1985

Hidden Challenges in Recent Applied General Equilibrium Exercises

John Whalley

ISSN 0228-4235
ISBN 0-7714-0634-7

THE CENTRE FOR THE STUDY OF INTERNATIONAL ECONOMIC RELATIONS

WORKING PAPER NO. 8511C

HIDDEN CHALLENGES IN RECENT APPLIED GENERAL EQUILIBRIUM EXERCISES

John Whalley

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

DEPARTMENT OF ECONOMICS
THE UNIVERSITY OF WESTERN ONTARIO
LONDON, CANADA
N6A 5C2

HIDDEN CHALLENGES IN RECENT APPLIED GENERAL EQUILIBRIUM EXERCISES

J. Whalley
University of Western Ontario

1 INTRODUCTION

The papers in this volume reflect the ways in which the emerging field of applied general equilibrium analysis has been evolving in recent years. The range and sophistication of policy applications has continued to expand, but at the same time the more fundamental issues in applying equilibrium theory to policy have hardly changed. Data remains poor; many of the key parameters in models are little more than best guesses; basic issues of model design (such as the use of a dynamic or static model) remain subjective judgement calls of the modeller.

This paper reviews some of these issues, and suggests that these problems are a reflection of wider difficulties facing the current generation of empirical economists raised in the post-war positivist tradition. The prerogative of the policy process establishes the need for numerical work with clear theoretical underpinnings, but the discipline of strict scientific principles (as in the natural sciences) always suggests that firm conclusions are premature.

Recent applied general equilibrium analyses seeking to contribute to policy debate therefore face a dilemma. If model results are dismissed as too inconclusive to form the basis for policy advice, then attempts to operationalize general equilibrium theory by selecting values for parameters of theoretical models may be of little significance for actual policy making. While general equilibrium theory will still

---

I am grateful to Rob Fisher, Michael Parkin, Herbert Scarf, and T.N. Srinivasan for comments on an earlier draft.

provide an organizational framework for thinking through the issues policy makers need to consider, on empirical grounds it may not be that useful for deciding the precise form any particular policy should take. On the other hand, if applied general equilibrium exercises are evaluated as useful for policy makers, then one has somehow to reconcile the large elements of subjectivity in the modelling process with the strong belief in hypothesis testing in modern economics. While valuable as an input into policy making, their place in modern empirical economics remains unclear.

2 Empiricism and Recent Applied General Equilibrium Analyses

Much of the recent literature on applied general equilibrium analysis has its origins in the development of general equilibrium computational techniques by Scarf in the 1960s, and in early attempts to use small dimensional numerical equilibrium models by Johansen (1960), Harberger (1962) and others for policy evaluation.

This field can, perhaps, best be understood as an attempt to use quasi realistic numerical general equilibrium models for policy and other analyses; an effort to bridge theory and practice. This mirrors the sense among many contemporary economists that much recent economic theory, including that in the general equilibrium area, has become too abstract, making it excessively remote from the practicalities of policy making. Since the level of analytical discussion within the policy making fraternity is often extremely limited, attempts such as those described in this volume (or those reviewed in the recent survey paper by Shoven and Whalley (1984)), have generally been applauded by theorists and welcomed (although somewhat more cautiously) by policy makers.

However, as the development of applied general equilibrium models has steadily progressed from merely demonstrating the feasibility of model construction and solution to serious application to policy, disquiet has grown in the economics profession over the appropriateness of using these models in this way. Recognizing the difficulties of parameter specification and the necessity for choosing between rival (and frequently contentious) assumptions, modellers have tended to emphasize the broad themes of their results rather than the precise numbers they produce. Builders of the tax and trade models, for instance, have stressed how their results challenge existing perceptions

as to the impacts of policies, which they often portray as driving the policy formation process. What seems to have prevailed in the use of these models thus far is a form of approximate numerical investigation, useful for exploring whether particular effects are large or small and signing the net outcome where different effects come into play.

Because of this rough empiricism, issues such as the frailness of the parameter specification, or the lack of statistical testing of the models are seen by some as detracting from their usefulness. Given the stress on broad themes of results, some have suggested that little has been learned from these models which could not have been guessed at as a possible outcome before the models were constructed, especially since the models do not provide a clear guide as to the actual outcome if real policy changes really occur.

A number of factors have contributed to this current sense of unease. One is that key parameter values, such as elasticities, play a pivotal role in all model calculations, but the amount that is known about which numerical values to use remains limited. As I have remarked on other occasions, it is quite extraordinary not only how little we know about numerical values of elasticities, given the significance that we attach to these in introductory courses in Economics, but how little we think we know changes as quickly as it does. In the savings area, for instance, 10 years ago, elasticities were thought to be small, 5 years ago they were thought to be large, and now once again they are thought to be smaller. For many years labour supply elasticities were thought to be small, and now they are in the process of being revised upwards. In the international trade area researchers commonly use import price elasticities in the neighbourhood of unity, even for small economies, even though estimates as high as nine appear in the literature. In many areas elasticity estimates differ in both size and sign, while for a number of the issues in which applied modellers are interested no relevant elasticity estimates exist. The choice of elasticity values in applied models is therefore frequently based on contradictory, or little or no empirical evidence. This obviously undermines confidence in model results.

Simultaneously, however, there are no more obviously attractive options available to policy makers who want to base their decisions on state of the art quantification of impacts of alternative policy changes on resource allocation and distribution. This is

especially the case if they wish to take into account relative price effects in a logically consistent way. Whether partial equilibrium, general equilibrium, or 'back of the envelope' quantification is used, key parameter values must be selected, and in so many of the areas involved in current policy debates, the applied econometrics literature is not particularly helpful.

Another problem modellers have been forced to confront is that of model preselection; the need to adopt key assumptions underlying the particular applied model to be used before any model calculations can begin. Both theoretical and applied modellers have long recognized the need for such assumptions as full employment and perfect competition in building general equilibrium models, and the constraints of tractibility have been recognized for many years as an inevitable part of the modelling process. However, in more recent work other equally important assumptions have come to the fore. These are now widely agreed to be capable of dramatically changing policy conclusions from models, but empirical evidence as to which of these alternative assumptions is more reasonable remains sparse.

An example is the set of possible assumptions one can make as to how international factor flows take place. In tax models, the choice between alternative assumptions substantially affects the incidence effects of capital income taxes. If capital is internationally mobile, it will not bear the burden of these taxes; but, in a closed economy, domestic capital owners can be affected. Another example arises with the treatment of time. In a static model, for example, a tax on consumption is distorting since capital goods are tax free, but this tax is non-distorting when analyzed in an intertemporal model.

Another issue in the applied models is the way the policies to be analyzed are represented. In the general equilibrium tax models, taxes have to be represented in model equivalent form, and yet for each tax there is substantial literature disagreement as to what is the most appropriate model 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 should be viewed as applying only to the equity return to capital rather than to the total return, i.e., as a tax on one financing instrument available to firms. This type of argument has even been used

by Stiglitz (1973) to argue that the tax is a lump sum tax, and, more recently, Gordon (1981) has argued that, in effect, the tax is a benefit-related tax. Whichever model treatment is adopted will change the results produced by the model. Numerical exercises obviously cannot settle disputes such as these, but some model treatment has to be adopted to analyze the policy issues; usually in full knowledge that the treatment followed may largely predetermine the conclusions.

Finally, 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 & Whalley (1984)). The issue is whether one can believe model results if there is no test of the reasonableness either of the model or of the parameter values.

This issue of testing is part of the wider issue of what we mean by empiricism in economics, to which I return to below. It is important to remember that, unlike econometric estimation, in determining parameter values by calibrating models to a single data observation, equilibrium features in the data to which calibration is applied are emphasized. Also, a characteristic of these procedures is that with enough flexibility in choice of the form of the deterministic model, it is usually possible to choose a model specification so as to exactly fit the data one is given. A purely deterministic equilibrium model in which consumers maximize utility and firms maximize profits can thus usually be constructed consistent with the observed data, provided that equilibrium conditions hold (such as demand and supply equalities).

The fact that models are not tested in a way which is acceptable to econometricians used to thinking in terms of models whose economic structure is simple but whose statistical structure is complex (rather than vice versa) should perhaps come as no surprise. In my opinion this concern with applied equilibrium exercises is not a criticism of applied general equilibrium models per se, but represents a challenge to our meaning of empiricism in modern economics, which has a wider relevance beyond these modelling exercises.

3 Precursors to Challenges

Prior to outlining the wider relevance of the experiences of recent modelling efforts to current debates on empiricism in economics, it is worth developing the links between the current applied general equilibrium exercises and some earlier debates on general equilibrium quantification.

My own opinion is that current concerns over applied general equilibrium exercises are largely a continuation of the debate on the feasibility of centralized calculation of a Pareto optimal allocation of resources. This debate was begun by Barone (1908), when he implicitly queried the operational significance of the Walrasian general equilibrium system. As is well known, the criticism by Marx of 19th century capitalism (in Das Kapital and the Communist Manifesto) did not provide a concrete blueprint as to how a socialist state was to be organized, and it was left to Barone and those who followed to deal with these questions. Barone posed the problem of socialist organization in terms of a Socialist Minister of Finance who must decide how to allocate state owned but scarce means of production. Barone's solution was to note that the only institutional change of any significance under socialism is the transfer of ownership of the means of production from private households to the state, and this should in no way affect the criterion one would adopt for defining allocative efficiency. Barone therefore suggested that a Socialist Minister of Finance should seek an allocation of resources which is Pareto efficient.

However, since resources are state owned, deciding on an appropriate allocation of resources involves solving the system of equations characterizing Pareto efficiency. We know this today to be the set of equations which also characterize a Walrasian competitive equilibrium. Barone was pessimistic about the feasibility of such an exercise, later termed by Wiles (1962) as "the perfect computation of perfect competition". He emphasized how it would be necessary to evaluate the potential profitability of all feasible activities, including those not currently in use. The number of such activities would be large, and Barone concluded that it would be a vast undertaking with a large informational requirement.

The debate initiated by Barone continued on into the 1920s and 1930s. von Mises (1924) questioned the feasibility of any meaningful economic calculation under socialism, stressing the organic nature of

capitalist activity as producers ruthlessly search for increased profit opportunities, and in the 1930s both Robbins (1934) and Hayek (1940) claimed that perfect computation under socialism was completely infeasible. Robbins raised the spectre of the millions of equations which would need to be solved, which, in turn, would be continually changing over time. An appropriate allocation of resources under socialism would not be able to be determined, and therefore socialism was regarded as infeasible as an institutional form which would achieve economic efficiency.

The response from Lange (1936), aimed largely at von Mises, was to suggest that it would not be necessary to make all the computations supposedly required under socialism. The Minister of Finance could decide upon the allocation of state owned resources in a decentralized market environment. Even though resources are state owned under socialism, Lange's point was that the state could rent them to private producers, and in this way find a market clearing rental price through a tatonnment procedure. This also proved to be the beginnings of the literature on market socialism.

What is interesting about these debates, is that in many ways they provided the impetus for the general equilibrium computational work in the 1960s, which in turn lead to the applied general equilibrium work of the 1970s and the 1980s. Schumpeter, in a famous quotation once described Walras' work on general equilibrium as the 'Magna Carta' of economics, and suggested that his main contribution lay in providing a broad tapestry outlining the interconnectedness of the economic system, rather than in generating a concrete operational framework for policy analysis. The debate on the feasibility of centralized computation of a Pareto optimal allocation under socialism and the debate today on the worth of applied general equilibrium models are continuations of this same discussion.

Recent work on applied general equilibrium has, however, also raised wider questions concerning the feasibility of centralized calculation not fully addressed in the original debate. In the 1960s Scarf took much of the inspiration from his work on general equilibrium computation from the debates of the 1930s, and largely equated the problems debated by Robbins and Lange and others with those of computational solution, i.e. the feasibility of solving the system of equations characterizing an equilibrium. Scarf himself thought that the

techniques he was developing would resolve the debate, and that once computation was shown to be possible it would open the way to wider developments with ultimate application both to the problem of centralized resource allocation discussed by Barone, von Mises, Robbins and others, and to that of policy evaluation in market economies.

While not directed at problems of central planning, recent applied general equilibrium work has nonetheless been concerned with problems closely related to those discussed in the socialist debate, i.e., policy evaluation in complex market-oriented economies where the alternative policy regimes to be considered each have many subtleties and important details whose impacts are not immediately apparent. What the applied models of today have been seeking is the same thing as the earlier socialist calculators; namely, to numerically determine the characteristics of an unobservable general equilibrium. This time around, its form is different. The equilibrium behaviour of a market economy under changes in economic policies is the issue rather than resource allocation in a centrally planned economy; and its implications are broader because economics has developed so much more since the 1930s.

In my opinion, recent applied equilibrium work has demonstrated that there is much more to the issue of feasibility of centralized calculation than has appeared either in the debates of the 1930s, or was assumed in the computational work of the 1960s. Issues of computational solution no longer dominate the literature. Instead, numerical specification is widely agreed to be the critical issue, since this preceeds computation. Before one solves the system of Paretian equations, one needs to write down the equations with specified parameter values.

In turn, the particular form for the Paretian equations has to be carefully specified, since model choice can substantially affect the conclusions from the analysis. The abstract general equilibrium formulation in Arrow and Debreu (1954), cleverly extended to include time through the subscripting of commodities provides an elegant general framework. Unfortunately, this is not sufficiently concrete for policy makers in complex economic systems making choices between various options. The need to adopt particular specifications in applied models for government expenditures, investment, foreign trade, tax policies, factor supplies, intertemporal behaviour, and a range of further complications is immediately apparent to anyone beginning to work

with these models, and yet the treatments adopted may crucially affect the policy conclusion.

The applied general equilibrium work of the 1970s and 1980s has thus expanded the whole debate on the feasibility of centralized calculation of Pareto Optimality to one which also includes the specification of the underlying equation system. From a mechanical point of view, solution is possible. However, the sensitivity of results to assumptions and parameter values (especially elasticities), and the fact that the applied general equilibrium models are not tested are sources of concern and in some circles outright skeptism. The same arguments can, of course, also be made with respect to centralized calculations of a Pareto optimal allocation under socialism.

These issues therefore bring us back to Schumpeter and hence to Walras. The basic issue is whether there is anything more than an organizational framework implicit in the Walrasian economic system, or is there something which can be made more concrete and ultimately useful to policy makers at a practical rather than conceptual level. Recent applied general equilibrium modelling activity has forced us to face this question more forcefully than perhaps any time in the development of economics over the last 100 years, and what may be at stake is the nature of empiricism in economics itself rather than just the applied models.

My own view is that economists have perhaps tended to too easily link positivism and empirical economics, influenced in part by Friedman's essay in 1947, even though recent work by Frazer & Boland (1983) has suggested that Friedman's essay may be closer to instrumentalism than positivism. The positivists of the 1950s and 60s, of course, stressed the idea that economics is a subject much akin to the natural sciences where theory followed by hypothesis testing is the only way to proceed. Other developments in the 1940s have gone less well recognized, particularly the rival characterization of economics as a policy science (see Laswell (1951)).

Under this competing view of the world, it is impossible to definitively test propositions in the policy sciences because of the absence of controlled repeatable laboratory experiments. Policy sciences have to deal with the imperative of the policy process and are in an inevitable state of permanent flux, with schools who disagree (sometimes violently) over various propositions. The imperative of the policy

process generates the need for decisions, and decision making will inevitably involve incomplete data, choosing between competing hypotheses, and subjective judgement. The contribution of policy sciences is not seen as establishing empirical laws as in the natural sciences but in raising the level of policy debate, increasing the level of understanding of how institutions may affect outcomes, challenging received wisdom, generating such data as may be relevant, and ultimately offering judgements on issues where there may be conflicting claims. Through such an adversarial process, the hope is that the policy-decision-making process will be improved. Even though definitive empirical evidence may not be at hand, such enterprises are not ruled out as unworthy scholarly activity. Indeed, they become an integral part of the policy process.

This approach both to policy making and the use of modelling in economics is something which I believe most of the applied general equilibrium modellers, many of whom were educated in the positivist tradition of the 1960s and 1970s, have inadvertently discovered for themselves. What we are witnessing in this field is a rediscovery of relevance by positivists previously seeking objective truth, and the implications of this for a generation of mathematically trained economists who have not been used to thinking in such subjective terms.

4 Challenges become Criticisms

It should by now be clear that my own view of recent applied general equilibrium analyses is that they are part of a wider challenge to empiricism in economics. This has both smaller and larger dimensions.

As far as the smaller challenges go, the problems of elasticities and other parameter values obviously suggest a reorientation of much of our empirical work in economics away from hypothesis testing and towards parameter generation. Parameter generation in recent years has been downplayed by econometricians in favour of hypothesis testing, and in the elasticity area this has become increasingly apparent to the applied modellers.

For instance, much of the work on systems of demand functions in the 1960s and 1970s has concentrated on system-wide estimation problems without concentrating in any sustained way on providing better estimates of elasticity parameters. The last survey piece on price elasticities that I have been able to find is by Hirsch in 1951. The

need is for empirical parameters more than tests of the theory. The tradition from Schultz and others from the 1930s of an empirical concern with parameter values per se, rather than with testing hypotheses seems to have been lost in recent econometric work, and yet the need for more reliable parameter values has been clearly revealed by the applied models.

A further challenge is whether it makes sense to continue to develop theoretical general equilibrium theory at such a high level of mathematical abstraction as has been true of recent work. In having to confront both current policy problems and the difficulties of building models to represent actual economies, the applied general equilibrium models have not encountered mathematical difficulties, but rather the need for special kinds of closing rules and more institutional features in their models. This requirement for closing rules has forced some of the models to run dangerously ahead of economic theory. Ad hoc procedures have at times been used whose properties are not well known. The challenge to theorists is to think in terms of more specificity as well as more generality in their models, and to trace through the implications of these closing rules and the specifications of institutional arrangements for model behaviour.

There are, however, a wider set of challenges implicit in these modelling exercises. The first is the challenge to positivism in economics to which I have already alluded. One could perhaps characterize current applied models as part of a move towards a new positivism in economics. This positivism is not of the traditional Popperian type where one attempts to positively test hypotheses, but positivism in the sense of allowing for positive judgements on policy options to be made by modellers. Models are to be used by analytically trained economists attempting to improve the state of the world. Judgement is offered rather than withheld because statistical test offers no absolute guide. The inability to definitively settle a debate does not preclude the analyst drawing out what he sees as the implications of his model for possible policy changes. Popperian positivism, which to my taste has resulted in so many superbly analytically trained economists to a large degree abdicating from the policy process, and even arguing that economists have nothing or little to say about policy because they cannot definitively settle their disputes, is therefore downplayed in the use of these models. The group of economists using these models do not show the same hesitations as the generation ahead of them in stating

their own judgements as to the desirability of possible policy changes based on their economic modelling. This, of course, is not without its dangers, since anything may become permissable once subjective judgement is widely accepted as part of the economist's role. The trend, however, seems to be clearly there in recent applied equilibrium work, and the challenge to the next generation of modellers will be how to monitor and evaluate the use of judgement which I believe will inevitably increase in this and other areas of economics as the perogative of policy process is more fully acknowledged.

Related to all this is the set of issues relating to the meaning of empiricism in economics. Applied general equilibrium models are complex in their economic structure and have demanding data requirements, but are statistically simple. Most of the models cannot be tested in a conventional sense because of their dimensionality. The contrast with modern econometric work is therefore obvious. Instead of models of increasing statistical richness in which the economic structure is downplayed, we now are witnessing an upsurge of interest in empirically based models of greater economic complexity than previously, in which concerns over economic structure dominate concerns over statistical structure. Taken to the extreme these applied general equilibrium models are such that a deterministic fit of models to single or even multiple data points becomes feasible, in which case statistical testing makes little sense.

Schumpeter's test of Walras was whether or not his general equilibrium approach had any operational significance. If the conclusion from recent applied general equilibrium models is that they have such weak empirical foundations that there is little value to policy makers, one perhaps has to go further and question whether there is much operational significance to general equilibrium theory itself. During the last 30 or 40 years, economics often has been presented as a discipline much akin to natural sciences with both strong logical and ultimately operational foundations. This I see at stake in the verdict on the worth of applied general equilibrium exercises. Since the essence of theory is simplification which in an exact sense must be wrong, the constraints of tractibility perhaps dictate that economic theory can ultimately be only an organizational framework for thinking about economic problems. This is clearly valuable activity, but whether we think that economic theory is merely philosophising or building the

foundation for an empirically based science makes a large difference to the way in which economic theorists proceed.

These issues also raise questions concerning the way we use models. Do we rely only on statistical tests or do we allow judgement to enter? Are we willing to examine our own perceptions of ourselves and our social institutions, in the belief that this is what shapes our policy making, rather than limit ourselves merely to attempting to track an often illusive objective reality.

My own belief is that the current applied general equilibrium models do generate insights and findings of interest to policy makers and clearly demonstrate both their relevance and the wider usefulness of economic theory. I also believe that much of the academic community and even more of the policy community remains skeptical, and that modellers must respond to this challenge of their own relevance more forcefully, and explain exactly what they see themselves as doing.

5 Future Directions for Applied General Equilibrium Analysis

Given the tone of the discussion thus far, a useful conclusion to this introductory chapter may be to lay out some of the implications of this line of argument for the future development of applied general equilibrium analysis. If I am right, and if the relevance and policy applicability of these models mark a new departure in equilibrium modelling, what types of future developments make sense?

Firstly, a change already seems to be underway in the evolution of models from the current state where there are a small number of larger scale multipurpose models (involving perhaps 20 to 30 sectors and multiple household groups) to one where there are many more models, each more issue specific and smaller. My belief is that in the future there will be less concern with developing general purpose modelling capabilities than in the last decade. The models developed in the 1970s focused on general purpose modelling capabilities partly as a continuation of the computational work of the 1960s. These models partially sought to demonstrate the feasibility of constructing applied general equilibrium models by showing they could handle much larger dimensions than theoretical models.

Model construction and solution have now both been shown to be possible. However, in applying these general purpose models to particular policy [illegible]ions, a substantial amount of model detail must be

carried along which is not directly applicable to the policy question at hand. In turn general purpose models applied to specific questions often need to be redesigned to target the model to the issues under investigation. As a result, recent modelling is focusing more on smaller scale issue specific models, and the themes emerging from the structure rather than the precise numbers are providing the main model output.

Another development is what, for want of a better term, I label general equilibrium econometrics. Much of the work in applied econometrics in the 1970s seems to be concerned with micro-econometrics, estimating more complex models of optimizing behaviour of households and firms than previously (such as with non-linear budget constraints). To those raised on general equilibrium theory, it is surprising that little of this activity has been taken further and used to analyze general equilibrium systems from an econometric point of view. This is, after all, the most appropriate vehicle for generating better parameter values for the equilibrium systems that modellers are now trying to solve. The basic two-person pure-exchange-economy model of economic equilibrium, for instance, emphasized in basic economic texts, has (so far as I know) never been econometrically estimated.

A further direction which also seems to be emerging is an expansion in the coverage of models to include such policy features as quantity constraints (in some cases with corresponding rent seeking activity). Such models are now widely perceived as generating more significant welfare costs of distortions than the more traditional models of tax and trade policies, because in equilibrium resources may be unused or wasted. Put simply, Krueger rectangles are bigger than Harberger triangles. Thus, a much more expansive analysis of the costs of distortions through applied general equilibrium models seems to be underway.

Other developments are occuring within the modelling fraternity itself. Modellers often complain about the necessity of being a jack of all trades. When involved in modelling activity in the applied general equilibrium area, one has to be familiar with general equilibrium theory, to be able to program (or at least communicate with programmers), to be familiar with data and be able to manipulate and convert it into a model admissible form, to be conversant with literature estimates of key parameters (including elasticities), to have a clear sense of policy issues and institutional structure, and to be

able to interpret results. With repeated modelling activity, one also has to be something of a librarian to be able to archive and file away results. When confronted with this range of activities it is perhaps not surprising that it becomes difficult for graduate students and others to enter this area. As a result, research efforts are being focussed more and more on modelling teams similar to those which have formed the basis for research work in the natural sciences.

Finally, it does seem clear to me that we are headed towards an increased recognition of the inevitability of subjectivity in both design and use of empirically based economic models. Indeed, I would go so far as to query whether we should even think in terms of models of particular economies or particular policy issues as constructed in isolation from the individual doing the modelling. Since the modellers have to make all manner of judgements including the orientation of the model, how they chose parameter values, and which features of results they explore and report, the models should to some extent be seen as an extension of the mind of the modellers.

Ultimately, the future for applied general equilibrium analysis seems likely to me to be determined by the response of the much larger group of non modellers to the challengers outlined in this paper. Time alone will tell whether these models lead to a new relevance and changed empiricism in economics, or merely to further frustrations with numerical modelling and the murky world of policy making.

References

Arrow, K.J. & Debreu, G. (1954). Existence of an equilibrium for a competitive economy. Econometrica, 22, 265-290.

Barone, E. (1908). Il Ministerio della Produzione nello stato colletivista. Giornale deqli Economistie Rivista di Statistica. (English translation In Collectivist Economic Planning, ed. F.A. Hayek, London, 1935).

Frazer, W.J. Jr. & Boland, L.A. (1983). An Essay on the Foundations of Friedman's Methodology. The American Economic Review, 73, no. 1, 129-144.

Friedman, (1947). Essays in Positive Economics, University of Chicago Press.

Grodon, R.H. (1981). Taxation of Corporate Capital Income: Tax Revenues vs. Tax Distortions. Massachusetts: National Bureau of Economic Research Inc., Working Paper Series No. 687.

Harberger, A.C. (1962). The Incidence of the Corporation Income Tax. Journal of Political Economy. 70, no. 3, 215-240.

Hayek, F.A. (1940). Socialist calculation: the competitive solution. Economica 7, 125-149.

Hirsch, W.Z. (1951). A Survey of Price Elasticities. Review of Economic Studies, 19, 50-60.

Johansen, L. (1960). A multi-sectoral study of economic growth. Amsterdam: North-Holland.

King, M.A. & Fullerton, D. (1984). The Taxation of Income from Capital: A Comparative Study of the United States, the United Kingdom, Sweden, and West Germany. (eds.) University of Chicago Press for the National Bureau of Economic Research.

Krueger, A.O. (1974). The Political Economy of the Rent-Seeking Society. American Economic Review, 64, 291-303.

Lange, O. (1936). On the economic theory of socialism. Review of Economic Studies, 4, 53-71, 123-142. Reprinted in O. Lange and F.M. Taylor, On the Economic Theory of Socialism, ed. B.E. Lippincott. Minneapolis: University of Minnesota Press, 1938.

Laswell, H.D. (1951). The Policy Orientation. In The Policy Sciences, ed. D. Lerner & H.D. Lasswell, pp. 3-15. Stanford: Stanford University Press.

Mansur, A. & Whalley, J. (1984). Numerical specification of applied general equilibrium models: estimation, calibration and data. In Applied General Equilibrium Analysis, ed. H.E. Scarf & J.B. Shoven, Cambridge University Press.

Robbins, L.C. (1934). The Great Depression. London: Macmillan.

Scarf, H. (1973). The Computation of Economic Equilibria, New Haven: Yale University Press.

———— (1960). Some examples of global instability of the competitive equilibrium. International Economic Review, 1, 157-172.

Shoven, J.B. & Whalley, J. (1984). Applied General Equilibrium Models of Taxation and International Trade. Journal of Economic Literature, 22, no. 3, 1007-1051.

Stiglitz, J.E. (1973). Taxation, corporate financial policy, and the cost of capital. Journal of Public Economics, 2, no. 1, 1-34.

von Mises, L. (1936). Socialism: An Economic and Sociological Analysis, transalted from the German by Jacque Kuhane, London: Johnathan Cape.

Whalley, J. (1984). "Trade, Industrial Policy, and Canadian manufacturing", A Review article of a monograph by Richard Harrs. Canadian Journal of Economics, LXVI, no. 2.

Wiles, P.J.D. (1962). The Political Economy of Communism. Oxford: Basil Blackwell.

1981

8101C Markusen, James R. Factor Movements and Commodity Trade as Compliments: A Survey of Some Cases.

8102C Conlon, R.M. Comparison of Australian and Canadian Manufacturing Industries: Some Empirical Evidence.

8103C Conlon, R.M. The Incidence of Transport Cost and Tariff Protection: Some Australian Evidence.

8104C Laidler, David. On the Case for Gradualism.

8105C Wirick, Ronald G. Rational Expectations and Rational Stabilization Policy in an Open Economy

8106C Mansur, Ahsan and John Whalley Numerical Specification of Applied General Equilibrium Models: Estimation, Calibration, and Data.

8107C Burgess, David F., Energy Prices, Capital Formation, and Potential GNP

8108C D SU Jimenez, E. and Douglas H. Keare. Housing Consumption and Income in the Low Income Urban Setting: Estimates from Panel Data in El Salvador

8109C D SU Whalley, John Labour Migration and the North-South Debate

8110C Manning, Richard and John McMillan Government Expenditure and Comparative Advantage

8111C Freid, Joel and Peter Howitt Why Inflation Reduces Real Interest Rates

1982

8201C Manning, Richard and James R. Markusen Dynamic Non-Substitution and Long Run Production Possibilities

8202C Feenstra, Robert and Ken Judd Tariffs, Technology Transfer, and Welfare

8203C Ronald W. Jones, and Douglas D. Purvis: International Differences in Response to Common External Shocks: The Role of Purchasing Power Parity

8204C James A Brander and Barbara J. Spencer: Industrial Strategy with Committed Firms

8205C Whalley, John, The North-South Debate and the Terms of Trade: An Applied General Equilibrium Approach

8206C Roger Betancourt, Christopher Clague, Arvind Panagariya CAPITAL UTILIZATION IN GENERAL EQUILIBRIUM

8207C Mansur, Ahsan H, On the Estimation of Import and Export Demand Elasticities and Elasticity Pessimism.

8208C Whalley, J. and Randy Wigle PRICE AND QUANTITY RIGIDITIES IN ADJUSTMENT TO TRADE POLICY CHANGES: ALTERNATIVE FORMULATIONS AND INITIAL CALCULATIONS

8209C DSU Jimenez, E. SQUATTING AND COMMUNITY ORGANIZATION IN DEVELOPING COUNTRIES: A CONCEPTUAL FRAMEWORK

1982

8210C Grossman, G.M. INTERNATIONAL COMPETITION AND THE UNIONIZED SECTOR

8211C Laidler,D. FRIEDMAN AND SCHWARTZ ON MONETARY TRENDS - A REVIEW ARTICLE

8212C Imam, M.H. and Whalley, J. INCIDENCE ANALYSIS OF A SECTOR SPECIFIC MINIMUM WAGE IN A TWO SECTOR HARRIS-TODARO MODEL.

8213C Markusen, J.R. and Melvin, J.R. THE GAINS FROM TRADE THEOREM WITH INCREASING RETURNS TO SCALE.

8214C INDUSTRIAL ORGANIZATION AND THE GENERAL EQUILIBRIUM COSTS OF PROTECTION IN SMALL OPEN ECONOMIES.

8215C Laidler, D. DID MACROECONOMICS NEED THE RATIONAL EXPECTATIONS REVOLUTION?

8216C Whalley, J. and Wigle, R. ARE DEVELOPED COUNTRY MULTILATERAL TARIFF REDUCTIONS NECESSARILY BENEFICIAL FOR THE U.S.?

8217C Bade, R. and Parkin, M. IS STERLING M3 THE RIGHT AGGREGATE?

8218C Kosch, B. FIXED PRICE EQUILIBRIA IN OPEN ECONOMIES.

1983

8301C Kimbell, L.J. and Harrison, G.W. ON THE SOLUTION OF GENERAL EQUILIBRIUM MODELS.

8302C Melvin, J.R. A GENERAL EQUILIBRIUM ANALYSIS OF CANADIAN OIL POLICY.

8303C Markusen, J.R. and Svensson, L.E.O. TRADE IN GOODS AND FACTORS WITH INTERNATIONAL DIFFERENCES IN TECHNOLOGY.

8304C Mohammad, S. Whalley, J. RENT SEEKING IN INDIA: ITS COSTS AND POLICY SIGNIFICANCE.

8305C DSU Jimenez, E. TENURE SECURITY AND URBAN SQUATTING.

8306C Parkin, M. WHAT CAN MACROECONOMIC THEORY TELL US ABOUT THE WAY DEFICITS SHOULD BE MEASURED.

8307C Parkin, M. THE INFLATION DEBATE: AN ATTEMPT TO CLEAR THE AIR.

8308C Wooton, I. LABOUR MIGRATION IN A MODEL OF NORTH-SOUTH TRADE.

8309C Deardorff, A.V. THE DIRECTIONS OF DEVELOPING COUNTRIES TRADE: EXAMPLES FROM PURE THEORY.

8310C Manning, R. ADVANTAGEOUS REALLOCATIONS AND MULTIPLE EQUILIBRIA: RESULTS FOR THE THREE-AGENT TRANSFER PROBLEM.

8311C DSU Mohammad, S. and Whalley, J. CONTROLS AND THE INTERSECTORAL TERMS OF TRADE IN INDIA.

8312C Brecher, Richard A. and Choudhri, Ehsan U. NEW PRODUCTS AND THE FACTOR CONTENT OF INTERNATIONAL TRADE.

8313C Jones, R.W., Neary, J.P. and Ruane, F.P. TWO-WAY CAPITAL FLOWS: CROSS-HAULING IN A MODEL OF FOREIGN INVESTMENT.

8314C DSU Follain, J.R. Jr. and Jimenez, E. THE DEMAND FOR HOUSING CHARACTERISTICS IN DEVELOPING COUNTRIES.

8315C Shoven, J.B. and Whalley, J. APPLIED GENERAL EQUILIBRIUM MODELS OF TAXATION AND INTERNATIONAL TRADE.

8316C Boothe, Paul and Longworth David. SOME IRREGULAR REGULARITIES IN THE CANADIAN/U.S. EXCHANGE MARKET.

8317C Hamilton, Bob and Whalley, John. BORDER TAX ADJUSTMENTS AND U.S. TRADE.

8318C Neary, J. Peter, and Schweinberger, Albert G. FACTOR CONTENT FUNCTIONS AND THE THEORY OF INTERNATIONAL TRADE.

8319C Veall, Michael R. THE EXPENDITURE TAX AND PROGRESSIVITY.

8320C Melvin, James R. DOMESTIC EXCHANGE, TRANSPORTATION COSTS AND INTERNATIONAL TRADE.

8321C Hamilton, Bob and Whalley, John. GEOGRAPHICALLY DISCRIMINATORY TRADE ARRANGEMENTS.

8322C Bale, Harvey Jr. INVESTMENT FRICTIONS AND OPPORTUNITIES IN BILATERAL U.S.-CANADIAN TRADE RELATIONS.

8323C Wonnacott, R.J. CANADA-U.S. ECONOMIC RELATIONS—A CANADIAN VIEW.

8324C Stern, Robert M. U.S.-CANADIAN TRADE AND INVESTMENT FRICTIONS: THE U.S. VIEW.

8325C Harrison, Glenn, H. and Kimbell, Larry, J. HOW ROBUST IS NUMERICAL GENERAL EQUILIBRIUM ANALYSIS?

8326C Wonnacott, R.J. THE TASK FORCE PROPOSAL ON AUTO CONTENT: WOULD THIS SIMPLY EXTEND THE AUTO PACT, OR PUT IT AT SERIOUS RISK?

8327C Bradford, James C. CANADIAN DEFENCE TRADE WITH THE U.S.
Conklin, David. SUBSIDY PACTS.
Rugman, Alan M. THE BEHAVIOUR OF U.S. SUBSIDARIES IN CANADA: IMPLICATIONS FOR TRADE AND INVESTMENTS.

1983

8328C Boyer, Kenneth D. U.S.-CANADIAN TRANSPORTATION ISSUES.

8329C Bird, Richard M. and Brean, Donald J.S. CANADA-U.S. TAX RELATIONS: ISSUES AND PERSPECTIVES.

8330C Moroz, Andrew R. CANADA-UNITED STATES AUTOMOTIVE TRADE AND TRADE POLICY ISSUES.

8331C Grey, Rodney de C. and Curtis, John. INSTITUTIONAL ARRANGEMENTS FOR U.S.-CANADIAN NEGOTIATIONS. PART I: CANADA-U.S. TRADE AND ECONOMIC ISSUES: DO WE NEED A NEW INSTITUTION? PART II: INSTITUTIONAL ARRANGEMENTS FOR MANAGING THE CANADA-U.S. ECONOMIC RELATIONSHIP.

1984

8401C Harrison, Glenn W. and Manning, Richard. BEST APPROXIMATE AGGREGATION OF INPUT-OUTPUT SYSTEMS.

8402C Parkin, Michael. CORE INFLATION: A REVIEW ESSAY.

8403C Blomqvist, Åke, and McMahon, Gary. SIMULATING COMMERICAL POLICY IN A SMALL, OPEN DUAL ECONOMY WITH URBAN UNEMPLOYMENT: A GENERAL EQUILIBRIUM APPROACH.

8404C Wonnacott, Ronald. THE THEORY OF TRADE DISCRIMINATION: THE MIRROR IMAGE OF VINERIAN PREFERENCE THEORY?

8405C Whalley, John. IMPACTS OF A 50% TARIFF REDUCTION IN AN EIGHT-REGION GLOBAL TRADE MODEL.

8406C Harrison, Glenn W. A GENERAL EQUILIBRIUM ANALYSIS OF TARIFF REDUCTIONS.

8407C Horstmann, Ignatius and Markusen, James R. STRATEGIC INVESTMENTS AND THE DEVELOPMENT OF MULTINATIONALS.

8408C Gregory, Allan W. and McCurdy, Thomas H. TESTING THE UNBIASEDNESS HYPOTHESIS IN THE FORWARD FOREIGN EXCHANGE MARKET: A SPECIFICATION ANALYSIS.

8409C Jones, Ronald W. and Kierzkowski, Henryk. NEIGHBORHOOD PRODUCTION STRUCTURES WITH APPLICATIONS TO THE THEORY OF INTERNATIONAL TRADE.

8410C Weller, Paul and Yano, Makoto. THE ROLE OF FUTURES MARKETS IN INTERNATIONAL TRADE: A GENERAL EQUILIBRIUM APPROACH.

8411C Brecher, Richard A. and Bhagwati, Jagdish N. VOLUNTARY EXPORT RESTRICTIONS VERSUS IMPORT RESTRICTIONS: A WELFARE-THEORETIC COMPARISON.

8412C Ethier, Wilfred J. ILLEGAL IMMIGRATION.

8413C Eaton, Jonathon and Gene M. Grossman. OPTIMAL TRADE AND INDUSTRIAL POLICY UNDER OLIGOPOLY.

8414C Wooton, Ian. PREFERENTIAL TRADING AGREEMENTS - A 3xn MODEL.

8415C Parkin, Michael. DISCRIMINATING BETWEEN KEYNESIAN AND CLASSICAL THEORIES OF THE BUSINESS CYCLE: JAPAN 1967-1982

8416C Deardorff, Alan V. FIRless FIRwoes: HOW PREFERENCES CAN INTERFERE WITH THE THEOREMS OF INTERNATIONAL TRADE.

8417C Greenwood, Jeremy. NONTRADED GOODS, THE TRADE BALANCE, AND THE BALANCE OF PAYMENTS.

8418C Blomqvist, Ake and Sharif Mohammad. CONTROLS, CORRUPTION, AND COMPETITIVE RENT-SEEKING IN LDCs.

8419C Grossman, Herschel I. POLICY, RATIONAL EXPECTATIONS, AND POSITIVE ECONOMIC ANALYSIS.

8420C Garber, Peter M. and Robert G. King. DEEP STRUCTURAL EXCAVATION? A CRITIQUE OF EULER EQUATION METHODS.

8421C Barro, Robert J. THE BEHAVIOR OF U.S. DEFICITS.

8422C Persson, Torsten and Lars E.O. Svensson. INTERNATIONAL BORROWING AND TIME-CONSISTENT FISCAL POLICY.

8423C Obstfeld Maurice. CAPITAL CONTROLS, THE DUAL EXCHANGE RATE, AND DEVALUATION.

8424C Kuhn, Peter. UNION PRODUCTIVITY EFFECTS AND ECONOMIC EFFICIENCY.

8425C Hamilton, Bob and John Whalley. TAX TREATMENT OF HOUSING IN A DYNAMIC SEQUENCED GENERAL EQUILIBRIUM MODEL.

8426C Hamilton, Bob, Sharif Mohammad, and John Whalley. RENT SEEKING AND THE NORTH-SOUTH TERMS OF TRADE.

8427C Adams, Charles and Jeremy Greenwood. DUAL EXCHANGE RATE SYSTEMS AND CAPITAL CONTROLS: AN INVESTIGATION.

8428 Loh, Choon Cheong and Michael R. Veall. A NOTE ON SOCIAL SECURITY AND PRIVATE SAVINGS IN SINGAPORE.

8429 Whalley, John. REGRESSION OR PROGRESSION: THE TAXING QUESTION OF INCIDENCE ANALYSIS.

8430 Kuhn, Peter. WAGES, EFFORT, AND INCENTIVE-COMPATIBILITY IN LIFE-CYCLE EMPLOYMENT CONTRACTS.

8431 Greenwood, Jeremy and Kent P. Kimbrough. AN INVESTIGATION IN THE THEORY OF FOREIGN EXCHANGE CONTROLS.

8432 Greenwood, Jeremy and Kent P. Kimbrough. CAPITAL CONTROLS AND THE INTERNATIONAL TRANSMISSION OF FISCAL POLICY.

8433 Nguyen, Trien Trien and John Whalley. EQUILIBRIUM UNDER PRICE CONTROLS WITH ENDOGENOUS TRANSACTIONS COSTS.

8434 Adams, Charles and Russell S. Boyer. EFFICIENCY AND A SIMPLE MODEL OF EXCHANGE RATE DETERMINATION.

8435 Kuhn, Peter. UNIONS, ENTREPRENEURSHIP, AND EFFICIENCY.

8436 Hercowitz, Zvi and Efraim Sadka. ON OPTIMAL CURRENCY SUBSTITUTION POLICY AND PUBLIC FINANCE.

8437 Lenjosek, Gordon and John Whalley. POLICY EVALUATION IN A SMALL OPEN PRICE TAKING ECONOMY: CANADIAN ENERGY POLICIES.

8438 Aschauer, David and Jeremy Greenwood. MACROECONOMIC EFFECTS OF FISCAL POLICY.

8439C Hercowitz, Zvi. ON THE DETERMINATION OF THE EXTERNAL DEBT: THE CASE OF ISRAEL.

8440C Stern, Robert M. GLOBAL DIMENSIONS AND DETERMINANTS OF INTERNATIONAL TRADE AND INVESTMENT IN SERVICES.

8441C Deardorff, Alan V. COMPARATIVE ADVANTAGE AND INTERNATIONAL TRADE AND INVESTMENT IN SERVICES.

8442C Daly, Donald J. TECHNOLOGY TRANSFER AND CANADA'S COMPETITIVE PERFORMANCE.

8443C Grey, Rodney de C. NEGOTIATING ABOUT TRADE AND INVESTMENT IN SERVICES.

8444C Grossman, Gene M. and Carl Shapiro. NORMATIVE ISSUES RAISED BY INTERNATIONAL TRADE IN TECHNOLOGY SERVICES.

8445C Chant, John F. THE CANADIAN TREATMENT OF FOREIGN BANKS: A CASE STUDY IN THE WORKINGS OF THE NATIONAL TREATMENT APPROACH.

8446C Aronson, Jonathan D. and Peter F. Cowhey. COMPUTER, DATA PROCESSING, AND COMMUNICATION SERVICES.

8447C Feketekuty, Geza. NEGOTIATING STRATEGIES FOR LIBERALIZING TRADE AND INVESTMENT IN SERVICES.

8448C Harrison, Glenn, W. and E.E. Rutstrom. THE EFFECT OF MANUFACTURING SECTOR PROTECTION ON ASEAN AND AUSTRALIA: A GENERAL EQUILIBRIUM ANALYSIS.

8501C

8502C Horstmann, Ignatius and James R. Markusen. UP YOUR AVERAGE COST CURVE: INEFFICIENT ENTRY AND THE NEW PROTECTIONISM.

8503C Gregory, Allan W. TESTING INTEREST RATE PARITY AND RATIONAL EXPECTATIONS FOR CANADA AND THE UNITED STATES.

8504C Kuhn, Peter and Ian Wooton. INTERNATIONAL FACTOR MOVEMENTS IN THE PRESENCE OF A FIXED FACTOR.

8505C Wong, Kar-yiu. GAINS FROM GOODS TRADE AND FACTOR MOBILITY.

8506C Weller, Paul and Makoto Yano. FUTURES MARKETS, REAL INCOME, AND SPOT PRICE VARIABILITY: A GENERAL EQUILIBRIUM APPROACH.

8507C Diewert, W.E. THE EFFECTS OF AN INNOVATION: A TRADE THEORY APPROACH.

8508C Ethier, Wilfred J. FOREIGN DIRECT INVESTMENT AND THE MULTINATIONAL FIRM.

8509C Dinopoulos, Elias. INSIDE THE BLACK BOX: (IN)TANGIBLE ASSETS, INTRA-INDUSTRY INVESTMENT AND TRADE.

8510C Jones, Richard, John Whalley, and Randall Wigle. REGIONAL IMPACTS OF TARIFFS IN CANADA: PRELIMINARY RESULTS FROM A SMALL DIMENSIONAL NUMERICAL GENERAL EQUILIBRIUM MODEL.

8511C Whalley, John. HIDDEN CHALLENGES IN RECENT APPLIED GENERAL EQUILIBRIUM EXERCISES.

8512C Smith, Bruce. SOME COLONIAL EVIDENCE ON TWO THEORIES OF MONEY: MARYLAND AND THE CAROLINAS.

8513C Grossman, S.J., A. Melino, and R.J. Shiller. ESTIMATING THE CONTINUOUS TIME CONSUMPTION BASED ASSET PRICING MODEL.

8514C Romer, Paul R. TAX EFFECTS AND TRANSACTION COSTS FOR SHORT TERM MARKET DISCOUNT BONDS.

8515C McCallum, Bennett T. ON CONSEQUENCES AND CRITICISMS OF MONETARY TARGETING.