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Applied General Equilibrium Modelling: Achievement, Failure and Potential

by

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General Paper No. G-106 June 1994

Reprinted December 1999

ISSN 1 031 9034 ISBN 0 642 10361 5

ABSTRACT

Over the last twenty years, applied general equilibrium models (AGEMs) have provided useful insights on the likely effects of disturbances in one part of the economy on activity in other parts; e.g. the effects of changes in manufacturing protection on exports of mineral products. On the other hand, AGEM-based analyses of the welfare effects of proposed policy changes have been unconvincing. Nor have forecasts derived from AGE models provided satisfactory guidance to people concerned with investment and other business decisions. This paper explains these views and discusses the research required to move AGE modelling closer to its full potential.

CONTENTS

Applied General Equilibrium Modelling: Achievement, Failure and Potential

by

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This paper contains three propositions.

(1) Applied general equilibrium models (AGEMs) have provided useful insights on the likely effects of disturbances in one part of the economy on activity in other parts;

(2) AGE-based analyses of the welfare effects of proposed policy changes have been unconvincing; and

(3) AGEMs are yet to provide satisfactory guidance to people concerned with investment and other business decisions.

1. Achievement: quantifying linkages between different parts of the economy

Before AGEMs there were input-output models. These emphasise input-output linkages between industries. These models imply that stimulation of the motor vehicle industry, for example, perhaps from the imposition of a tariff, stimulates the sheet metal industry. In turn, this simulates the steel industry and so on.

Input-output computations imply that good news for any one industry generates good news for all industries with widespread employment gains. Not surprisingly, input-output models have been and remain a popular tool of lobbyists seeking government favours for their industries.

AGEMs go beyond input-output models by linking industries via economy-wide constraints. These include constraints on the size of government budget deficits, constraints on deficits in the balance of trade, constraints on the availability of labour, capital and land, and constraints arising from environmental considerations such as air and water quality.

With these constraints in place, the economy-wide implications of stimulation of one industry can be negative. In other words, good news for one industry can generate bad news for other industries. An obvious example of this type of result is in AGE analyses of the effects of increases in protection.

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* This paper is preliminary. After revisions it will form part of a chapter being prepared by Brian Parmenter and me for the *Handbook of Computational Economics* to be published by North-Holland in 1995. We would welcome comments and suggestions. Anyone interested in receiving a copy of our draft chapter in January 1994, please let us know.

Since 1977, there have been a large number of studies of the effects of changes in protection in Australia using the AGE model, ORANI.[1] The general flavour of the results is as follows.

- An increase in protection for textiles, clothing, footwear and motor vehicles saves jobs in these industries.
- However, it increases the prices of their products, thereby increasing the CPI.
- With wage rates being linked to the CPI, there is an increase in nominal wage rates.
- This causes cost increases throughout the economy with a profit squeeze and job losses in those industries which are poorly placed to increase their selling prices.
- Industries in this category are those relying largely on exports for their sales. Selling prices for these industries are determined on world markets, independently of their costs.
- Thus in ORANI, with the protected sector and the exporting sector linked through the labour market, the initial good news for TCF and motor vehicles arising from an increase in protection is translated into bad news for agriculture, mining and other export-oriented activities.
- With the real wage rate fixed economy-wide, ORANI implies that increases in protection have little effect on aggregate employment. The number of jobs gained in protected industries is balanced by the number of jobs lost in export-oriented activities.
- Changes in protection change the regional allocation of activity in Australia with Victoria gaining from increases in protection and Queensland and Western Australia losing. Similarly, changes in protection change the occupational composition of employment.

As well as analyses of the effects of protection, ORANI has been used in many other studies in which economy-wide constraint linkages are important. I give one recent example taken from Adams and Parmenter (1993).

Part of the question to be answered in that report was 'What would be the implications for the states of a general stimulation of international tourism in Australia. Part of the ORANI-generated answer was that Queensland would be a small loser. The explanation relies on linkages between different parts of the economy provided by constraints on the trade accounts.

Certainly international tourists spend money in Queensland, although not as much as one might have thought prior to becoming familiar with the relevant statistics. Although many tourists travel in Queensland, the bulk of their money is

1 The main reference on ORANI is Dixon, Parmenter, Sutton and Vincent (1982). Chapter 7 of that book is a detailed report of an ORANI tariff simulation.

spent in NSW, especially on airline tickets for flights in and out of Sydney. Thus, the Queensland economy experiences moderate (not huge) gains from the expenditures of international tourists.

The downside for Queensland comes from the trade accounts. With stimulation of international tourism, there is, according to ORANI, a strengthening of the exchange rate. This impacts adversely on export-oriented activities including mining and agriculture. With these activities representing a comparatively large share of its gross state product, Queensland is left as a net loser from general tourism stimulation.

It is in the tracing out of linkages arising from economy-wide constraints that AGE modelling has had its greatest successes. With the advent of AGE modelling, the input-output approach, with its exclusive reliance on linkages arising from flows of intermediate inputs, is no longer credible.

2. Failure: analysis of welfare effects

Much of AGE modelling over the last twenty years, especially in North America, has been concerned with the welfare implications of proposed policy changes, for example changes in protection, changes in taxes and changes in environmental regulations. Usually, these welfare implications have been measured by calculating the variation in consumer income which would produce the same variation in consumer utility as that generated in the AGE simulation of the policy change under consideration. In the AGE simulation it is normally assumed that the proposed policy change has no effect on total employment of labour and capital. That is, it is assumed that welfare changes arise only from a reallocation of a given quantity of scarce factors of production.

Such AGE calculations of welfare changes often produce very small numbers. I consider two examples. The first is the welfare implication for Australia of a 25 per cent across-the-board reduction in protection. Typical ORANI calculations show a gain of less than 0.2 per cent of GDP. This is not a number likely to stimulate anti-protectionist action.

In Australia, where there have been considerable reductions in protection over the last 20 years, costs of protection (welfare) numbers derived from AGE models have been ignored. In implementing anti-protection measures, policy makers have referred to mechanisms not usually included in AGE calculations. Among these omitted mechanisms are the effects of increased competition on the structure of industries and on the behaviour of both management and unions. With lower protection, policy makers have argued

(a) that there are likely to be reductions in numbers of firms and product lines allowing lower costs through economies of scale, and

(b) that management is likely to spend less time on golf courses and unions are less likely to take actions imposing cost increases on firms.

Recognizing that they are missing the main motivations for reductions in protection, AGE modellers have sometimes enhanced their welfare calculations by assuming that tariff cuts are accompanied by exogenously given improvements in productivity. This can produce welfare numbers more in keeping with the views of anti-protectionists. However, such AGE calculations merely illustrate the implications of anti-protection arguments. They neither explain these arguments nor provide evidence in their support.

What is needed for convincing AGE calculations of the costs of protection is models incorporating empirically-based descriptions of industrial-organization aspects of industries, of economies of scale, and of management and union behaviour. The most celebrated AGE work incorporating some of these features is Harris and Cox (1984). In Australia, the work of Harris and Cox was taken up by Horridge (1987). However, much remains to be done before AGE models will be able to produce convincing calculations of the cost of protection.

My second example of the inadequacies of AGE-based welfare analysis concerns the costs to Australia of reducing CO_2 emissions by 20 per cent by 2005, i.e., the costs of meeting the Toronto target. Using a version of ORANI, the Industry Commission (1991) concluded that the main action required in Australia to meet the Toronto target is the substitution in electricity generation of low CO_2 fuels, such as oil and gas, for high CO_2 fuels, especially brown coal. They found that this would involve an annual welfare cost of about 1.5 per cent of GDP.

As with most AGE welfare calculations, the IC calculations were comparative static. The IC compared two pictures of the Australian economy in 2005: one in which Australian electricity generation continued to rely mainly on coal with CO_2 emissions being of no concern, and the other in which a major fuel switch had taken place to facilitate a sharp reduction in CO_2 emissions. As the IC recognized, adjustment costs over the period between now and 2005 were omitted from their calculations. For example, no account was taken of the extra investment needed over this period to replace brown-coal-fired generation plants in the La Trobe valley.

The IC's work on CO_2 emissions indicates that if we want convincing AGEM welfare analyses, we need to add dynamics and adjustments costs to the list of required features of the model. Unfortunately, the dynamics required are complicated. Because they do not deal adequately with scrappage, simple dynamic models, assuming perfectly malleable capital stocks, are inadequate. Dynamic analyses of the costs of meeting CO_2 emission targets which have adopted the malleability assumption (brown-coal-fired generation capacity can be converted effortlessly into oil/gas capacity) include Jorgenson and Wilcoxen (1992). These analyses, as with comparative statics may seriously underestimate the costs of adjusting to meet environmental objectives.

3. Potential: disaggregated forecasting

Most work in AGE modelling has been concerned with the effects of proposed policy changes or the effects of exogenous events, e.g., the discovery of mineral deposits. However, there is strong demand for forecasts. Disaggregated forecasts are required to help policy makers, investors, trade unions and households to form realistic expectations concerning

- real wage growth;
- the costs of capital relative to labour;
- the industrial composition of economic activity;
- employment growth in different occupations and industries;

and

- growth rates in different regions.

Early attempts at practical multisectoral forecasting relied on strongly empirical but theoretically loose models. I have in mind the DRI and Wharton models. In these models, the role of economic theory was mainly to suggest variables to be tried on the right-hand sides of regression equations. For example, in the demand equation for motor vehicles, theoretical reasoning suggests that we should include on the right-hand side disposable income and various prices: the price of motor vehicles, the prices of complementary goods, e.g., fuel, parking services and repairs, and the prices of substitutes e.g., train and taxi services. Having established such a list of candidates for the right-hand side, the usual approach was to run regression equations, discarding variables which did not appear to add to the explanation of historical movements in the left-hand variables.

The problem is that the historical record is not rich enough for a predominantly statistical approach to quantify adequately the effects of all of the important right-hand variables. An example of what can go wrong was provided by forecasts made in the early seventies suggesting that the first oil-price shock would have very little impact on economic activity in the US or in the rest of the world. Later, it became apparent that the oil-price shock was a major cause of world-wide recession. Because the historical record up to the time of the shock had no examples of large oil-price movements, the predominantly statistical models underestimated the impact of this event in influencing the future course of the world economy.

AGE models employ tight theoretical structures. Households, producers, importers, exporters and distributors are modelled as agents whose behaviour is described by optimizing problems (e.g., utility maximization and cost minimization). Under this approach, plausible values are assigned to coefficients for which the historical record cannot reveal values. Although the historical record may not have contained direct information on the effects of changes in oil prices, it did contain information on the effects of other cost increases. With the tight theoretical approach of AGE modelling, empirical evidence on the effects of one sort of cost increase helps us to fix values for the coefficients describing the effects of other sorts of cost increases. Consequently, it is unlikely that an AGE model would have generated the forecast that a sharp increase in the price of oil would be a matter of little importance.

Nevertheless, AGE models have not yet proved themselves to be valuable forecasting tools. While a tight theoretical structure is an attractive feature, it is far from sufficient. In our efforts to transform ORANI into a forecasting tool we have identified the following areas as requiring major effort.

Getting the macro right

The first attempt to use ORANI in forecasting mode was Dixon (1986). Forecasts were produced for the period 1986 to 1990. The main feature of these forecasts at the macro level was a sharp reduction in Australia in the costs of capital. This was supposed to follow from two sources:

(a) a reduction in real interest rates world-wide in response to a contraction in the US budgetary deficit, and

(b) the formation of market expectations that the Australian exchange rate would be strong through the forecast period.

The assumed reduction in the costs of capital produced in our forecasts an investment boom, rapid real wage growth and average annual GDP growth of over 5 per cent. At the industry level, we projected good prospects for investment-related industries such as construction.

In later papers, e.g., Dixon and Parmenter (1987), we argued that foreign financiers would insist that Australia stabilize its foreign debt as a share of GDP by the end of 1990. Through ORANI, we found that this implied a sharp real devaluation of the exchange rate with high real interest rates and costs of capital. This led to forecasts of only modest real GDP growth, poor prospects for real wage growth and poor prospects for investment and investment-related industries.

None of our early ORANI forecasts have been close to reality. It is now clear that we did not know enough about how to forecast the macro economy. Because our macro forecasts were inaccurate, our industry forecasts were unrealistic.

Our current approach is to use Syntec Economic Services to provide macro forecasts. Syntec has been specializing in macro forecasting for 20 years with considerable success. They pay particular attention to movements in overseas economies. As they demonstrate in their numerous publications (see, for example, Syntec 1993a and b), Australia's business cycle is closely connected with that of the US. The explanation is that growth in the US and other OECD economies is the main determinant of movements in Australia's terms of trade. Those movements exert a strong influence on GDP, the exchange rate and other macro variables in the Australian economy.

In summary, the philosophy behind our decision to build an alliance with Syntec has three elements:

(a) we know that the value of CGE-based forecasts of industry, regional and occupational variables depends critically on the reliability of the associated macro forecasts,

(b) we think that Syntec does a good job of macro forecasting, and

(c) macro forecasting can be separated from the development and application of a CGE model. This makes possible productive specialization of labour, with COPS dealing with industry, regional and occupational issues while Syntec works on the macro and international situation.

Getting the input-output data up-do-date

The latest ABS input-output tables are for 1986-87. This is not a satisfactory starting point for forecasting in the 1990s. As explained in Dixon and McDonald (1993a), we have devoted considerable resources to updating the tables to 1990-91.

Among the spinoffs from the update project have been a detailed quantification for the second half of the 1980s of technological change and of changes in consumer tastes. This has helped us to develop forecasts of these variables for the 1990s. In addition, the update project has given us a framework for analysing structural changes in the Australian economy (see Dixon and McDonald, 1993b).

Getting to know what the statistics for the industries represent

In most AGEMs the same specification (e.g., Leontief, CES, nested CES, etc) is used for all industries to describe technology. Only the parameter values differ between industries. Similarly, there is a uniform specification of how imported products compete with domestic products (e.g., the Armington specification). In forecasting, we are finding that standard specifications often fail to represent adequately the statistical entities being modelled. I give two examples.

- *Communication*. In the ABS input-output tables this industry has considerable imports and exports. Does this mean that output and employment in the industry are highly sensitive to exchange rate movements and to costs in Australia relative to costs overseas? This is the conclusion that follows in ORANI under standard specifications of the behaviour of trade flows. On getting to know about the nature of trade flows in communication, we find that this is not a sensible conclusion. Communication imports are mainly payments by Australia's Telecom to overseas telephone companies for facilitation of the transmission of calls from Australia. There is also a rental component for Australian use of foreign-owned communication satellites. Communication exports are mainly payments to Australia's Telecom for facilitating the transmission of calls coming from overseas. Given the nature of these trade flows, we expect future movements in exports to be approximately in line with those in imports (calls go to and fro). After modifying our specification of the industry to recognize the links between its imports and exports, we no longer find that its output and employment are highly sensitive to its international competitiveness.
- *Aircraft.* Does an upsurge of imports of aircraft harm employment and output in the Australian aircraft industry? This is the result that ORANI gives under standard specifications. However, on looking into what the industry does we find that its product is complementary with imports rather than competitive. The local industry specializes in aircraft repairs and the manufacture of parts. On changing the standard specification to reflect this, we find that the local industry is likely to prosper during a period of strong growth in the volume of imported aircraft.

In our forecasting version of ORANI (the MONASH model) there are 112 industries. It is a long and tedious task to think about what the statistics for each of these industries really represent. However, if we are to develop a valuable forecasting tool, this task cannot be avoided.

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