The Impact of Computable General Equilibrium Models on Policy

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Abstract

This paper reviews the experience of the use of computable or applied general equilibrium (CGE or AGE) models to affect public policy. The range of issues on which CGE models have had an influence is quite wide, and includes structural adjustment policies, international trade, public finance, agriculture, income distribution, and energy and environmental policy. In the cases where CGE models have enlightened the policy debate, the reasons have to do with one or more of the following: (i) consistency between results from CGE models and other types of analysis (for instance in the debate on NAFTA); (ii) the fact that the CGE models captured particular features of the economy, such as some structural rigidities and institutional constraints, that rules of thumb, based on simpler analysis failed to capture; or (iii) CGE models provided a consistent framework to assess the linkages and tradeoffs among different policy packages. We also consider misuses of CGE models in policy. Most of these stem from: (i) pushing the model beyond its domain of applicability; (ii) violating the principle of Occam's razor—use the simplest model suited to the task; (iii) the "black box syndrome"—results whose link with the policy change is opaque. In assessing the use of models in policy, it is important to distinguish between stylized and applied models. Both have been used in policy debates, but there are important differences in their uses, particularly in their domain of applicability. Stylized models tend to be small, narrowly focused, and emphasize a particular causal chain or policy. Applied models are usually larger, seek to capture important institutional characteristics of the economy being modeled, and encompass a wider spectrum of issues; but they are vulnerable to the black-box syndrome and violation of Occam's razor. Complementary use of stylized and applied CGE models has enhanced the effectiveness of both in policy debates.

Introduction

In the four decades since Johansen's (1960) model of Norway, applied or computable general equilibrium models (AGE or CGE) have grown in importance, as a tool of both research and policy analysis.[1] Initially confined to universities and research institutions, CGE models today are routinely used by governments in policy formulation and debate. Modeling capacity, either in government agencies or policy research institutes, can be found in at least twenty countries around the world.[2] This paper selectively reviews the experience of the use of CGE models to affect public policy.[3] The range of issues on which CGE models have had an influence is quite wide, and includes international trade, public finance, agriculture, structural adjustment policies, and income distribution. We start by describing desirable properties that policy models need to have in order to be useful in policy formulation and debate. We then review the experience of CGE models in policy in several areas by examining whether or not the models had these properties.

In reviewing the experience, we find it useful to distinguish between stylized and applied CGE models.[4] Stylized models can be described as "putting numbers to theory", staying as close to the underlying analytic model as possible in order to isolate the empirical importance of a linkage that theory identifies as potentially important. Stylized models are not meant to be "realistic" since they are designed to focus on particular causal mechanisms that theory indicates are important, often ignoring other effects that might be important empirically. Applied models tend to be larger, seek to incorporate more descriptive detail of the economy being modeled, and encompass a wider spectrum of issues. Both stylized and applied models have been used in policy debates, but there are important differences in their uses. Stylized models tend to be narrowly-focused, but their simplicity can be a virtue in explaining results to policymakers. When pushed beyond their narrow domain of applicability, however, they can be misused. While applied models, by design, incorporate more institutional and structural detail, their additional complexity may lead to problems in identifying the main causal mechanisms at work—the "black box syndrome" that critics argue is a common problem with simulation models. In short, to be useful for policy and avoid some of the pitfalls, modelers would do well to be guided by their own version of Occam's Razor: "Use the simplest model adequate to the task at hand."

In this review, we start by laying out desirable features for policy models if they are to be used effectively in policy debates. We then discuss uses of CGE models in policy debates

[1] In this paper, we will use CGE and AGE as synonyms.
[2] We did an informal enquiry and found government CGE modeling capability in the United States, Denmark, Norway, the Netherlands, France, Sweden, Switzerland, Australia, Argentina, Brazil, India, Bangladesh, Thailand, Indonesia, China, Vietnam, South Africa, and Mozambique. Many other countries regularly use CGE models in policy analysis, relying on consultants and non-governmental research institutions.
[3] The term "selectively" is crucial here. Our intent is not to survey the numerous applications of CGE models to policy. Rather, we choose some selected examples to illustrate the lessons learned from this wide-ranging experience.
[4] See Robinson (1989).

in a number of areas: trade policy, public finance, structural adjustment, and income distribution.

Desiderata for Policy Models

To be useful for policy analysis, economic models should have a number of desirable features:

(1) Policy relevance. The models should link values of policy variables to economic outcomes of interest to policy makers and useful in policy debates.

(2) Transparency. The links between policy variables and outcomes should be easy to trace and explain.

(3) Timeliness. Policy models must be based on relevant data, which implies that they must be implemented with recent data if they are to be used in ongoing policy debates.

(4) Validation and estimation. Estimated model parameters and model behavior need to be validated for the "domain of application" of the model. That is, the model must be determined to achieve accurate results for the domain of potential policy choices under consideration in the policy debate.

(5) Diversity of approaches. Validating results from policy models is greatly strengthened by analysis using a variety of models and at different levels of aggregation. Such diversity tests the robustness of the results and the importance of assumptions made in the various approaches.

Model Design

The first two criteria argue strongly for using structural models. Reduced-form models typically do not incorporate explicit links between policy variables and economic outcomes. Or, if they do, the reduced-form structure of such models makes it difficult, if not impossible, to identify the underlying structural relations, and hence difficult to trace out the links between policy variables and outcomes. Quite simply, reduced-form models tend to be "black boxes" whose results are difficult to explain.

Policy relevance requires modelers to address issues of interest in the policy debate. An academic perspective might lead to a focus on indicators of aggregate welfare, such as equivalent or compensating variation. Policy debates, however, are rarely concerned with such aggregate measures and tend, instead, to focus on identifying the winners and losers from proposed policy changes. Political reality, not to mention good welfare economics, requires us to identify who is affected by policy changes in order to determine if compensation schemes are feasible to generate ex post Pareto improvements and, if not, to understand the tradeoffs between distributional and aggregate impacts. For policy analysis, tracing out the impact of shocks on changes in the structure of production, trade, and employment is at least as important as generating aggregate welfare measures.

The issue of transparency argues for the use of stylized models, since it is relatively easy to describe the results and the causal chains involved. Policy relevance, however, often

requires more sectoral and institutional detail, which mandates the use of applied models that are larger and more complex. While applying Occam's Razor, it is also important to note that a CGE model provides the policy analyst with a simulation laboratory that supports individual, controlled experiments. Any empirical result from an applied model can be explained in terms of parameters, structural data, and behavioral specification. A CGE model can, and often does, generate empirical surprises, but it cannot generate theoretical surprises. In policy analysis, one important lesson is that it is crucial to decompose any policy results through the use of controlled experiments to determine the empirically important causal chains at work.

Timeliness is very important for ongoing debates, but historical analysis may also be useful. One can use a policy model to analyze the impact of past policy choices in order to draw lessons for current debates. The problem is that it is then necessary to show how the historical analysis is applicable to the current debate, which requires showing both that the historical structural model is relevant and that the domain of applicability of the past policy changes is similar enough to draw valid lessons for current policy. Usually, credibility in policy debates requires up-to-date models and data.

Estimation and Validation

The issue of validation of a policy model also argues for a structural model. The domain of applicability of a reduced-form econometric model must be contained within the historical range of the data used to estimate the model. The domain of applicability of a structural model depends on the applicability of the structural relations and on the stability of its parameters in the period of analysis.

An example can make this discussion more concrete. During the various oil crises of the 1970s, a number of large macroeconometric models were used to analyze the impact on the U.S. economy of large changes in oil prices. These models were estimated over past periods in which oil prices were relatively stable, and turned out not to capture in their (largely reduced-form) specification the relevant links between oil prices and economic performance. While these models included oil prices, their domain of applicability was too limited to capture the impact of large changes in world oil prices. To capture these links, new structural models were developed which explicitly incorporated links between oil prices and the rest of the economy. A number of CGE models were developed for this purpose.

In model validation, there is a tradeoff between using a structural model, which requires estimation of a large number of structural parameters, and a reduced-form model with far fewer parameters. Structural models such as CGE models are highly nonlinear, and are based on data such as input-output tables which are only available for a few periods, with long gaps. Reduced-form models are usually much sparser in their parameter requirements, and can be estimated with readily available time-series data. On the one hand, structural models such as CGE models use data from a single year (a Social Accounting Matrix or SAM) to estimate input-output coefficients and expenditure shares, and draw on other partial studies for estimates of important behavioral parameters such as elasticities determining supply and demand behavior of economic actors. On the other hand, many reduced-form models are so limited in their domains of applicability as to be virtually useless in policy analysis. The experience of the past twenty years seems to

demonstrate that it is better to have a good structural model capturing the relevant behavior of economic actors and their links across markets, even if the parameters are imperfectly estimated, because the domain of applicability of such models makes them far more useful for policy analysis.

Furthermore, recent advances in methods of econometric parameter estimation should reduce the intensity of this particular debate. The specification of a structural model incorporates a great deal of knowledge from economic theory regarding the values of the structural parameters. For example, both theory and econometric work provide prior information on the likely range of values of various structural elasticity parameters in production and demand. In reduced-form models, on the other hand, there is little if any prior information available even regarding signs of various parameters. The issue for parameter estimation in structural models in general, and CGE models in particular, is how to use the available information in econometric procedures. New methods of "maximum entropy econometrics" are providing a framework for econometric estimation that supports use of information in many forms, and from many sources, in estimating structural parameters. The philosophy is to use all available information for estimation, but only that information—do not make any assumptions that imply the use of information that is not available. The approach supports the use of theoretical information about the parameters of structural models that is usually not available for reduced-form models, and to use scattered data from a variety of sources in a unified estimation framework. Recently, these new methods have been used to estimate SAMs for a large number of countries and for estimating crucial elasticity parameters in a single-country model.[5]

For CGE models, there are essentially two kinds of parameters that need to be estimated:

(1) Share parameters such as intermediate input costs, consumer expenditure shares, average savings rates, import and export shares, government expenditure shares, and average tax rates. These share parameters can be estimated from a recent social accounting matrix (SAM) under the assumption that the base year represented by the SAM is an equilibrium solution of the CGE model.

(2) Elasticity parameters describing the curvature of various structural functions (e.g., production functions, utility functions, import demand functions, export supply functions). These cannot be estimated from a single SAM, but require additional data.

The use of a SAM, coupled with the assumption that the base data represent an equilibrium solution of the model, to estimate share parameters has been described as "benchmark estimation" and has been widely used in CGE models.[6] The assumption of base-year equilibrium is very powerful and imposes a great deal of prior information on parameter estimation. The estimation of elasticities, however, is more difficult.

[5] See, for example, Golan, Judge, and Robinson (1994); Robinson, Cattaneo, and El Said (2001); and Arndt, Robinson, and Tarp (2002). The general approach is described in Golan, Judge, and Miller (1996).
[6] See Mansur and Whalley (1984). The benchmark approach was used in the earliest CGE models. See, for example, Johansen (1960) and Dixon et al. (1982), who use a solution approach that requires that the model start from an equilibrium data base.

Knowledge of a base-year SAM and the assumption that the base is an equilibrium do not provide any information about the values of elasticities. Additional information and data are required for estimation of these parameters.

Model validation requires both estimation of model parameters and testing of the ability of the model to accurately trace out the impact of policy changes. Validation is necessarily linked to the issues to be analyzed, and should provide an indication of the domain of applicability of the model. One way to validate a policy model is to test it with historical data relevant to its intended domain of applicability. How well does the model explain past events? This sort of heuristic validation can be done with incomplete historical data. The model can be used in simulation mode to map out the model's response function for relevant shocks. These can be compared to the stylized facts for historical experience, or even from experience of comparable countries.

In standard econometric models, there is a tendency to combine parameter estimation and model validation in the same analysis. If such a model is to be used for policy analysis, it is important that parameter estimation be done over a time period which contains information relevant for the model's intended domain of applicability. Having lots of data is nice, but not useful if the data do not contain relevant information for the policy questions under consideration.

Effective Use of Policy Models

The issue of using a diversity of model approaches in policy analysis is closely linked to issues of model validation. For example, a number of trade-focused CGE models were used to analyze the impact of the North American Free-Trade Agreement (NAFTA) on U.S. and Mexican agriculture. One common result was that trade liberalization would increase Mexican exports of fruits and vegetables to U.S. markets. These results were obtained under a number of simplifying assumptions in the CGE models, such as: the use of simple neoclassical production functions (e.g., CES functions) for agriculture; no consideration of marketing costs; no capacity constraints in rural transportation infrastructure in either country; and no consideration of seasonality. While the results were suggestive, they became much more persuasive when detailed commodity studies of potential increased production and distribution of fruits and vegetables indicated that such increases were feasible. Also, since the CGE studies were comparative static, detailed commodity analysis provided indications of how long it would take for the changed incentives from NAFTA to generate supply and demand responses in particular markets.

Policy models are often used to analyze the impact of existing policies and to aid in the design of better or even "optimal" policies. In policy debates, an effective approach is to use the CGE model in simulation mode and do controlled experiments that map out "policy response" relationships. The idea is to look for empirically important effects and indirect, general equilibrium, links. There is often a lot of synergy between policies, and the model can be used to explore mixes of policies in various second-best environments. From the perspective of the policy maker, the model provides a simulation laboratory—acting like the "real world" for its domain of applicability. The policy maker need not know or understand in detail how the simulation laboratory works—no more than a pilot

needs to understand the insides of a flight simulator. Both need only be confident that the simulator works well for the situations they will likely face.

When explaining the results from a CGE model used for policy analysis, the model can effectively disappear. The CGE model produces all price and quantity data resulting from policy experiments. The analyst should be able to explain the causal chains determining the results by standard, usually simple, economics. If results arise from complex interactions, they can be sorted out by controlled simulation experiments designed to decompose the various effects at work. The use of an explicit model can significantly elevate the policy debate, providing a structure for discussing the validity of results in terms of the strengths of the various forces at work and the links between policy choices and outcomes.

Trade Policy

We turn now to the first of several areas where CGE models have been used to affect policy. It is perhaps fitting to start with trade policy. Most of the effects surrounding trade policy, such as those captured in the Stolper-Samuelson Theorem, are general-equilibrium effects. Not surprisingly, therefore, CGE models have been used extensively to analyze, and in some cases influence, trade policy. The models themselves have been surveyed elsewhere.[7] Rather than review the experience with all the models applied to policy, we concentrate on a particular episode, namely, the negotiation of the North American Free Trade Agreement in the early 1990s. The extensive use of CGE models in this debate illustrates many of the uses (and some abuses) of this class of models to inform policy.

NAFTA

In 1990, the Mexican government formally asked the U.S. government to negotiate a free trade agreement (FTA) between the two countries. Since the U.S. had recently completed such an agreement with Canada, the negotiations quickly involved all three countries and resulted, in late 1993, in Congressional approval of the North American Free Trade Agreement (NAFTA). Starting with the request to Congress by the first Bush Administration for "fast track" authority to negotiate NAFTA through to its final approval during the Clinton Administration, CGE models were widely and effectively used to inform the policy debate. The models were used both in the negotiating process and in the political debate regarding approval of the final deal.

A number of questions were raised early in the debate, and continued to be the focus of analysis throughout the negotiations:

(1) What would be the benefits and costs to the three countries if NAFTA were implemented? While there was some mild interest in whether the U.S., Canada, and Mexico would gain in terms of some aggregate measures of

[7] See de Melo (1988) and Francois and Shiells (1994).

welfare, most of the concern and policy debate centered on identifying winners and losers.

(2) What would be the impact on labor in the U.S., both in terms of employment and wages? The labor unions argued that there would be, in the words of Ross Perot, a "giant sucking sound" of jobs moving to Mexico as employers took advantage of cheap Mexican labor, resulting in loss of jobs and lower wages in the U.S.[8] Proponents argued that increased U.S. trade in North America would help U.S. exports, resulting in increased employment in relatively high-wage jobs in exporting sectors.

(3) What would be the impact of NAFTA on migration between Mexico and the U.S.? Migration was a contentious issue well before NAFTA was proposed, but the NAFTA debate gave it a new focus, even though NAFTA, as proposed and as finally passed, did not include any provisions concerning migration.[9]

(4) What would be the impact at the sectoral level in the three countries? A few sectors were particularly sensitive and the focus of much debate: agriculture, autos, and textiles. However, in the negotiations and in the political debate in the U.S. Congress, there was an enormous amount of policy attention to detailed analysis of sectoral and commodity impacts.

(5) What would be the impact of NAFTA on the U.S. and Mexican trade balances, particularly the bilateral balance between Mexico and the U.S.? Coupled with this was a concern about the impact of the agreement on flows of private financial capital to Mexico. The labor unions worried about capital flight from the U.S. to Mexico. The financial community wanted more open financial markets. Only a few economists were concerned about the overvaluation of the Mexican peso and whether capital inflows into Mexico were sustainable.[10]

CGE Models in the NAFTA Debate

At the time NAFTA was proposed, a great deal of work was already underway to analyze the impact of the ongoing Uruguay Round of GATT negotiations, which had started in 1987. A number of single-country and multi-country CGE models had been developed to analyze various reform scenarios in the Uruguay Round, and researchers quickly adapted these models to look at the potential effects of NAFTA. There were also many detailed industry and sectoral studies underway, which could be, and were, adapted to look at NAFTA. The result was that, from the beginning and throughout the negotiations, high-quality economic analysis was available on a timely basis to inform the debate.

Most of the analysis in the U.S. was either performed by or done in close collaboration with government agencies, particularly the Economic Research Service of the U.S. Department of Agriculture (ERS/USDA), the International Trade Commission (ITC), the Department of Labor, the Department of Commerce, and the Congressional Budget

[8] See Perot and Choate (1993).
[9] With the exception of some guarantees that businessmen would be able to travel without restrictions across the three countries.
[10] See, for example, Manchester. and McKibbin,(1995) and Congressional Budget Office (1993).

Office (CBO). All these agencies either produced or used CGE models, as well as detailed partial-equilibrium studies. As Francois and Shiells (1994a) put it (p. 5):

> For the first time in the United States, the AGE trade policy-modeling community found itself in the limelight, providing direct input for the government's trade policy process … Ambassador Hills employed these studies in her frequent statements in favor of the agreement before the Congress and the public.

Policy makers in both Mexico and Canada also had access to and used CGE models to analyze the impact of NAFTA on their countries. In the case of Mexico, the lead minister responsible for the negotiations, the Secretary of Commerce and Development, was Jaime Serra-Puche, who had done his Ph.D. thesis on a CGE model of Mexico. Various other government officials in Mexico, including in the important Ministries of Agriculture and Foreign Affairs, were familiar with these models and effective consumers of the work.

Equally important to the policy debate were the impartial surveys of the economic work, which summarized the areas of agreement and controversy across the various studies. Influential and timely surveys were done by the Brookings Institution, the ITC, the CBO, the Congressional Research Service (CRS), the General Accounting Office (GAO), and the Department of Labor.[11] These surveys were influential in the policy debate because they were correctly seen as impartial evaluations of the results of economic analysis of NAFTA, including a lot of work with CGE models. These reviews were highly critical of some of the methodologies used to evaluate NAFTA (e.g., the use of simple macro trade multipliers), and provided balanced, generally approving, evaluations of the CGE work and the various detailed micro studies. The result was that the summaries, especially the first three, helped define the boundaries of "good" analysis, and work outside of this mainstream was discounted in the policy debate.

The surveys also found a great deal of agreement among the various studies, which was surprising considering the wide variety of models and methodologies, at various levels of aggregation, that were employed. The CBO study summarized the results (p. xi):

> A thorough review of the myriad changes brought about by NAFTA, and of their interactions, leads to the single resounding conclusion that the net effect on the U.S. economy would be positive and very small. The biggest changes introduced by NAFTA would be those related to Mexico …

These evaluations appear to have been correct, as Burfisher, Robinson, and Thierfelder (2001), in their survey of studies of the actual impact of NAFTA on the U.S. since it was passed, conclude (p. 141):

> … economists can do a reasonably good job of projecting the gains from trade liberalization agreements. The mainstream forecasts during the NAFTA debate were basically correct: NAFTA has had relatively small

[11] See Lustig, Bosworth, and Lawrence (1992); U.S. International Trade Commission (1992); Congressional Budget Office (1993); and U.S. Department of Labor (1993). Francois and Shiells (1994b) brought together some of the important CGE work, based largely on the ITC survey.

> positive effects on the U.S. economy and relatively large positive effects on Mexico.

There was also a broad consensus among the studies relying on CGE models, surveyed by Brown (1992) and the ITC (1992) during the debate. Francois and Shiells (1994a) conclude (p. 34):

> The main conclusions that can be drawn from the large, multisector AGE models of NAFTA are as follows. First, models that incorporate some form of imperfect competition obtain larger impact effects than models that assume perfect competition. … Second, nontariff barriers (NTBs) are potentially as important as tariff barriers … Third, international capital mobility induced by NAFTA is potentially more important than trade liberalization contained in NAFTA, especially for Mexico. … Finally, real wages in Canada and the United States are expected to rise as a result of NAFTA, in sharp contrast to what would be expected based on the Stolper-Samuelson theorem.

Burfisher, Robinson, and Thierfelder (2001) also surveyed the prospective CGE studies of NAFTA which addressed the issue of whether NAFTA, as a preferential trade agreement, would be net trade creating or net trade diverting (p. 140):

> The studies of NAFTA, whether in a single or multi-country context, all concluded that NAFTA was net trade creating and would benefit all three countries, with the largest relative gains for Mexico.

They also conclude that the prospective studies were correct. Post-NAFTA studies, at various levels of aggregation, have concluded that NAFTA has been net trade creating, and that actual trade diversion was much smaller than had been feared during the NAFTA debate.

These results, and the consistency of results across many studies, contributed to raising the level of the NAFTA debate, essentially preventing studies based on weak analysis from ever dominating the discussion. For example, the book by Perot and Choate (1993), arguing that NAFTA would devastate the U.S. labor market, was quickly discredited for its weak analytic foundation and baseless conclusions.

The open discussion of the various models also helped increase their credibility. For example, the CGE model by Roland-Holst, Reinert, and Shiells (1994), which was developed at the ITC, generated estimates of the gains from NAFTA that were larger than those from any other static model. Surveys of the CGE work by Brown (1992) and Francois and Shiells (1994) sorted out why: the model included imperfect competition, economies of scale, large non-tariff barriers, and aggregate employment effects.[12] These outlier results were able to be put in perspective, and were somewhat discounted in the debate.

While the eventual role of applied general equilibrium models was certainly beneficial to the NAFTA debate, there are also lessons concerning how *not* to use CGE models in

[12] The version of the model that Brown (1992) surveyed was described in a 1992 working paper.

policy debates.[13] During the early debate concerning whether Congress should grant the Bush Administration fast-track negotiating authority for NAFTA, the ITC published a study in early 1991 that drew on studies of particular industries and also presented results from a highly stylized CGE model, which was developed internally by an ITC staff member. This toy empirical model was designed to explore Stolper-Samuelson effects within a neoclassical two-country trade model, with a large country trading with a small one. Not surprisingly, the model found that the Stolper-Samuelson theorem is correct: with increasing trade, the real wage went up in the small developing country and went down a tiny bit in the large developed country. The ITC did not publish the model and only reported the qualitative result that NAFTA might lead to a "slight" fall in the average wage of unskilled labor in the U.S. The AFL-CIO immediately put out a press release saying that an official U.S. government study showed that NAFTA would cause wages of unskilled labor in the U.S. to fall. The ITC did not define "unskilled labor" so the AFL-CIO said that it must amount to 60 percent of the labor force, and that NAFTA was therefore a very bad idea.

For reasons that remain unclear, the initial response of the ITC was to state that it would not release the CGE model, or even describe it in detail—although they eventually released the estimates of the change in the wage, which ranged from –0.002 percent to +0.01 percent! The next day, the AFL-CIO issued a press release stating that a *secret* U.S. government study showed that 60 percent of workers in the U.S. would be hurt by NAFTA. Fortunately for the reputation of CGE models, results from a series of larger, more realistic, applied models appeared quickly and provided a far better, open, and transparent framework for discussion and debate.[14]

This experience provides a couple of lessons. First, do not use a stylized model when a more realistic, applied model is called for. The issues around employment and wages were obviously controversial and contentious, and any adequate analysis would obviously require serious attention to the modeling of the labor markets. Second, policy models are useful only if they can provide a framework for discussion and debate, which requires that they be publicly available and that their results be "explainable". A "secret" model is worse than useless—it raises suspicions, diverts discussion into fruitless speculation, and generates heat but no light. Fortunately, the ITC redeemed itself by later sponsoring a public symposium on NAFTA models, and by doing an excellent job of evaluating and synthesizing the results.

Agriculture, Migration, and Labor Markets

The analysis of the impact of NAFTA on labor markets ranged from micro industry studies, input-output multiplier studies, CGE models, and Keynesian macro trade multiplier models.[15] The macro multiplier models were very influential, especially early in the debate, but were heavily criticized on methodological grounds—they seem to be

[13] Francois and Shiells (1994a, p. 5) tell part of this story. See also Hinojosa and Robinson (1992).
[14] In particular, early CGE models by KPMG-Peat Marwick (1992) and Hinojosa-Ojeda and Robinson (1992) found potential gains for labor in the U.S. Many other applied models followed.
[15] This work was surveyed by Hinojosa and Robinson (1992), CBO (1993), and U.S. Department of Labor (1992).

completely inappropriate for evaluating the long-run impacts of trade liberalization.[16] While the multiplier models were never really fully discredited during the debate, the combination of work by CGE models and sector studies gradually dominated the discussion of the impact of NAFTA on labor, focusing on the extent of labor displacement. The CBO (1993) surveyed the available studies and concluded that the aggregate job losses related to NAFTA would be very small relative to normal labor turnover in the U.S. economy, but also warned that (p. xi): "That the net effects for the United States are positive, of course, should not obscure the painful adjustments and losses some U.S. workers, firms, and communities will undoubtedly experience."

In response to the concerns about labor displacement, the Clinton Administration and the Congress agreed to legislation creating a NAFTA Trade Adjustment Assistance Program (NAFTA-TAA). Given the wide agreement among analysts, including those working with CGE models, that the aggregate employment effects of NAFTA would be small, the NAFTA-TAA program was designed as an open-ended commitment to provide assistance to all workers who could show that they had lost their jobs due to NAFTA. This open-ended commitment was quickly enacted by Congress. If the estimates of job displacement had been very large, this legislation would have been much more controversial. In the event, the predictions were correct and the number of applications for NAFTA-TAA assistance has been relatively small, although significant—just under a quarter of a million certified participants as of July 1999.[17]

While NAFTA did not include any provisions regarding migration, concerns about Mexican-US migration were a major issue in the NAFTA negotiations. This turned out to be an issue in which CGE models played a significant role. Before NAFTA was proposed, Mexico embarked on a program of major reform of its agricultural sector. These reforms were being designed and implemented as the NAFTA negotiations were in progress, and involved politically difficult policy choices by the Mexican government. The concern from the Mexican side was that too rapid reform would displace a large number of small farmers in the Mexican countryside, leading to a major increase in migration to the cities, and also to the U.S. The reforms needed to be timed in such a way that the displaced workers could be absorbed in new, labor intensive agricultural activities (e.g., high value fruits and vegetables) and in a growing industrial labor market in the cities. NAFTA, which was to include liberalization of agricultural trade between the U.S. and Mexico, was a potential threat to the Mexican reform process, possibly forcing the pace of reform in Mexico too quickly.

A number of CGE models were developed to analyze the impact on Mexico of agricultural reform combined with trade reform, and the impact of these reforms on rural-urban migration within Mexico and migration to the U.S.[18] Complemented by sector and commodity studies, these CGE models were especially influential. All were applied

[16] Hinojosa and Robinson (1992) described them as "striking in their lack of theoretical underpinnings." See also Burfisher, Robinson, and Thierfelder (2001) who criticize the use of Mercantilist models in evaluating the effects of trade liberalization.

[17] See Burfisher, Robinson, and Thierfelder (2001), p. 129.

[18] Especially important were models by Levy and van Wijnbergen (1994); Hinojosa and Robinson (1991); Burfisher, Robinson and Thierfelder (1992, 1994, 1997); and Robinson et al. (1993). The model by Levy and van Wijnbergen was of Mexico alone, while the others were all multi-country NAFTA models.

models in which the authors included institutional details of the labor markets in the two countries, trade policies, agricultural policies, and adequate disaggregation of the agricultural sectors to capture the effects of policy changes in both countries. A number of robust conclusions emerged:

- Opening Mexican corn markets to U.S. imports would be good for U.S. farmers. U.S. exports would increase significantly.
- Too rapid increased corn imports into Mexico would greatly disrupt Mexican agriculture, especially poor corn farmers, and lead to large migration out of the rural sector, with significant increases in migration to the U.S.
- Opening up of U.S. agricultural markets to Mexican exports of high value agriculture (e.g., fruits and vegetables) would help keep rural employment up in Mexico, ameliorating migration pressures. The effect, however, was not as large as the impact of increased corn imports, especially given the time needed to increase production of high value crops.
- Given time and successful Mexican growth, the economy could absorb the rural workers displaced by agricultural reforms. In the long run, Mexican growth should reduce migration pressure.

From the U.S. perspective, trade reform represented a stark tradeoff between what would be good for Iowa corn farmers, and bad for California and Texas labor markets. From the Mexican perspective, the problems were how to design and implement the agricultural reforms, and how to prevent NAFTA from complicating the delicate process of reform that they had already initiated.[19]

In the event, the results of the various studies increased sensitivity on both sides of the negotiations. The final NAFTA agreement provided fifteen years for implementation of the provisions regarding agriculture, which effectively meant that NAFTA did not constrain Mexican agricultural reform policies.[20] However, the fact that NAFTA set a schedule for trade liberalization in agriculture meant that farmers in Mexico could see that agricultural policy changes had to occur—the government's reform efforts became more credible.

Public Finance

Harberger's (1964) seminal paper on the distortionary effects of taxation, which used an extremely simple general-equilibrium model for their calculation, set the stage for CGE models' entry into the domain of public finance. And since public finance is the quintessential concern of policymakers, it would be natural for CGE models to enter into the policy arena through this field. Some of the earliest CGE models of the United States,

[19] This process has continued since the passage of NAFTA, and there is a continuing work program using CGE models to analyze the impact of changes in agricultural policies on NAFTA countries. See, for example, Burfisher, Robinson, and Thierfelder (2000).

[20] The letter of transmittal that the Bush administration sent to Congress with the completed NAFTA agreement actually stated that the reason that they had agreed that agriculture should have a fifteen-year transition period was that studies had shown the dangers from too-rapid reform.

for instance, were designed to examine questions of tax reform.[21] Subsequent versions of their model were installed in the U.S. Treasury to examine tax reform proposals. Similarly, large-scale CGE models have been used to evaluate public-finance issues in other developed countries, such as Canada and Australia (Powell and Snape (1993)). In retrospect, CGE models' influence on public finance policy has been significant, but limited. The reason for their limited application in policymaking is similar to that identified elsewhere in this paper: questions of tax reform or the evaluation of public projects are too important to be decided by one class of models. CGE models have helped shape the debate, and in some cases provided valuable support to the final policies adopted. But their influence has been greatest when model results have coincided with those obtained from other types of analysis, including stylized models, partial-equilibrium models and microsimulation models.

The two specific areas where CGE models have been used are (i) estimates of the marginal cost of funds; and (ii) analyzing tax reform.

Marginal Cost of Funds

At first glance, it would seem that the marginal cost of funds (MCF) were ideal candidates for estimation by CGE models: the estimate depends on second-best considerations which can only be captured by a general-equilibrium framework. Yet, a large number of estimates of the MCF are carried out without using CGE models. One reason is that there are a host of conceptual issues surrounding the calculation, and these are best illustrated using simple, stylized models. These conceptual issues are well surveyed in Fullerton (1991) and Ballard and Fullerton (1992). Pigou, Harberger (1964), and Browning (1987) implicitly compare distortionary taxes with equal revenue lump-sum taxes. Since income effects are equal by construction, their analysis involves only substitution effects and depends upon compensated demand and supply elasticities. Because these substitution effects are distortionary, the MCF is necessarily (weakly) greater than one. By contrast, in Stiglitz and Dasgupta (1971) and Atkinson and Stern (1974) taxes are raised to spend on a public project. Since the taxes generate income effects, their analyses depend upon uncompensated demand and supply elasticities. Because these income effects offset the (distortionary) substitution effects, the MCF is not necessarily greater than one. If public spending is not separable in utility, the MCF will also depend upon the effect of that spending. The difference between these approaches was noted in Wildasin (1984).

Approaches to estimating the MCF empirically have followed one of two routes: analytical formulae and numerical simulations. Browning (1987) uses an analytical, partial-equilibrium formula to estimate the marginal excess burden (MEB) of labor taxes in the United States. Ahmad and Stern (1987) use a simplified analytical formula based on effective taxes (the amount by which government revenue would increase if there were a unit increase in final demand for a good) to calculate the welfare cost of various taxes in India. Ahmed and Croushore (1994) derive MCF estimates for the U.S. when public spending is non-separable in utility. Snow and Warren (1996) derive a more general analytical formula to reconcile a variety of previous MCF estimates.

[21] Shoven and Whalley (1984).

Among estimates that rely on simulation models, Stuart (1984) and Ballard, Shoven, and Whalley (1985) use computable general equilibrium (CGE) models of the U.S. to estimate the MCF. Hansson and Stuart (1985) use a CGE model of Sweden to estimate a MCF that is sensitive to both the type of tax and spending. As noted in Fullerton (1991) and Snow and Warren (1996), it should be emphasized that these studies encompass myriad approaches and definitions. Nevertheless, it is worth noting that the majority of the estimates, across countries and using different methods, fall within the range of 1.2 – 2.2.

Table 1. Estimates of the Marginal Cost of Funds (with CGE model-based estimates in boldface)

Country	*Tax type*	*Estimate*	*Source*
United States	surcharge	1.17-1.56	**Ballard, Shoven, and Whalley (1985)**
	Labor	1.21-1.24	Stuart (1984)
	Labor	1.32-1.47	Browning (1987)
	Labor	1.08-1.14	Ahmed and Croushore (1994)
Sweden	surcharge	0.67-4.51	**Hansson and Stuart (1985)**
New Zealand	labor	1.18	Diewert and Lawrence (1994)
India	excise	1.66-2.15	Ahmad and Stern (1987)
	sales	1.59-2.12	
	import	1.54-2.17	
Bangladesh, Cameroon, Indonesia	trade, sales	0.5-2.2	**Devarajan, Suthiwart-Narueput and Thierfelder (2001)**

Despite the considerable care with which the MCF has been estimated, by CGE models or other methods, the use of these estimates in public policy has been varied. In some cases, such as in Sweden, the estimates of a high MCF served to reinforce the notion that the tax system in the country was highly distorted. Here it was not the precise magnitude of the MCF estimate, but its broad range that influenced policy. In other cases, the large differences in the MCF across tax instruments opened policymakers' eyes to how distorted the current tax system was, and to potential areas for tax reform (Jorgenson and Yun (1986), Ahmad and Stern (1987)). Almost never were these estimates used in the evaluation of public projects. But the reasons have more to do with the principle of using the MCF in evaluating projects, rather than with the techniques used to calculate the MCF in a country (Devarajan, Squire and Suthiwart-Narueput (1997)).

Tax Reform

The use of CGE models in tax reform have followed a similar route. Simple, stylized models have given way to larger, complex models that capture a myriad of effects. Perhaps the most comprehensive effort in this area has been the work of Dale Jorgenson (1997). His co-authors and he demonstrated the overwhelmingly favorable effects of unifying the corporate and personal income tax in the United States, of replacing capital taxation with consumption taxation, and so forth. All of these could have been

demonstrated with the use of a simple, stylized model. But Jorgenson and his collaborators showed, using a dynamic, multi-sectoral, multi-household model, that the welfare gains from undertaking such tax reforms could be substantial indeed. While U.S. tax policy did move in this direction (albeit more slowly than the Jorgenson analysis would deem optimal), it is curious that the welfare gains from the Jorgenson analysis were hardly cited in the public discussion. One reason could be that the technical sophistication behind the estimates were not appreciated by policymakers. Another could be that those who supported the tax reform did not need convincing, and those opposed to it would not be influenced by a tool they did not understand.

A particular area of tax policy that has attracted several CGE applications has been energy and environmental taxation. Energy and environmental issues became hot, both literally and figuratively, in the mid-1980s, just as CGE models were beginning to come on stream as standard tools of policy analysis. Furthermore, especially in the case of energy, the general-equilibrium effects are significant, as almost every industry and household in the economy uses energy (Hudson and Jorgenson (1974)). Similarly, with environmental issues such as climate change, intertemporal aspects, increasingly captured by CGE models, were the reason for using CGE models (Nordhaus (1990), Manne et al. (1995). The influence of these models on policy has mirrored the experience with other public-finance applications. When, as in energy models, other tools exist for corroborating CGE model results, the impact on policy has been substantial. Model results have informed U.S. energy policy, from gasoline taxes to greenhouse gases. In Europe, they have influenced nuclear energy policy (Bergman (1989)) and carbon taxes (Nieuwkoop (2001)). For example, in Sweden, an environmental CGE model has been used to develop the government's policy on climate change, including calculating the level of carbon taxation required to meet the Kyoto protocols (Nilsson (2001)).

Even when other tools are not available, CGE models have been influential when they represent a second-generation of a well-established model. For example, in Australia, the ORANI model was first developed in 1977. By the late 1990s, its successor, ORANI/MONASH and derivative models have played an important role in public debates on motor vehicle tariffs, textile tariffs, overall protection and sales taxes (Dixon (2001)).

CGE models have been used in tax policy beyond simply providing welfare calculations. For instance, the introduction of a value added tax, when (as in most cases) the VAT does not cover the entire economy, requires an CGE model to gauge the effects of the tax. Bovenberg's (1987) analysis of the difference between zero-rating and exemptions in a VAT regime, and its implications for tax incidence, had an effect on tax reforms in numerous countries, including Thailand (the country of Bovenberg's model). In the early 1990s, the Philippine government, despite a looming budget deficit, was reluctant to increase energy taxes because the poor spent a larger fraction of their income on energy than the rich. However, an CGE analysis by Devarajan and Hossain (1998) showed that the rich actually consumed more energy intensive goods, rendering the overall incidence of energy taxes broadly neutral. As a result, the Philippine government raised energy taxes and proceeded to enjoy an unprecedented period of economic growth. Finally, without relying on a particular empirical estimate, CGE models have played a role in shaping the structure of taxes. Perhaps the most significant has been the debate about

whether it is better to have uniform or variegated import tariffs. While there may be plenty of reasons to adopt uniform import tariffs, including administrative simplicity and resistance to lobbying, welfare maximization is not one of them, as pointed out in by several authors, using stylized models (Panagariya (1994), Hatta (1994), and confirmed by some CGE models (Dahl et al. (1994)).

There are also examples in the public finance literature where CGE models have been misused in policy debates. For example, during a national debate about South Africa's fiscal deficit, Gibson and Seventer (1994) published a column in the newspaper where they described simulations with their CGE model of South Africa that revealed that a slight increase in the fiscal deficit would increase the GDP growth rate. It turned out that this result was achieved by assuming that public spending "crowds in" private spending. However, the critical parameter that determines the extent of crowding in (the effect of pubic spending on private investment) was assumed to be quite large in the Gibson-Seventer model, with almost no empirical evidence to substantiate the assumption. It was not surprising, therefore, that they obtained this unusual result. Inasmuch as there were several models of the South African economy engaged in the debate, and the Gibson-Seventer model was alone in showing a positive GDP growth effect of an increase in the fiscal deficit, it was viewed as an extreme outlier and the newspaper column had little impact on the policy debate.

In sum, despite their natural affinity to analyze public-finance issues, CGE models have had a modest, but significant, influence on policy in the area. Where particular estimates from CGE models have been influential, they have usually been confirmed by studies from other methods. In other cases, CGE models have played the role of uncovering a particular mechanism that had not been apparent before. In such instances, the benefits of CGE models are enhanced when their application is timely, and when the mechanism being uncovered is simple enough to be communicated to policymakers.

Structural Adjustment

The oil price shocks of the 1970s caused severe disruptions in developing countries, requiring them to adjust their exchange rate and other macroeconomic policies in response. Many of these countries had distorted structural policies, such as trade restrictions, as well. The realization that the more distorted the structure, the worse the impact of the shock (Balassa (1983)), led some countries, with support of the World Bank and International Monetary Fund, to undertake structural adjustment programs aimed at restoring macroeconomic balance while reducing distortions in economic structure. In many ways, CGE models were ideally suited for evaluating such programs. They were able to portray the macroeconomic adjustments, such as a depreciation of the real exchange rate, alongside some of the microeconomic policies, such as reduction of trade barriers, in a consistent framework. Furthermore, inasmuch as the economic structure was changing, standard macro-econometric models, where parameters such as the import demand elasticity were based on historical relationships, were clearly inappropriate.

Accordingly, during the 1980s a reasonably large number of CGE models of developing countries were built, mostly under the sponsorship of the World Bank. While this effort led to a substantial amount of research only a few of these models actually ended up directly supporting policymakers.[22] One reason was that, at that time, the technology of building and running CGE models was not as developed as it is today, so that a modeling exercise would often take longer than the policymaker's time horizon. Another reason was that the data required to estimate or even calibrate these models were hard to come by, further delaying the process. Nevertheless, on at least three occasions, a second-generation model was used to underpin a structural adjustment program. In Yugoslavia, an CGE model showed the high costs in terms of output and foreign exchange of the country's system of foreign exchange allocation; a few months later the system was abandoned (Dewatripont et al. (1990)). The model of Turkey pointed out that the real exchange rate depreciation required in response to the combined oil-price and workers' remittance-shocks was much greater than what standard methods of calculation, such as the purchasing-power-parity method, would yield (Lewis and Urata (1984)). Although Turkey chose to devalue by a smaller amount, the new exchange rate was short-lived, the regime collapsed, and the lire eventually approached a level close to that predicted by the CGE model. Finally, in the early 1990s, most observers agreed that the CFA Franc, the currency of thirteen francophone African countries, was overvalued. Yet the standard PPP estimates yielded only mild degrees of overvaluation, since inflation in these countries was close to French inflation (the CFA Franc was pegged to the French Franc). However, a simple CGE-model calculation, taking into account the terms of trade shocks these countries faced in the late 1980s/early 1990s, showed the CFA Franc to be overvalued by almost 50 percent. On January 14, 1994, the CFA Franc was devalued by 50 percent (Devarajan (1997)).

The experience with structural adjustment demonstrates both the potential and limits of CGE models in informing policy. The potential lies in their ability to integrate the micro and macro elements of a structural adjustment program, especially as it affects the structure of trade and the real exchange rate. They also can provide some simple and easy-to-communicate lessons about adjustment policy, such as the formula for calculating the real exchange rate depreciation required to adjust to a terms of trade shock (Devarajan, Lewis and Robinson (1993)), or that trade reform without accompanying tax measures could undermine the intended benefits of that reform.

The limits of CGE models in analyzing issues of structural adjustment arise from the same source; namely, the problems of integrating micro and macro aspects in a single model. The neoclassical CGE framework, specifying simultaneous flow equilibria across many well-functioning markets in a single period and determining only relative prices, is an uneasy host for any analysis of the impact of macro shocks. The sorts of financial crises that typically accompany structural adjustment problems are inherently dynamic, working through changes in financial markets that, in the short run, throw product and factor markets out of long-run equilibrium. There is still an enormous theoretical gap between neoclassical general equilibrium models and short-run, dynamic macro models.

[22] Dervis, de Melo, and Robinson (1982), Gelb (1988), and Mitra (1992). The model of Turkey by Dervis, de Melo, and Robinson (1982, chapter 8) was used to support a World Bank mission to Turkey in 1978 to deal with their foreign exchange crisis that started in late 1977.

There is, of course, a vast literature on imposing macro adjustment mechanisms on CGE models in a "top down" manner, working with alternative "macro closures" of the CGE models.[23] A number of applied CGE models in this tradition have been used in policy debates. All these models embody some necessarily ad hoc assumptions about the operation of markets or behavior of agents in order to impose realistic macro behavior on the neoclassical CGE model. Critics such as Bell and Srinivasan (1984) and Srinivasan (1982) particularly disliked the mixing of macro and Walrasian elements in a CGE model.

On the other side, however, there is an active and growing literature using CGE models to provide the supply side in dynamic macro models—for example, see Agénor and Montiel (1996), and McKibbin and Sachs (1991).[24] There is also a literature which incorporates financial assets and asset markets in dynamic CGE models—see Bourguignon, de Melo and Suwa (1991) and the survey of this work by Robinson (1991), who relates it to the literature on macro closure. There is much interesting research underway from both the CGE and macro sides on developing better dynamic models that incorporate expectations, asset markets, financial instruments, and "nominal" variables, and also incorporate elements of the CGE specification of flow equilibria in product and factor markets, but in models that allow for unemployment.

Given the present state of research, however, policy analysis has usually proceeded with care, using separate CGE and macro models. The corroboration of CGE model results with those from other types of analysis, such as partial-equilibrium models or simple macro models, is one way of reassuring policymakers and their advisers that the common lessons coming from these models may be saying something important.

Income Distribution

The earliest CGE models of developing countries were designed to examine issues of income distribution.[25] Partly due to the complexity of these models, and partly because distributional issues left center stage in the policy arena during the debt-crisis and adjustment era of the 1980s, these models had little influence on policy. Nevertheless, the power of CGE models to illuminate distributional questions continues to make them the dominant tool. Beginning in the early 1990s, a series of CGE models examined the distributional consequences of adjustment policies (Sahn (1996), Bourguignon, de Melo, and Morrison (1991)). These models were the first to be able to specify a counterfactual in analyzing structural adjustment: how would the poor, say, have fared in the absence of adjustment policies. The fact that different models of different countries led to similar conclusions—the poor would have fared worse, although adjustment policies could be improved by better cushioning the poor from transitory effects—gave the model results some credence, especially in policy circles. The critics of adjustment policies now had to

[23] Any discussion of macro closure is well beyond the scope of this paper. A survey of the early debate is provided by Rattso (1982) and Robinson (1989).

[24] The McKibbin-Sachs model was used to evaluate the impact of NAFTA. See Manchester. and McKibbin, (1995) and Congressional Budget Office (1993).

answer to a set of rigorous, empirically-based results that contradicted what they were saying. While the scale of the debate and rhetoric did not subside, it became more nuanced and refined.

The most recent development in this arena is the introduction of country-owned poverty reduction strategies to underpin foreign aid and concessional lending from multilateral agencies. Since these strategies have to show the effects of all government policies (including macroeconomic and structural policies) on poverty, various CGE models are currently being used to develop these poverty reduction strategies.[26]While some of these have been used for the macroeconomic framework of these strategies, it is too early to tell whether CGE models' influence in poverty-reduction policy will be significant. There is also a growing literature on incorporating household survey data into an economywide framework provided by an CGE model. These microsimulation models appear to have potential for analyzing the links between macro policy choices and shocks, and the distribution of income at the household level.[27]

Conclusion

Responsible economists who do policy analysis believe in the obverse of Gresham's Law applied to policy debate—good numbers drive out bad numbers. While not always true, and acknowledging that a significant amount of policy formulation and debate does not rely on any numbers, experience in policy debates covering a variety of issues in a variety of countries supports qualified optimism—good analysis does matter and can affect policy choices. But, to be effective, economists must provide policy analysis that is relevant, transparent, and timely. Their methods and models must meet acceptable standards of validation. And finally, credibility in policy debates is greatly enhanced when a variety of different approaches and models are applied, and there is a consensus about the results. Robustness is more important than elegance.

It has been about forty years since the first applied or computable general equilibrium model was developed for Norway by Lief Johansen. Active work with these models started up in the 1970s, with continuing advances in theory, data, and computing power. CGE models have now become part of the standard toolkit of economists, and recent advances in software have made them accessible to anyone with undergraduate training in economics. They are widely used in academic research and in policy analysis, whenever it is necessary to consider the empirical implications of simultaneous equilibrium in a number of markets. In policy analysis, they are useful whenever policy changes affect a large share of economic activity or when it is important to consider changes in the sectoral structure of output, trade, demand, employment, and/or prices.

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[25] Adelman and Robinson (1978) and Lysy and Taylor (1979).
[26] Agénor et al. (2001), Devarajan and Go (2001).
[27] See Bourguignon, Fournier, and Gurgand (2001), Cogneau and Robilliard (2001), and Bourguignon, Robinson, and Robilliard (2002).

The CGE models used in policy work vary widely in size, complexity, and domain of applicability—but all are designed to analyze the links between policy choices and economic outcomes. The questions driving the policy debate also must drive the models. What an academic researcher considers to be the "relevant" questions may differ greatly from the questions considered important in the political arena. Furthermore, academics and policy analysts may have different time horizons, with the latter having to deliver advice that is timely. Finally, the policymaker is more concerned about getting consensus results from different analytical tools than with polishing and sharpening any one particular tool. Given the overriding need for relevance and timeliness in policy debates, it is hardly surprising that much of the work developing and using CGE models for policy analysis takes place in government agencies or research institutes.

In the past thirty years, there has been a healthy and productive tension between policy applications of CGE models and developments in theory, econometrics, and data. Sometimes the models have been ahead of the theory, incorporating ad hoc specifications to capture what are considered to be empirically important effects, or to achieve realism in applied models—a good example is the work on structural adjustment models. In many cases, the response of the research community has been to advance the theory, develop new data sources, improve estimation methods, and develop new solvers to meet the needs of modelers. On the other side, theoretical developments in modeling household behavior, dynamics, and the operation of markets are starting to show up in empirical models. With advances in software and computer capacity, the time gap between developing a new theory and implementing it in an empirical model is now quite short, so there is even more scope for productive collaboration between theorists, applied econometricians, and policy modelers. The numbers should get better, the policy debate will be better focused, and the result could be better policies.

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A Computable General Equilibrium Micro-Simulation Analysis of the Impact of Trade Policies on Poverty in Zimbabwe.1. Margaret Chitiga2 (University of Pretoria) Ramos Mabugu3 (University of Pretoria) Tonia Kandiero4 (National Treasury).Â to study the impact on poverty of a complete removal of tariffs in Zimbabwe. The model incorporates 14006 households derived from the 1995 Poverty Assessment Study Survey. This paperâ€™s novelty is that it is one among a small group of papers that incorporates individual households in the CGE model as opposed to having representative households. Therefore, computable general equilibrium (CGE) models have become the standard tool for the analysis of the economy-wide impacts of climate and trade policies on resource allocation and the associated implications for incomes of economic agents (see e.g. Weyant, 1999 for a recent survey on applications to climate policy; Shoven and Whalley, 1984 and 1992, provide an introduction to trade policy analysis). Keywords. Computable General Equilibrium Final Demand Computable General Equilibrium Model Social Account Matrix Substitution Elasticity. These keywords were added by machine and not by the Computable general equilibrium (CGE) models are a class of economic models that use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors. CGE models are also referred to as AGE (applied general equilibrium) models. A CGE model consists of equations describing model variables and a database (usually very detailed) consistent with these model equations. The equations tend to be neo-classical in spirit, often assuming cost-minimizing