	1831	1464	4977	2442	1326	0.70
svces	7906	20323	3987	1789	1756	3039	7593	0.07
Totals	-382	96984	15582	21208	21408	14182	22446	2.76

Source: GTAP data base, modified to include pre-Uruguay Round protection links.

with the highest overall export intensity, as shown in the final column of Table 9.9.[27] Distribution of these exports is relatively even across destination regions, with North America, Other Asia and ROW all showing about $22 billion of total sales.

The distribution of textiles and wearing apparel exports in Table 9.9 is particularly significant in this application, since sales to the United States, Canada and Europe are currently restricted under the Multifiber Agreement. Fifty-eight percent of wearing apparel exports from Korea are destined for the North America (NAM) and Europe, Australia, and New Zealand (EAZ) regions. The average quota rates on these exports (Table 9.6) are 12 percent and 19 percent, respectively. Thus, elimination of the bilateral quotas on wearing apparel will result in a significant loss of rents, which is unlikely to be made up by the increases in *f.o.b.* prices on clothing exported to third countries.[28] In the case of textile products, the share sent to restricted markets is only about 17 percent and the average quota rents are much smaller. As a result, elimination of the Multi-Fibre Arrangement (MFA) as it pertains to textiles is more likely to benefit Korea.

IV.5 General Equilibrium Elasticities of Demand Facing Korea

Having reviewed key features of the multi-region data base, as it pertains to Korea, we may now examine how this data base works in concert with the model structure, parameters and closure. A convenient method for examining the local behavior of any non-linear CGE model (be it single-region or multi-region) is to generate so-called general equilibrium elasticities of demand (Hertel et al., 1996). These elasticities embody the response of all agents (in the neighborhood of the benchmark equilibrium) to a perturbation in the market price of a given commodity. As such, these elasticities capture the impact of factor market interactions, inter-industry and income effects, as well as any special closures used in the model. The qualitative relationships which are revealed greatly facilitate subsequent analysis of policy shocks.

Before turning to these elasticities, we must say something about the GTAP model, which we employ in this section.[29] This is a relatively standard AGE model in which perfectly competitive firms produce subject to con-

27 Machinery and equipment also shows a high export intensity, but is a net importer in the aggregate because of a high level of intra-industry trade.

28 See Yongzheng, Martin, and Yanagishima (1996) for a detailed analysis of the welfare impacts of reforming the MFA.

29 The GTAP model is documented in Hertel and Tsigas (1996).

Table 9.10. *Own- and cross-price, general equilibrium elasticities of demand for Korean products (single region elasticities in parentheses)*

	crops	othagr	extract	food	textiles	apparel	crp	metals	trnseq	macheq	othmnfc	svces
crops	-0.761 (-0.764)	-0.02	0.07	-0.15	0.03	0.02	0.01	0.09	0.1	0.18	0.03	0.43
othagr	-0.9	-0.56 (-0.561)	0	-0.63	0.01	0	0	0.09	0.09	0.19	-0.04	0.38
extract	0.08	0	-1.029 (-1.034)	0.01	0.08	0.06	0.05	0.08	0.18	0.3	0.11	0.36
food	-0.13	-0.09	-0.01	-0.553 (-0.554)	-0.03	-0.02	-0.03	0.04	0.03	0.1	-0.12	0.38
textiles	0.11	0.01	0.25	0.04	-2.454 (-2.525)	-0.8	-0.44	0.38	0.43	0.75	-0.28	0.79
apparel	0.15	0.02	0.32	0.07	-1.6	-4.222 (-4.244)	-0.16	0.47	0.53	0.9	0.22	1.01
crp	0.02	0	0.08	-0.01	-0.22	-3.43	-1.096 (-1.106)	0.17	0.18	0.26	-0.1	0.54
metals	0.18	0.03	0.16	0.14	0.28	0.19	0.21	-2.048 (-2.069)	-0.05	0.01	0.32	0.67
trnseq	0.23	0.04	0.43	0.2	0.38	0.27	0.28	-0.1	-4.568 (-4.604)	0.4	0.57	1.06
macheq	0.17	0.03	0.29	0.14	0.28	0.19	0.17	0.01	0.21	-3.178 (-3.206)	0.39	0.82
othmnfc	0.11	-0.01	0.38	-0.25	-0.27	0.19	-0.21	0.54	0.83	1.32	-5.025 (-5.108)	1.31
svces	0.08	0.01	0.05	0.03	0.03	0.01	0.04	0.06	0.07	0.14	0.06	-0.414 (-.405)

Source: GTAP data base and model, using procedures discussed in Hertel et al. (1996).

stant returns to scale technology. As noted, it embodies an Armington structure, with composite imports sourced by agent. As is often done in multi-region models, separability between primary factors and intermediate inputs is assumed, and there is no scope for substitution among composite inputs and value added. The latter is a CES function of land, labor and capital. Final demand is determined by a Cobb–Douglas utility function specified over consumption, government spending and savings. Private purchases are modeled using the non-homothetic, Constant Difference of Elasticities (CDE) implicitly additive expenditure function. Government budget shares are assumed constant via the Cobb–Douglas specification.

Table 9.10 presents the GE elasticities for the commodity aggregation used in the following analysis. In this particular closure, we assume that endowments, technology and *ad valorem* equivalent policy distortions are exogenous, and the global bank's investment portfolio is fixed, i.e., $RORFLEX=\infty$. Each column in the table refers to the change in equilibrium output when the output tax on that particular commodity is raised by enough to cause a 1 percent increase in market price. Thus the GE, own-price elasticity of demand facing the Korean crops sector equals –0.761. Most of this is due to competition from imports, as the own-price elasticity of final demand for crops is very small and there is no scope for substitution among composite intermediate inputs in the model.

Running down the diagonal of Table 9.10, we note that some of these own-price elasticities are greater than 1 in absolute value. This elastic response is attributable to adjustments in export demands. When the export share of output is large (see the last column in Table 9.9), the Armington parameters in other regions come to play an important role in the sectoral own-price elasticity of demand. Indeed, in the case where all of the output is exported and the exporter's share in composite imports in the receiving region is small, then the GE demand elasticity equals the export demand elasticity, which in turn approaches the Armington elasticity in absolute value. This is why the GE demand elasticity for other manufactures is so large. The Armington elasticity of substitution among imports in all regions is equal to 6.7 for Other Manufactures and 70 percent of output is exported. Therefore, roughly $(0.7 \cdot 6.7)/5.025$, or more than 90 percent of the price responsiveness in this sector, is due to export demand.

The cross-price elasticities in Table 9.10 are largely positive in sign. This is because of Korean factor market equilibrium conditions. When the GE demand for Machinery and Equipment falls, output falls as well, releasing resources for use in other sectors, all of which tend to expand. Depending on the size and factor intensity of the contracting sector, and the GE elasticity facing the other sector, the resulting expansion may be quite large. Indeed, in the case of a 1 percent price hike in services, all of the non-food manufacturing sectors in Korea expand by a greater percentage than the services sector contracts. This is because 59 percent of the value added in Korea is in services (Table 9.7), and the manufacturing sectors are generally highly dependent on price responsive exports (Table 9.9).

However, there are some notable negative entries off-diagonal in Table 9.10. For example, crops and other agriculture and crops and food are complementary goods, because of their close inter-industry linkages. Crops products are inputs into the other sectors and when this price rises, so does the price of other agriculture and food, thereby leading to a decline in equilibrium output. These relationships tend to be symmetric, since if it is the price of food products which increases, thereby reducing equilibrium food output, then the demand for intermediate agricultural inputs will fall, thereby leading to a decline in output of those sectors. Other notable complementary relationships in Table 9.10 arise among textiles, wearing apparel and chemicals/rubber/plastics (as a result of the use of synthetic fibers). Other manufacturing is also complementary with a number of sectors.

Table 9.10 also presents information that is pertinent to the question of multi- versus single-region closures. In the GTAP framework, it is possible to create *partial equilibrium closures*.[30] In order to investigate the importance of adjustment in non-Korean regions, for Korean demand elasticities, we reproduced Table 9.10 under a *partial equilibrium* closure in which activity levels, endowment prices, own-commodity prices and expenditures *in the non-Korean regions* are all fixed. The resulting own-price elasticities of demand are given in parentheses in Table 9.10. It is immediately clear that there is little difference between the two: Korea really is a small economy when it comes to global economic adjustments (recall Table 9.7). *Adjustments in other regions to shocks emanating from Korea are simply not large enough to result in significant GE feedbacks to Korea.* This is good news for the single-region modeller. If she/he can accurately implement the trade policy experiment of interest in the single-region model, then the omitted feedback effects are unlikely to be a serious problem. However, the "if" qualification in the previous sentence is an important one, as we will see in the next section.

30 Technically, this is done by swapping "slack variables" with complementary variables that are normally endogenous. For example, by endogenizing the income slack variable in GTAP, it is possible to eliminate the equation linking regional income and expenditure. In order to retain equal numbers of endogenous and exogenous variables, it is then possible to fix expenditure in selected regions of the model. In a similar fashion we may drop zero profit conditions and fix activity levels in selected sectors; drop market-clearing relationships and fix the associated prices for tradable commodities; and drop endowment market clearing conditions and fix primary factor prices.

V Results from Uruguay Round Reforms

V.1 Implications for Output and Pattern of Sales

In this section, we discuss the impact on Korea of the Uruguay Round reforms outlined in Tables 9.3–9.6, from two different perspectives. In the first case, we simulate the full package of reforms, taking advantage of the multi-region (MR) data base and modeling framework. We refer to these as the MR solution. These results are reported as the top entry in Table 9.11. In the second case (bottom entry), we implement only the shocks that can be incorporated into our specification of the Korean region of the model.

The single-region (SR) shocks include all of those given in Table 9.4, but none of the shocks in Table 9.5 (other regions' cuts). We implement reform of the MFA in the same manner we would expect a single-region modeller to proceed, namely, by eliminating the Korean export tax equivalents associated with these quotas. In sum, the comparison of numbers in Table 9.11 illustrates the value added of incorporating a better specification of the Uruguay Round experiment. *Both sets of results rely upon the same model and closure.* We could have built a parallel, single-region model, using only information from Korea. However, as we have seen from comparison of the diagonal entries in Table 9.10, the global, GE feedback effects for Korea are small. Therefore, if the two models are specified in an equivalent manner (hardly a trivial task), they should give similar results for a Korea-only shock.

Table 9.11 compares the impact of the MR and SR shocks on output, domestic sales, exports and bilateral trade. Examination of these results shows that some outcomes are quite robust in the face of ignoring the non-Korea shocks associated with the Uruguay Round. For example, SR (lower entry) output changes in crops, extractive industries, other agriculture, food, chemicals, rubber and plastics, transport equipment and services are very close, if not identical, to the MR (upper entry) predictions. However, the proportionate divergences are quite large in the cases of textiles, apparel, metals, machinery and equipment and other manufactures. Here, the policy changes in the rest of the world (Table 9.5 and rows 2 and 3 of Table 9.6) are significant enough to make a difference. For example, the average bilateral import price cuts in the JPN, NAM and EAZ regions on Korean exports of metals products range from 3 to 5 percent. This is enough to stimulate a significant increase in overall metals exports (12 percent from the third column of Table 9.11), as compared to a predicted 3 percent *decrease* in exports under the SR Uruguay Round shocks.

Table 9.11. *Impact of Uruguay Round on Korean output and distribution of sales (percentage change)*

	qo	*qds*	*qxw*	*Bilateral Exports*				
	Output	*Domestic Sales*	*Total Exports*	*JPN*	*OAS*	*NAM*	*EAZ*	*ROW*
crops	-8	-8	-7	-20	8	39	35	55
	-8	**-9**	**32**	**32**	**31**	**32**	**32**	**31**
othagr	-1	-2	37	29	55	29	28	36
	-1	**-1**	**29**	**29**	**29**	**30**	**29**	**29**
extract	-1	-1	0	-1	0	3	13	3
	-2	**-2**	**-8**	**-8**	**-8**	**-8**	**-8**	**-8**
food	3	3	35	27	40	39	40	55
	4	**3**	**43**	**44**	**43**	**44**	**43**	**43**
textiles	35	28	51	29	64	63	69	28
	47	**52**	**38**	**32**	**28**	**88**	**78**	**30**
apparel	40	4	77	46	53	104	105	28
	121	**5**	**248**	**23**	**22**	**452**	**371**	**24**
crp	4	3	11	11	10	7	10	16
	4	**4**	**5**	**6**	**5**	**6**	**6**	**6**
metals	-3	-6	12	21	2	13	24	15
	-8	**-9**	**-3**	**-3**	**-3**	**-3**	**-3**	**-3**
trnseq	-3	-2	-4	12	-10	3	-4	-6
	-3	**-2**	**-5**	**-5**	**-5**	**-5**	**-5**	**-5**
macheq	-2	-9	10	16	7	11	7	11
	-6	**-10**	**2**	**2**	**2**	**2**	**2**	**2**
othmnfc	16	3	21	20	22	16	27	25
	10	**6**	**12**	**12**	**12**	**12**	**12**	**12**
svces	0	0	-7	-8	-4	-9	-9	-9
	0	**0**	**-10**	**-11**	**-12**	**-11**	**-11**	**-11**

Source: GTAP model simulation. Note: For each commodity, we first report numbers from the MR solution file. In the second row we report (boldface) numbers from the solution file in which we use SR shocks.

Of course, it is not always the case that the omitted shocks work in the same direction. For example, there are significant tariff cuts on textiles and wearing apparel in the other regions. Taken alone, this should stimulate additional Korean exports. However, from Table 9.11, it can be seen that the increase in exports is much smaller under the MR shocks (top entry). In the case of apparel, the difference is quite striking: MR=77 percent increase, while SR=248 percent increase. What accounts for this difference? To answer this question, we must return to Table 9.6. Here, we see that abolishing the MFA quotas also affects textiles and apparel exports from other Asian countries and ROW. Indeed, the current bilateral quotas are even more binding for some of those flows. Thus, when the MFA is abolished, there is a very strong surge from these regions. As a result, the overall increase in Korean exports is much smaller under the true, MR, Uruguay Round experiment.

V.2 Effects of Alternative Macroeconomic Closures

We turn next to the macroeconomic effects of the Uruguay Round on the Korean economy. Outcomes based on multi-region and single-region shocks are reported in Table 9.12 for a variety of macroeconomic closures. As was the case with Table 9.11, we record the MR shocks in the upper entry, and the SR shocks in the lower entry. Consider first the impact of the MR shocks over alternative closures. In the first column, we have the case where the global bank's portfolio is fixed. In terms of equation (9.3), this means that $RORFLEX=\infty$. That is, expected rates of return on investment across regions are not required to be equated. In the absence of significant changes in regional incomes, we expect little change in net domestic savings and hence global savings. Since this determines global investment in our neoclassical closure of the model, that variable does not change much either. Therefore, the fixed portfolio assumption effectively fixes regional investment as well. Having tied down regional savings and investment, we have also effectively tied down the trade balance, via equation (9.2). Exports increase by about the same amount as imports and the change in the trade balance reported in the second row of Table 9.12 is very small.

However, trade liberalization in Korea has a significant impact on the current rate of return to capital in that region, by boosting production in the relatively capital intensive manufacturing sectors and by lowering the cost of imported investment goods. For this reason, it is interesting to consider the case where the global bank's investment portfolio is responsive to changes in the relative rates of return across regions. Table 9.13 reports changes in current rates of return under the flexible portfolio assumption. The equilibrium value of the Korean RORC (equation [9.3]) rises by more than 6 percent, whereas increases in other regions are generally less than 1 percent. As a result, there is a significant incentive to increase investment in Korea, provided $RORFLEX<\infty$. With domestic savings determined by income, which changes relatively little (see Table 9.12), this increased investment must be diverted from other regions. In the second column of Table 9.12, we report results from the Uruguay Round experiment with $RORFLEX=10$. Here we see that the current account deteriorates by \$3.4 million because of the decline in the left-hand side of equation (9.2), as the global bank in-

Table 9.12. *Selected macro variables for Korea under alternative assumptions about regional allocation of global investment (outcomes with single region shocks in parentheses)*

Variable	*Fixed Portfolio*	*Variable Portfolio*	
		$\Delta TBAL \neq 0$	$\Delta TBAL = 0$
Export Volume (Δ%)	13 (15*)	10 (11)	13 (15)
Trade Balance ($ million)	363 (921)	-3412 (-3763)	0 (0)
TOT (Δ%)	-1.3 (-1.0)	-.6 (-0.24)	-1.2 (-0.9)
Utility (Δ%)	1.4 (2.1)	1.9 (2.72)	1.4 (2.2)
EV ($ million)	3828 (5760)	5121 (7267)	3762 (5831)

Source: GTAP model simulation.
* Parenthetic entries refer to cases where only Korea specific shocks are applied.

creases the allocation of investment to Korea in response to the increased rate of return.

The final column in Table 9.12 illustrates the impact of adopting the macroeconomic closure in which Korea's trade balance is explicitly fixed and Korean savings adjust to equilibrate the system. As can be seen from a comparison of this column with the first, in which the global portfolio is fixed, there is little difference between the two. Therefore, this popular macroeconomic closure (fixed current account balance) may be viewed as a special case of the more general specification in which the global banking sector intermediates between savings and investment and *RORFLEX* is chosen to reflect the degree to which current rates of return on investment across regions are expected to be equalized. Adherents to this macroeconomic view would find the fixed trade balance assumption quite restrictive, and perhaps implausible, at least in the short run, in the case of Korea.

The choice of macroeconomic closure can have strong implications for the terms of trade effects of a policy shock. This is of critical importance as a result of the tendency of terms of trade effects to dominate the welfare picture in CGE models with Armington structures. The third row in Table 9.12 illustrates this point. Since Korean liberalization is significantly greater than that in the other regions (see Tables 9.5 and 9.6), the pressure to increase imports is stronger than the increase in demand for Korean exports.

Table 9.13. *Implications of the Uruguay Round for current rates of return on investment (RORC) using flexible portfolio and variable trade balance (single region shocks in parentheses)*

Region	
KOR	6.37[a] (6.79)
JPN	.59 (0.02)
OAS	2.36 (-0.11)
NAM	.34 (0.02)
EAZ	.62 (0.01)
ROW	.79 (-0.07)

Source: GTAP model simulation.
[a] Entries are percentage changes in the level of the rate of return NOT percentage point changes. If the initial rate of return is 20 percent per year, then a 6.3 percent change translates into a 1.27 percentage point increase so the new rate of return is 21.27 percent per year.

In order to maintain balance of payments equilibrium in the face of the import surge and a fixed trade balance, *f.o.b.* prices for Korean exports must fall. This leads to a significant deterioration in the terms of trade (1.2 percent from the last column of Table 9.12).

In contrast, when the variable portfolio assumption is introduced, the surge in imports is accompanied by a rise in the rate of return on investment. From equation (9.3), it can be seen that this offsets to some degree (although not entirely) the pressure caused by the increased imports. The trade balance is allowed to worsen and as a result, the necessary decline in *f.o.b.* export prices is less and Korea's terms of trade deteriorate by only half as much. This, in turn, has important consequences for welfare.[31]

The final two rows in Table 9.12 refer to the welfare consequences of the Uruguay Round simulations under alternative macro closures. They indicate that the welfare gain to Korea under the MR shocks is 33 percent greater when the flexible portfolio assumption is employed. This is a direct

31 The investment inflow implies a reduction in the current account surplus (or increase in the deficit) and, *ceteris paribus*, reduces the amount by which Korean exports increase in the current period. However, depending on the nature of this increased investment it may well contribute to increased exports in some future period. In this sense one might argue that the terms of trade consequences of liberalization have simply been postponed.

consequence of the dampened decline in the regional terms of trade. This serves to emphasize the extent to which alternative macroeconomic closures can influence the results of applied trade policy analysis.

A comparison of the upper and lower entries in Table 9.12 also permits us to analyze the macroeconomic consequences of using single-region, rather than multi-region, shocks in our analysis of the Uruguay Round and the Korean economy. From this comparison, it is clear that simple use of the single-region shocks leads to a considerable overstatement of the welfare gains due to the Round. In the case of a variable portfolio, the degree of overstatement is more than 40 percent! This difference is largely driven by the overly optimistic analysis of the consequences of abolishing the MFA (see Tables 9.6 and 9.11).

VI Conclusions

The purpose of this chapter has been to discuss conceptual issues as well as data problems associated with multi-region AGE modeling. We have approached this task by comparing multi-region methods and analysis to those employed by single-region trade policy modellers. Key issues that arise when going beyond a single region involve the treatment of import sourcing and global macroeconomic closure. The question of bilateral variation in protection also comes into play. In general, it is a very large task to construct a data base in which bilateral trade, transport and protection values are accurately identified and are matched up with regional input–output information.

Our empirical example, which focuses on Korea's role in the Uruguay Round, seeks to identify the value added obtained by examining this problem in a multi-region context. We find that single-region analysis provides a good approximation to the multi-region outcome for many variables. However, Korean welfare gains from the Round are substantially overstated in the one-region case. This is due to the significance of non-Korean cuts in protection on metal products, machinery and equipment, and other manufactures. Also, the impact of the response of other Asia economies to the elimination of the bilateral quotas on textiles and wearing apparel is quite important for the Korean economy, and can only be captured in a multi-region model.

While there are some significant benefits of the move to global modeling, there clearly are also substantial costs. Because of the sometimes prohibitive expense of assembling a global data base, global trade analysis is only feasible for most researchers if they use an existing data base, such as that provided by the GTAP consortium. This limits the degree of disaggregation of firms and households. Global models are typically also much larger, and therefore considerably more complex to interpret. Furthermore, we find that the multi-region feedback effects of Korea-specific shocks, through the rest of the world and back to Korea, are quite limited. For this reason we argue that the step to multi-region AGE analysis should only be taken if the problem at hand is truly global in scope, as is the case with the Uruguay Round analysis presented here.

In closing, we would like to emphasize the importance of several aspects of multi-region AGE analysis that deserve more attention in the future. In our empirical results, we show the importance of the global, macroeconomic closure for Korea's terms of trade in the wake of the Uruguay Round. In particular, this effect, and hence aggregate welfare in Korea, depend on whether the resulting increase in the expected rate of return on capital generates additional foreign investment. Perhaps the most common closure in static, global AGE analysis, namely, that of a fixed current account, does not permit this type of response. Is this is a reasonable assumption? What alternatives exist, short of moving to a full inter-temporal model?

This paper has not dealt at all with the question of international factor mobility. In the debate over NAFTA, this has proved to be an important part of the analysis (see Francois and Shiells, 1994). More work on this feature of global trade models is very important. Incorporation of imperfect competition in global trade modeling has received somewhat more attention, but this area remains underdeveloped in terms of the data required to support serious calibration of such models to differing types of industry structures across regions and sectors (see Chapter 11). Finally, there remains the challenge of dealing with both the time and regional dimensions in a single model. That is beyond the scope of this chapter, but it is clearly on the long-term agenda for many researchers in this area.[32]

References

Alston, J.M., C.A. Carter, R. Green, and D. Pick. 1990. "Whither Armington trade models?" *American Journal of Agricultural Economics* 72:455–467.

Anderson, S.D., A. de Palma, and J. Thisse. 1992. *Discrete Choice Theory of Product Differentiation*. Cambridge, Massachusetts: MIT Press.

Armington, P.A. 1969. "A theory of demand for products distinguished by place of production." *IMF Staff Papers* 16:159–178.

Brown, D. 1987. "Tariffs, the terms of trade and national product differentiation." *Journal of Policy Modelling* 9:503–526.

32 See Chapters 12 and 13 for discussions of dynamic modeling.

Brown, D.B. 1991. "Tariffs and capacity utilization by monopolistically competitive firms." *Journal of International Economics* 30:371–381.

Brown, D. 1994. "Properties of applied general equilibrium trade models with monopolistic competition and foreign direct investment." In *Modelling Trade Policy: Applied General Equilibrium Models of North American Free Trade*, edited by J.F. Francois and C.R. Shiells. Cambridge: Cambridge University Press.

Burfisher, M.E., S. Robinson, and K.E. Thierfelder. 1994. "Wage changes in a U.S.–Mexico free trade area: Migration vs. Stolper–Samuelson effects." In *Modelling Trade Policy: Applied General Equilibrium Models of North American Free Trade*, edited by J.F. Francois and C.R. Shiells. Cambridge: Cambridge University Press.

Deardorff, A. and R. Stern. 1986. *The Michigan Model of World Production and Trade*. Cambridge, Massachusetts: MIT Press.

Deaton, A. and J. Muellbauer. 1980. "An almost ideal demand system." *American Economic Review* 70:312–326.

Dervis, K., J. de Melo, and S. Robinson. 1982. *General Equilibrium Models for Development Policy*. Cambridge: Cambridge University Press.

Dewatripont, M. and G. Michel. 1987. "On closure rules, homogeneity, and dynamics in applied general equilibrium models." *Journal of Development Economics* 26:65–76.

Dixit, A.K. and J.E. Stiglitz. 1977. "Monopolistic competition and optimum product diversity." *American Economic Review* 67:297–308.

Dixon, P.B., B.R. Paramenter, J. Sutton, and D.P. Vincent. 1982. *Orani: A Multisectoral Model of the Australian Economy*. Amsterdam: North-Holland.

Dornbusch, R. 1980. *Open Economy Macroeconomics*. New York: Basic Books.

Ethier, W.J. 1979. "Internationally decreasing costs and world trade." *Journal of International Economics* 9:1–24.

Ethier, W.J. 1982. "National and international returns to scale in the modern theory of international trade." *American Economic Review* 72:950–959.

Finger, J.M., ed. 1993. *Antidumping: How It Works and Who Gets Hurt*. Ann Arbor: University of Michigan Press.

Francois, J. 1992. "Optimal commercial policy with international returns to scale." *Canadian Journal of Economics* 23:109–124.

Francois, J. 1994. "Global production and trade: Factor migration and commercial policy with international returns to scale." *International Economic Review* 35:565–581.

Francois, J. 1996. "A note on import substitutability and regional integration." World Trade Organization. Staff working paper RD-96-9.

Francois, J., B. McDonald, and H. Nordstrom. 1994. "The Uruguay Round: A global, general equilibrium assessment." CEPR Discussion Paper No. 1067.

Francois, J., B. McDonald, and H. Nordstrom. 1995. "Assessing the Uruguay Round." Paper No. 6, Developing Economies and the Uruguay Round. Washington, D.C.: World Bank.

Francois, J.F. and C.R. Shiells, eds. 1994. *Modeling Trade Policy: Applied General Equilibrium Assessments of North American Free Trade*. Cambridge: Cambridge University Press.

Gehlhar, M.J., J.K. Binkley, and T.W. Hertel. 1991. "Estimation of Trade Margins for Food Products: An Application of the UN Bilateral Trade Data." NC-194 Occasional Paper Series OP-24.

Gehlhar, M.J., D. Gray, T.W. Hertel, K. Huff, E. Ianchovichina, B.J. MacDonald, R. McDougall, M.E. Tsigas, and R. Wigle. 1996. "Overview of the GTAP data base." In *Global Trade Analysis: Modeling and Applications*, edited by T.W. Hertel. Cambridge: Cambridge University Press.

Goldin, I., O. Knudsen, and D. van der Mensbrugghe. 1993. *Trade Liberalisation: Global Economic Implications*. Paris and Washington: OECD Development Center and World Bank.

Goulder, L.H. and B. Eichengreen. 1992. "Trade liberalization in general equilibrium: Inter-temporal and inter-industry effects." *Canadian Journal of Economics* 25:253–280.

Hambley, J. 1992. "Early stage processing of international trade and input–output data for SALTER." SALTER Working Paper No. 15.

Harrison G., T. Rutherford, and D. Tarr. 1995. "Quantifying the Uruguay Round." Paper presented at the World Bank Conference on Developing Economies and the Uruguay Round, Washington, D.C.

Hathaway, D.E. and M.D. Ingco. 1995. "Agricultural Liberalization and the Uruguay Round." Paper presented at the World Bank Conference on Developing Economies and the Uruguay Round, Washington, D.C.

Helpman, E. 1981. "International trade in the presence of product differentiation, economies of scale and monopolistic competition: A Chamberlin–Heckscher–Ohlin Approach." *Journal of International Economics* 11:305–340.

Helpman, E. and P.R. Krugman 1985. *Market Structure and Foreign Trade.* Cambridge, Massachusetts: MIT Press.

Helpman, E. and P.R. Krugman 1989. *Trade Policy and Market Structure.* Cambridge, Massachusetts: MIT Press.

Hertel, T.W. 1994. "The procompetitive effects of trade policy reform in a small, open economy." *Journal of International Economics* 36:391–411.

Hertel, T.W., ed. 1996. *Global Trade Analysis: Modeling and Applications.* Cambridge: Cambridge University Press.

Hertel, T.W. and D.K. Lanclos. 1994. "Trade policy reform in the presence of product differentiation and imperfect competition: Implications for food processing activity." In *Agricultural Trade and Economic Integration in Europe and in North America*, edited by M. Hartmann, P.M. Schmitz, and H. von Witzke. Kiel: Wissenschaftsverlag Vauk Kiel KG.

Hertel, T.W., D.K. Lanclos, K.R. Pearson, and P.V. Swaminathan. 1996. "Structure of GTAP." In *Global Trade Analysis: Modeling and Applications*, edited by T.W. Hertel. Cambridge: Cambridge University Press.

Hertel, T.W., W. Martin, K. Yanagishima, and B. Dimaranan. 1995. Paper presented at the World Bank Conference on Developing Economies and the Uruguay Round, Washington, D.C.

Hertel, T.W. and M.E. Tsigas. 1996. "Structure of GTAP." In *Global Trade Analysis: Modeling and Applications*, edited by T.W. Hertel. Cambridge: Cambridge University Press.

Howe, H. 1975. "Development of the extended linear expenditure system from simple saving assumptions." *European Economic Review* 6:305–310.

Jomini, P., J.F. Zeitsch, R. McDougall, A. Welsh, S. Brown, J. Hambley, and J. Kelly. 1991. *SALTER: A General Equilibrium Model of the World Economy*. Vol. 1. *Model Structure Database and Parameters*. Canberra: Australian Industry Commission.

Krugman, P.R. 1979. "Increasing returns, monopolistic competition, and international trade." *Journal of International Economics* 9:469–479.

Krugman, P.R. 1980. "Scale economies, product differentiation, and the pattern of trade." *American Economic Review* 70:950–995.

Lancaster, K. 1980. "Intra-industry trade under perfect monopolistic competition." *Journal of International Economics* 10:151–175.

Magee, S. 1972. "The welfare effects of restrictions on U.S. trade." *Brookings Papers on Economic Activity* 3:645–701.

Markusen, J.R. and R.M. Wigle. 1989. "Nash equilibrium tariffs for the United States and Canada: The roles of country size, scale economies and capital mobility." *Journal of Political Economy* 97:368–386.

McDougall, R. 1993. "Incorporating International Capital Mobility into SALTER." Working Paper No. 21. Canberra: Australian Industry Commission.

Perroni, C. and T. Rutherford. 1995. "Regular Flexibility of Nested CES Functions." *European Economic Review* 39:335–343.

Preckel, P.V., E. DeVuyst, D.K. Lanclos, and T.W. Hertel. 1993. "Sensitivity analysis in CGE models using discrete approximating probability distributions (abstract)." *American Journal of Agricultural Economics* 75:1297.

Roland-Holst, D.W., Reinert, K.A., and Shiells, C.R. 1994. "A general equilibrium assessment of North American economic integration." In *Modelling Trade Policy: Applied General Equilibrium Models of North American Free Trade*, edited by J.F. Francois and C.R. Shiells. Cambridge: Cambridge University Press.

Sen, A.K. 1963. "Neo-classical and neo-Keynesian theories of distribution." *Economic Record* 39:54–64.

Shiells, C.R. and K.A. Reinert. 1993. "Armington models and terms-of-trade effects: Some econometric evidence for North America." *Canadian Journal of Economics* 26:299–316.

Shoven and Whalley. 1992. *Applying General Equilibrium*. New York: Cambridge University Press.

Spence, M.E. 1976. "Product selection, fixed costs, and monopolistic competition." *Journal of International Economics* 43:217–236.

Staiger, R. and F. Wollak. 1994. "Measuring industry-specific protection: Antidumping in the United States." *Brookings Papers on Economic Activity* 2:51–103.

Taylor, L. ed. 1990. *Socially Relevant Policy Analysis: Structuralist Computable General Equilibrium Models for the Developing World*. Cambridge, Massachusetts: MIT Press.

Taylor, L. and F.J. Lysy. 1979. "Vanishing income redistributions: Keynesian clues about model surprises in the short run." *Journal of Development Economics* 6:11–29.

Tsigas, M.E., T.W. Hertel, and J.K. Binkley. 1992. "Estimates of systematic reporting biases in trade statistics." *Economic Systems Research* 44:297–310.

U.S. Department of Commerce. 1994. "Antidumping and countervailing duty orders, findings, and suspension agreements currently in effect." Washington, D.C. December.

Venables, A.J. 1987. "Trade and trade policy with differentiated products: A Chamberlinian–Ricardian model." *Economic Journal* 97:700–717.

Whalley, J. 1985. *Trade Liberalisation Among Major World Trading Areas.* Cambridge, Massachusetts: MIT Press.

Winters, L.A. 1984. "Separability and the specification of foreign trade functions." *Journal of International Economics* 17:239–263.

Yongzheng, Y., W. Martin, and K. Yanagishima. 1996. "Structure of GTAP." In *Global Trade Analysis: Modeling and Applications*, edited by T.W. Hertel. Cambridge: Cambridge University Press.