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Introduction

The aim of this book is to make more widely available a body of recent research activity that has become known as applied general equilibrium analysis. The central idea underlying this work is to convert the Walrasian general equilibrium structure (formalized in the 1950s by Kenneth Arrow, Gerard Debreu, and others) from an abstract representation of an economy into realistic models of actual economies. Numerical, empirically based general equilibrium models can then be used to evaluate concrete policy options by specifying production and demand parameters and incorporating data reflective of real economies.

We have earlier summarized a number of these modeling efforts in a survey article (Shoven and Whalley 1984). Here we try to go one stage further and give readers more of a sense of how to do their own modeling, including developing an appropriate equilibrium structure, calibrating their model, compiling counterfactual equilibria, and interpreting results. The first part of the book develops the techniques required to apply general equilibrium theory to policy evaluations. The second part presents a number of applications we have made in our previous research.

The Walrasian general equilibrium model provides an ideal framework for appraising the effects of policy changes on resource allocation and for assessing who gains and loses, policy impacts that are not well covered by empirical macro models. In this volume, we outline a number of ways in which applied versions of this model are providing fresh insights into long-standing policy controversies.

Our use of the term "general equilibrium" corresponds to the well-known Arrow–Debreu model, elaborated in Arrow and Hahn (1971). The number of consumers in the model is specified. Each consumer has an initial endowment of the N commodities and a set of preferences, resulting in demand functions for each commodity. Market demands are the sum of each consumer's demands. Commodity market demands depend on all prices, and are continuous, nonnegative, homogeneous of degree zero (i.e., no money illusion), and satisfy Walras's law (i.e., that at any set of prices, the total value of consumer expenditures equals consumer incomes. On the production side, technology is described by either constant-returns-to-scale activities or nonincreasing-returns-to-scale production functions. Producers maximize profits. The zero homogeneity of demand functions and the linear homogeneity of profits in prices (i.e., doubling all prices doubles money profits) imply that only relative prices are of any significance in such a model. The absolute price level has no impact on the equilibrium outcome.

Equilibrium in this model is characterized by a set of prices and levels of production in each industry such that the market demand equals supply for all commodities (including disposals if any commodity is a free good). Since producers are assumed to maximize profits, this implies that in the constant-returns-to-scale case, no activity (or cost-minimizing technique for production functions) does any better than break even at the equilibrium prices.

Most contemporary applied general equilibrium models are numerical analogs of traditional two-sector general equilibrium models popularized by James Meade, Harry Johnson, Arnold Harberger, and others in the 1950s and 1960s. Earlier analytic work with these models has examined the distortionary effects of taxes, tariffs, and other policies, along with functional incidence questions. More recent applied models, including those discussed here, provide numerical estimates of efficiency and distributional effects within the same framework.

The value of these computational general equilibrium models is that numerical simulation removes the need to work in small dimensions, and much more detail and complexity can be incorporated than in simple analytic models. For instance, tax-policy models can simultaneously accommodate several taxes. This is important even when evaluating changes in only one tax because taxes compound in effect with other taxes. Also, use of a tax-policy model permits an evaluation of comprehensive tax-reform proposals such as those debated in the United States during the 1984–6 period. Likewise, the complexities of the issues handled in trade negotiations in the General Agreement on Tariffs and Trade (GATT), such as simultaneous tariff reductions in several countries or codes to limit the use of nontariff barriers, cannot be analyzed in ways useful to policy makers other than through numerical techniques. Models involving 30 or more sectors and industries are commonly employed, providing substantial detail for policy makers concerned with feedback effects of policy initiatives directed at specific products or industries.

In the next chapter we briefly review the theory of general equilibrium relevant for applied general equilibrium analysis. We sketch proofs of existence, and discuss in detail the inclusion of such policy instruments as taxes and tariffs for which a modeling of government behavior is also required. The applied models that follow in later chapters are consistent with the Arrow–Debreu theoretical structure, reflecting the attempt in applied general equilibrium work to make that structure relevant to policy.

The techniques and models described in this book have been applied to a range of policy questions in a number of economic fields over the last ten or so years. These include public finance and taxation issues, international trade-policy questions, evaluations of alternative development strategies, the implications of energy policies, regional questions, and even issues in macroeconomic policy.

Policy makers daily confront the need to make decisions on all manner of both major and minor policy matters that affect such issues as the intersectoral allocation of resources and the distribution of income. Some form of numerical model is implicit in the actions of any policy maker. Techniques such as those presented here can, in our opinion, help policy makers by making explicit the implications of alternative courses of action within a framework broadly consistent with that currently accepted by many microeconomic theorists. Although model results are not precise owing to data and other problems, they nonetheless provide a vehicle for generating initial null hypotheses on the impacts of policy changes where none previously existed. They also yield assessments of the impacts of policies, which may challenge the received wisdom that guides policy making. We emphasize the large elements of subjective judgment involved both in building and in using these models, and also their large potential for generating fresh insights on policy issues of the day.

We hope that the insights gained from particular models will become clearer as the reader proceeds with the description of the various models, but some examples may be helpful at this stage. One result of applied general equilibrium tax models' use has been a reassessment of the importance of the efficiency costs of taxes relative to their equity consequences. Twenty years ago it was commonly believed that the resource misallocation costs of taxes were relatively small (perhaps 1% of GNP), and that the tax system in total did little to redistribute income. The applied models have challenged this view by producing estimates of combined welfare costs from distortions in the tax system of 8%–10% of GNP, and estimates of their marginal welfare costs as large as $0.50 per additional dollar of revenue raised. These models have also indicated that there are more significant redistribution effects caused by the tax system than had previously been believed. The models have also been used to provide a ranking of various tax-policy alternatives, and have showed how interactions among the various parts of the tax system can affect the evaluation of tax-reform alternatives.

Applied general equilibrium trade models that assume constant returns to scale have in the main suggested that the welfare costs of trade distortions are smaller than those of tax distortions, confirming the suggestions made by previous partial equilibrium calculations. Such trade models have, however, found a significantly different geographical pattern in results owing to terms-of-trade effects. When increasing returns to scale are incorporated along with market structure features, larger effects are discovered.

Further insights have been gained in cases involving more specific analyses. For instance, in analyzing the impacts of regional trade agreements, results suggest that the more important effects arise from the elimination of trade barriers in partner countries and the benefits from improved access abroad, rather than from the internal trade creation and trade diversion effects discussed in the theoretical literature. Analyses of the impact of protection in the North on developing countries have put the annual costs to the South at about the value of the aid flow from the North, suggesting that these aid and trade effects roughly cancel out. (See Section 8.4.)

Another example of a model-generated insight concerns the international trade dimensions of the basis used for indirect taxes by American trading partners. Given that these taxes are heavier on manufactures than nonmanufactures, model results have shown that a destination basis abroad (taxes on imports, but not on exports) may be better for the United States than an origin basis (taxes on exports, but not on imports). This follows if the United States is a net importer of manufactures in its trade with the country involved. This suggests that an origin basis abroad need not be in the U.S. interest, as is often assumed; nor should the United States push for the same basis in all its trading partners.

These and other insights could, no doubt, have been obtained in other ways, but the virtue of using applied general equilibrium models is that, once constructed, they yield a facile tool for analyzing a wide range of possible policy changes. Such analyses generate results that either yield an initial null hypothesis, or challenge the prevailing view. It may be that subsequently the conclusions from the model are rejected as inappropriate; the assumptions may be considered unrealistic, errors may be unearthed, or other factors may undermine confidence in the results. But there will be situations in which the modeler and those involved in the policy decision process will have gained new perspectives as a result of using the model. In our opinion, this is the virtue of the approach, and is the reason why we believe its use in the policy process will spread further than the applications we report.

Applied general equilibrium analysis is not without its own problems. As the development of applied general equilibrium models has progressed from merely demonstrating the feasibility of model construction and solution to serious policy applications, a variety of issues has arisen. Most modelers recognize the difficulties of parameter specification and the necessity for (possibly contentious) assumptions. Elasticity and other key parameter values play a pivotal role in all model outcomes, and no consensus exists regarding numerical values for most of the important elasticities. The choice of elasticity values is frequently based on scant empirical evidence, and what evidence exists is often contradictory. This limits the degree of confidence with which model results can be held. On the other hand, there are no clearly superior alternative models available to policy makers who base their decisions on efficiency and distributional consequences of alternative policy changes. Whether partial equilibrium, general equilibrium, or back-of-the-envelope quantification is used, key parameter values must be selected, yet current econometric literature in so many of the areas involved is not particularly helpful.

Modelers have also been forced to confront the problem of model preselection: the need to specify key assumptions underlying the particular applied model to be used before any model calculations can begin. Both theoretical and applied modelers have long recognized the need to use particular assumptions in building general equilibrium models, assumptions such as full employment and perfect competition. There are also other equally important assumptions that enter these analyses. One example involves international factor flows. In tax models, the incidence effects of capital income taxes are substantially affected by the choice of this assumption: If capital is internationally mobile, capital owners will not bear the burden of income taxes; in a closed economy, however, domestic capital owners may well be affected. Another example is the treatment of time. In a static model, a tax on consumption may appear distorting since capital goods are tax free, but this effect will be absent when the tax is analyzed from an intertemporal viewpoint.

A further difficulty with general equilibrium analysis is how the policies themselves are represented in applied models. Taxes must be represented in model-equivalent form, and yet for each tax there is substantial disagreement in the literature as to the appropriate treatment. In the case of the corporate tax, for instance, the original treatment adopted by Harberger (1962) of assuming average and marginal tax rates on capital income by industry to be the same can bias results. Recent literature has emphasized that this tax could be viewed as applying to only the equity return on capital rather than to the total return, that is, as a tax on one financing instrument available to firms. This view has been used by Stiglitz (1973) to argue that the tax is a lump-sum tax; more recently, Gordon (1981) has argued that the corporate tax is in effect a benefit-related risk-sharing tax. Similar difficulties arise in other areas of application. With trade models, for instance, the modeling of nontariff barriers is an especially difficult and contentious issue.

A final and somewhat broader issue is that most of the applied general equilibrium models are not tested in any meaningful statistical sense. Parameter specification usually proceeds using deterministic calibration (often to one year's data), and there is no statistical test of the model specification (see Mansur and Whalley 1984). In determining parameter values by calibrating to a single data observation, equilibrium features in the data are emphasized. A purely deterministic equilibrium model in which consumers maximize utility and producers maximize profits is thus constructed in a manner consistent with the observed economy. With enough flexibility in choosing the form of the deterministic model, one can always choose a model so as to fit the data exactly. Econometricians, who are more accustomed to thinking in terms of models whose economic structure is simple but whose statistical structure is complex (rather than vice versa), frequently find this a source of discomfort.

PART I

Techniques

2

General equilibrium theory

2.1 Introduction

Applying general equilibrium analysis to policy issues requires a basic understanding of general equilibrium theory, which we attempt to provide in this chapter. A general equilibrium model of an economy can be best understood as one in which there are markets for each of N commodities, and consistent optimization occurs as part of equilibrium. Consumers maximize utility subject to their budget constraint, leading to the demand-side specification of the model. Producers maximize profits, leading to the production-side specification. In equilibrium, market prices are such that the required equilibrium conditions hold. Demand equals supply for all commodities, and in the constant-returns-to-scale case zero-profit conditions are satisfied for each industry.

A number of basic elements can be identified in general equilibrium models. In a pure exchange economy, consumers have endowments and demand functions (usually derived from utility maximization). In the two-consumer–two-good case, this leads to the well-known Edgeworth box analysis of general equilibrium of exchange. In the case of an economy with production, endowments and demands are once again specified, but production sets also need to be incorporated into the analysis.

2.2 Structure of general equilibrium models

The simple pure trade general equilibrium model can be represented as one in which there are N commodities, $1, \ldots, N$, each of which has a nonnegative price $p_i \geq 0$. Market prices are denoted by the vector $\mathbf{p} = p_1, \ldots, p_N$. The term W_i represents the nonnegative economywide endowment of commodity i owned by consumers, assumed to be strictly positive for at least one i; $\xi_i(\mathbf{p})$ are the market demand functions, which

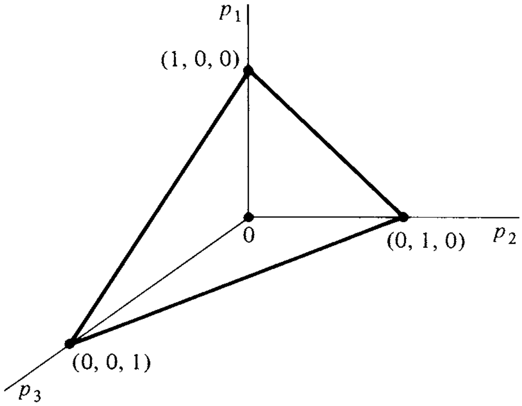

Figure 2.1. A 3-dimensional unit price simplex.

are nonnegative, continuous, and homogeneous of degree zero in $\mathbf{p}$. The latter assumption implies that doubling all prices doubles incomes and hence the physical quantities demanded are unchanged.

Because the demand functions are assumed to be homogeneous of degree zero in prices, an arbitrary normalization of prices can be used; we will ordinarily set

$$\sum_{i=1}^{N} p_i = 1. \tag{2.1}$$

The prices of the N commodities lie on a unit simplex. The case where $N=3$ is depicted in Figure 2.1.

A key further assumption usually made on the market demands is that they satisfy Walras's law. Walras's law states that the value of market demands equals the value of the economy's endowments, that is,

$$\sum_{i=1}^{N} p_i \xi_i(\mathbf{p}) = \sum_{i=1}^{N} p_i W_i, \tag{2.2}$$

or the value of market excess demands equals zero at all prices,

$$\sum_{i=1}^{N} p_i(\xi_i(\mathbf{p}) - W_i) = 0. \tag{2.3}$$

This condition must hold for any set of prices, whether or not they are equilibrium prices. Walras's law is an important basic check on any equilibrium system; if it does not hold, a misspecification is usually present

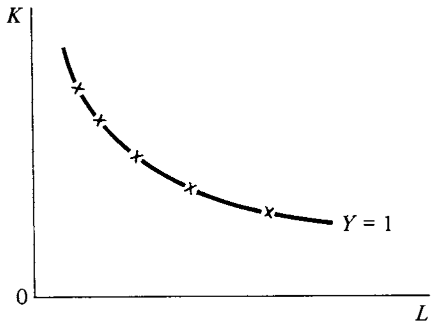

Figure 2.2. Approximating a unit isoquant by a series of linear activities.

since the model of the economy in question violates the sum of individual budget constraints.

A general equilibrium in this system is a set of prices p_i^* such that

$$\xi_i(\mathbf{p}^*) - W_i \leq 0, \tag{2.4}$$

with equality if $p_i^* > 0$. Equilibrium prices, therefore, clear markets.

A general equilibrium model with production is similar, but would also include a specification of a production technology. One representation of production has a finite number K of constant-returns-to-scale activities or methods of production. Each activity is described by coefficients a_{ij} denoting the use of good i in activity j when the activity is operated at unit intensity. A negative sign indicates an input and a positive sign an output.

These activities can be displayed in the nonsquare matrix A, which lists the many possible ways of producing commodities and can be used in any nonnegative linear combination:

$$A = \begin{bmatrix} -1 & 0 & & 0 & a_{1,N+1} & \cdots & a_{1,j} & \cdots & a_{1,K} \\ 0 & -1 & & 0 & \cdot & & \cdot & & \cdot \\ \cdot & 0 & \cdots & \cdot & \cdot & & \cdot & & \cdot \\ \cdot & \cdot & & 0 & \cdot & & \cdot & & \cdot \\ 0 & \cdot & & -1 & a_{N,N+1} & \cdots & a_{N,j} & \cdots & a_{N,K} \end{bmatrix}. \tag{2.5}$$

The first N activities are "slack" activities reflecting the possibility of free disposal of each commodity. In the case of only two inputs (capital and labor) and one output, these technology activities can be thought of as approximating a unit isoquant through a series of activities giving linear facet isoquants, as shown in Figure 2.2.