An Introduction to Australian Economy-Wide Modelling

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by

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This paper was written for a conference on the macroeconomic models of Australia, that I arranged at the University of New England in December, 1988. The participants at the conference were people from the private and public sector and as such were not academic macroeconomists. This paper was thus meant to be a broad introduction covering the main developments in macroeconomic modelling since its beginnings with the work of Jan Tinbergen in the late 1930's. After discussing some of the earliest ideas in mathematical modelling of the economy, the first models and their problems will be discussed leading up to the developments at the Brookings Institution. Then some of the major theoretical events over the last 20 years in dynamic macroeconometric modelling will be discussed followed by the development of other types of models such as applied or computable general equilibrium models. I will conclude with some comments upon the value of these models.
1. Early Beginnings up to the 1930's

In his posthumous and monumental work, "History of Economic Analysis", Joseph Schumpeter points out how, thousands of years before Christ, the Egyptians were running a planned economy and, hundreds of years before Christ, the Chinese were running exchange controls. Although many people were clearly thinking about economic subjects, it is only with the Ancient Greeks that we begin to find economic analysis along the lines that we know today. Here we find Aristotle wrestling with the concepts of 'value', 'money' and 'interest', and Plato discussing the Division of Labour and basically originating the Cartal theory of money whereby money is not just another commodity used as a medium of exchange (usually metal for practical reasons) but an intrinsically valueless 'token' which is socially accepted as a medium of exchange.

It is amazing how little development of economic thought there was from this time right up until the 1600's. Here the warring state of affairs between England and Spain and between England and Holland caused much discussion of the best way to increase the wealth of England. Many Englishmen feared the wealth of Spain in particular and its ability to buy large Armadas. Then with the Cromwellian revolution there arose a parliament thirsting for information upon which to make decisions about the nation and taxes in particular.
1.1 Sir William Petty, 1623-87.

The 1600's saw a large number of great talents but one particularly striking character was Sir William Petty. And he only arose as a great figure because he broke his leg while a 14 year old cabin boy on an English merchantman. After being dumped ashore in France he explained his pitiful circumstances so well in Latin to the Jesuits that they not only cared for him but admitted him to their college and there started his career as one of the Renaissance's self-made 'Universal' men of enormous versatility - physician, surgeon, mathematician, inventor, engineer, member of parliament, public servant and businessman - who refused the peerage twice before finally accepting a third offer. One idea that he spent much time upon was the 'Double Bottom', a sort of catamaran; on one trial, one of these outstripped all the boats in Dublin Harbour but Petty was never able to obtain such good results again.

With Sir William Petty one has possibly the beginnings of today's mathematical economics and econometrics, with his "Political Arithmetik, the art of reasoning by figures upon things related to government". In this treatise he writes -

"Instead of using only comparative and superlative Words, and intellectual Arguments, I have taken the course ... to express in Terms of Number, Weight or Measure; to use only Arguments of
Sense, and to Consider only such Causes, as have visible foundations in Nature."

Petty is most famous in economics for his discussion of money and the velocity of money in particular, but possibly of greater relevance here is his analysis of National Income.
### Table I: Sir William Petty's Analysis of National Income in "Verbum Sapienti", 1665

<table>
<thead>
<tr>
<th>(£m)</th>
<th>(£m)</th>
<th>Total Worth</th>
<th>Rent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land: 24m acres @ 6s/8d p.acre</td>
<td></td>
<td>144</td>
<td>8</td>
</tr>
<tr>
<td>Houses: London - 28,000 @£15p.a. = £420,000pa =&gt; 5.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer London - as many but not worth so much each, so same =&gt; 5.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cities and Market towns = 2 x London =&gt; 10.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside cities and towns, approx same =&gt; 10.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houses Total</td>
<td>say</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Shipping: 500,000 tuns at 6d per tun</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Cattel Stock: 1/4 of land value</td>
<td></td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Coined Gold and Silver:</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Wares, Merchandises, Utensils of Plate &amp; Furn.</td>
<td></td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Total of non-land</td>
<td>106</td>
<td>106 =&gt;5.89 say 7</td>
<td></td>
</tr>
<tr>
<td>Wealth of the Nation</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Proceed of Wealth</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Expenditure:- 6 million people @ £6/13/4d => 40m per annum

"Then the Labour of the People must furnish the other 25"

As 250=>15, the Value of the people => 25 and so Human value => 416.67m

i.e. 420/6 = £70 each
In Table I, an attempt is made at summarising the logic used in Petty's "Verbum Sapienti" of 1665. He starts by saying that there are 24 million acres of land worth on average about 6s/8d per acre (a third of a pound sterling), creating a total worth of £144m which should provide a rental income of £8m. As to the houses on the Land, he separates these into various categories in and outside London. In London there are about 28,000 houses with an average rental of £15p.a. giving a total rental of £420,000p.a., so they must be worth £5.04 million. Houses in the outer London suburbs are at least as many as those in London but not worth so much, so, say, another £5.04 million. Houses in the other cities and market towns must be worth twice as much as London and hence £10.08 million, and finally all other houses must be worth about the same again and hence another £10.08 million. All in all this makes a housing total of, say, £30 million.

To this we must add £3 million worth of shipping (500,000 tuns at 6d per tun, 6d=£0.025), £36 million of 'cattel' stock (say a quarter of the land value), say £6 million worth of coined gold and silver, and say £31 million worth of Wares, Merchandise, Utensils of Plate and Furniture. This creates a total non-land wealth of £106 million, leading to a convenient total wealth of the nation of £250 million. Then just as the £144m land wealth led to a rental income of £8 million, the non-land wealth leads to, let us say, £7 million creating an annual total proceed of wealth of a nice round £15 million.
Now there are 6 million people spending about £6/13/4d p.a., (£6.66), making £40 million p.a. Given the £15 million from 'rent', "Then the Labour of the People must furnish the other 25". Probably for the first time, we have here none other than an expression of the key national income-expenditure identity that is at the core of all macroeconomic models.

He goes on to say that since £250 million of property wealth led to £15 million worth of 'rents', the value of the people that creates £25 million of income must be £250 × 25/15 = £416.67 million. Given that there are 6 million people, then on average each person is worth just £70. This must also be one of the first evaluations of the modern concept of human wealth. He developed this argument as a reason for spending the equivalent of a few pounds per person to save Londoners from the ravishes of the plague; for his purposes, there was no reason to be numerically more accurate.

Sir William Petty was the leader of a small group of outstanding people including Gregory King, Charles Davenant and John Graunt, the founder of demography. In Gregory King's "Natural and Political Observations and Conclusions upon the State and Condition of England in 1696" we find the first definite expression of demand equations that was not to be improved on for over two hundred years. In discussing the demand for wheat he comments that, if production fell by 10% or 20% etc., below normal, then the price will rise by some
30% and 80% above trend. This image of a demand curve was not to be improved upon till the early 20th century with the work of Moore. For an interesting re-appraisal of Petty, see the book by Alessandro Roncaglia (1977, English text 1985) wherein the author tries to escape from the linear development of economic thought implied by Schumpeter's historical analysis; Roncaglia argues that the many aspects of Petty's thought, other than those developed by later economists, are now of relevance today.

1.2 Adam Smith, 1723-90, and David Ricardo, 1772-1823.

While Petty had been a very dramatic figure of his age, a man about whom there are many tales, not all apocryphal, the next great watershed came with a very different type of man. In an amazing indictment Schumpeter writes about Adam Smith, 'Few facts and no details are needed about the man and his sheltered and uneventful life (1723-90). It will suffice to note: first that he was a Scotsman to the core, pure and unadulterated; second, that his immediate family background was the Scottish civil service ... ; third, that he was a professor, born and bred, ... by character indelebilis; fourth ... that no woman, excepting his mother, ever played a role in his existence: in this as in other respects the glamours and passions of life were just literature to him. ... He was conscientious, painstaking to a degree, methodical, well-poised, honorable. He acknowledged obligation where honour
required it, but not generously. He never uncovered the footprints of predecessors with Darwinian frankness. In criticism he was narrow and ungenerous. He had the courage and energy that exactly fit the scholar's task and go well with a good deal of circumspection.' (op.cit. p181-2).

Like many 'great' works, Adam Smith's Wealth of Nations, published in 1776, was in no way innovative but rather it was a detailed methodical statement of the ideas of the day put into a logically consistent form. As such it publicised the ideas, and economics became an established subject. 'But no matter what he actually learned or failed to learn from his predecessors, the fact is that the Wealth of Nations does not contain a single analytic idea, principle or method that was entirely new in 1776.' (Samuelson p184).

One of the major changes of this time was the relatively important position given to the concept of labour. Value was no longer a matter of exchange but of labour "conceived as toil and time, the working day that divides up, and uses up, men's lives." (Sheridan, p66). Michel Foucault in his magnificent analysis of human thought, 'Les mots et les choses', marks this point as the move away from the Classical Age of representation.

Foucault's translator, Alan Sheridan, says "By making labour the constant measure of exchange value" Adam Smith "laid the
foundations for a political economy that could be based not on exchange (representation), but on production. But in Smith's analysis labour is still regarded as a commodity that can be bought and sold. As long as representation retained its precedence all commodities represented a certain labour and all labour a certain quantity of commodities. The second stage of the founding of political economy was the work of David Ricardo. ... Ricardo pointed out that labour could not be used as a constant measure since it is 'subject to as many fluctuations as the commodities compared with it'. This insight led him to make the productive activity of labour itself not the measure of value but the source of value. Value is no longer a sign in the system of equivalences but a product of labour, which is prior to any system of exchange. The theory of production must now precede that of circulation. Circular causality has been replaced by linear causality. Ricardo has made possible the articulation of economics on history." (Sheridan p68-9). From here it was only a natural progression in one respect to the historicological work of Marx and the mathematical 'causal' models of Popperian positivism.

1.3 Leon Walras, 1834-1910.

The next major figure, however, of relevance to us, arising from the organismic systemic thinking of the 19th century, is the Frenchman, Leon Walras, with his 'Elements d'economie
politique pure' in 1874; Schumpeter referred to his system as 'the Magna Carta of economic theory' (op.cit. p242). Although Isnard back in 1781 was possibly the first to try mathematically to define and prove the concept of economic equilibrium, it is in Walras's theory of general equilibrium that we finally see a system that 'determines the equilibrium values of all the economic variables, to wit: the prices of all products and factors, that would be bought in perfect equilibrium and perfect competition by all households and firms.' (Schumpeter, p998-9).

Although this is the foundation of modern economics, Leon Walras gained very little credit for it during his own lifetime. As he himself once wrote in a letter to a friend, "If one wants to harvest quickly, one must plant carrots and salads; if one has the ambition to plant oaks, one must have the sense to tell oneself: my grandchildren will owe me this shade."

1.4 John Maynard Keynes, 1883-1946.

The thrust of development in economic thought turned from comparative statics to analysis over time, and the business cycle in particular. On the econometric side we have the path-breaking work of Henry Moore and his 'Economic Cycles: Their Law and Cause' (1914) and 'Generating Economic Cycles' (1923). Joseph Schumpeter wrote his own two-volume historical book on
'Business Cycles', (1939). On the economic side we have John Maynard Keynes and 'The General Theory of Employment, Interest and Money', (1936). Although this may be in part a synthesis of the work of Joan Robinson, R.G.Hawtrey, R.F.Harrod and R.F.Kahn, and at the same moment, contemporaries in Sweden, E.R.Lindahl and C.Fohl, were in the process of writing down the same ideas, Keynes had a startling analytical flair. Although nobody seems to read the original Keynes any more, I would at least highly recommend reading such works as 'The Economic Consequences of the Peace' (1919), 'The Economic Consequences of Mr Churchill' (1925), 'Can Lloyd George Do It?' (1929) and 'How to pay for the War' (1940).

Keynes' major economic innovation was possibly what Schumpeter beautifully describes as his stagnationist image of "an arteriosclerotic economy whose opportunities for rejuvenating venture decline while the old habits of saving formed in times of plentiful opportunity persist". (op.cit. p 1171). As far as today is concerned, however, one must remember that Keynes' concept of unemployment was that of cyclical unemployment, not the Marxian structural unemployment which may seem more relevant today.

2.1 Jan Tinbergen's Early Models

While Henry Moore's analysis of cycles and his estimation of elasticities possibly led to the partial equilibrium analysis of Allen, Wold and Stone, the general interest in cycles also led to the pioneering work of Jan Tinbergen who may well be called the forefather of macroeconomic models of today. As early as 1935 he published a model of the Dutch economy, but more famous is his 1939 model of the US economy. Though his structures owe more possibly to common-sense considerations than pure economic theory, they are no mean feats. The US model has 32 stochastic equations and 18 identities with 14 exogenous variables. There are three consumption, three investment and three liquidity preference functions and it even includes the stockmarket. In his 1951 model of the UK economy there are 45 equations with 9 exogenous variables. The gold stock is modelled endogenously thus linking the monetary sector to international trade and share prices are also modelled endogenously.

A major aspect of Tinbergen's work is that the statistical analysis was used to estimate parameters and test hypotheses resulting from theory, not the other way around. In particular, it was not like the more statistical analysis of Wesley Mitchell and the NBER, whose analysis aimed more at
establishing the facts so that the theory could be based on a firm foundation. While Tinbergen's approach has held sway, the other methodology has reappeared recently with the VAR modelling started by Christopher Sims (1980, "Macroeconomics and Reality", Econometrica, 48, 1-48) who was worried about the inaccuracies arising from imposing unproven theoretical constrictions on the data. We will return to this approach later.

A major factor in the late 1930's and the 1940's was the quality of the data. Firstly, for the major time series, only annual data was available. Secondly, what with two world wars and a depression, the economies had not been going through a stable period from which stable statistical results could be derived. For lack of other information, it is not surprising that many economists, during World War II, predicted another depression after this war. Note also how, when estimating a model in 1950 to analyse business cycles, Tinbergen used 44 observations from 1871 to 1914. Nobody now would use observations over thirty years old to estimate a model to be of relevance to today. Klein used 20 pre-war observations to estimate his 1950 model and the Klein-Goldberger (1955) model was estimated with 13 pre-war and 7 post-war observations!

2.2 The Age of Klein.

The post-war period saw a great explosion of macrodynamic modelling led by the work of Lawrence Klein. One might almost
call this jubilant confidently optimistic period, the 'Age of Klein'. People had such high hopes for economics; the world's problems would soon be solved. These grandiose claims were not the fault of economic theory but rather forced upon it by the social attitudes of the time. When scepticism started to creep in, economics, and macroeconomic modelling research in particular, were criticised more than they deserved. Now people are beginning to be more realistic in their attitudes and are realising that, while macroeconomic models do not represent the economy perfectly, they are a valuable source of information needed to make reasonable business and policy decisions.

The first Klein model was an extraordinarily simple demand-driven model of expenditure; note how many things are missing. There is

1. no explicit production function and so no analysis of the supply side and technological effects,
2. no price or wage equations and so no analysis of inflation,
3. no labour market and so no analysis of unemployment,
4. no financial sector and so no analysis of interest rates,
5. no international linkages are modelled and so no analysis of the balance of trade, the exchange rate etc.

And so the list could go on. This is not meant as a criticism
of this early model, but, when you think of all the questions attacked by modern models, it shows just how far such models have developed over only thirty years.

One could say that model development really got under way with a rush of new models when quarterly data became available. Most models were fairly small with some 28-37 equations - Duesenberry et al's recursive model (1960), Klein-Popkin (1961), Fromm (1962) and Liu (1963). On the other side one had the idea that greater detail would lead to greater accuracy and one has the Brookings model developed over 1961-4. This had some 272 equations, of which 125 were stochastic, 51 a priori and 96 definitional. The debate over whether models need to be highly disaggregated or not still continues today and may never be decided; rather than asking this in general, it may be more useful to ask such a question only in the context of a specific planned use of the model.

2.3 'Brookings'.

The Brookings Bureau was an unparalleled phenomenon. For many years it seemed to tower over macrodynamic theory. It showed clearly how collecting a group of researchers together into a Bureau can be so productive, especially in its early exciting formative years (two books and forty-three papers in four years). The Bureau is probably more famous for its innovative research than any one model.
To list just a few of the Bureau's earliest ideas -

a) Detection of Structural Change - they found significant changes across 1953 and so omitted the 1948-1953Q2 data and used just 1953Q3 to 1962,

b) Use of an Input-Output Core, relating final demand categories to industrial sectors - 7 price equations, 9 price conversion equations relating industrial sector prices to final demand prices, 7 equations relating industrial sector outputs to components of GNP,

c) Use of Demographic Information with separate labour participation rates for men and women of different ages and even a marriages equation,

d) Modelling 'intentions' to invest separately from 'realisations',

e) Use of a Highly Disaggregated Government Sector to model federal expenditures separately from state expenditures,

and so the list could go on and on. But let us not imply that the USA had total hegemony over this new modelling enterprise. Many models were being developed in countries all over the world, especially Canada, England, Holland, Japan and also Australia (see Nerlove, 1966).
2.4 The Neo-Classical Input

Early Brookings and Klein were part of this optimistic period of the 1950's and early 1960's, the glowing age of the welfare state. By the late 1960's a dramatic social change had set in. For many people this is marked by the dramatic events in France in May 1968, especially on the streets of the Latin Quarter in Paris. This was possibly more a social emanation/release of something that had been brewing for a while, a disaffection with the state, a fear of the state and disbelief in its benevolence and even its ability to 'do good' if it tried. So many people at the time wanted to express their dissatisfaction with 'the powers that be', whatever they might be.

Within this atmosphere arose a shift of opinion against government interference, what one might call the 'keep your hands off' revolution, the so-called neo-classical revolution in economics and the rise of monetarism. The word 'revolution' over-emphasises the number of new innovative ideas and probably reflects more of a social phenomenon amongst economists. Although Milton Friedman had written his "Studies in the Quantity Theory of Money" as early as 1956, his ideas only really gained public notice in the late 1960's at which time he published 'The Optimum Quantity of Money' (1969).

There are three major effects upon modelling that are still being felt today - longer time horizons, supply side modelling
and greater financial modelling. With the concept of 'permanent income' and the longer time horizon also came the analysis of technical change.

Now we automatically distinguish between models that have shorter or longer horizons, as what you can assume to be fixed depends on your time horizon. In the short-run the labour-supply is fixed and there is no resolution of disequilibria. In the long-run 'all' can vary and so there must be a method of resolving disequilibria. Because of the extra effort needed to do this, long-run models tend to be smaller. Also it may not be sensible to model the immense detail of some models in the long run as the structure of the economy is probably not stable enough. A difficulty with long-run models is that of testing, in that we never experience an economy settling down to a long-run stable equilibrium. Thus these models have to be assessed more by consistency with theory rather than data, raising many methodological questions.

Long-run models tend to be Classical as what we term 'Keynesian' economics is more interested in the short run. With the revived classical use of production functions also came the introduction of the supply side, and with the discussion of the velocity and supply of money came much greater financial modelling. In the so-called 'Keynesian' model, supply was fixed and so output was demand driven; there was no real production function. This meant, for instance, that one could not study the effects of short-run capacity
constraints and disequilibria. Above all, these models are useful as logically consistent expressions of a body of theory and its implications; I will return later to the use of models to express theory concisely and consistently.

A few of the major developments are probably worth mentioning as they feature in most macroeconometric models in one way or another. I will relate them in particular to four Australian models -

a) the Treasury model called NIF88 (see Simes, 1988),
b) the MURPHY model (see Murphy, 1988),
c) the McKibbin and Sachs Global Model called MSG (see McKibbin, 1988)
d) the computable general equilibrium model called ORANI (see Dixon et al, 1982).

3.1 Wealth and the Consumption Function

Firstly there is the analysis of wealth and in particular the Modigliani/Ando consumption function. A typical expression of this function, used in both the NIF model and the Murphy model of Australia, would be -

$$\text{Con} = f(\text{current labour income, non-human wealth (lags of), NPOPxPI})$$

The left-hand-side is real per-capita consumption (consumption divided by the population and a relevant price index). Note that the current labour income is seen as arising from human wealth; this distinction reminds one of Petty's original work.
With wealth comes the introduction of a new stock variable, that we still find very hard to measure. This also led to the demand for stock-flow consistent models such as Warwick McKibbin and Sach's MSG model of the world that includes a specific Australian sub-model. With the lengthening of the time-horizon and the emergence of new, better data, one can now deal with stock-flow effects and, in particular, see the work of E.P.Davis of the Bank of England.

3.2 Investment and Interest Rates.

An example of a stock effect is Tobin's Q, the valuation ratio. This is the ratio of the market valuation of equity to the replacement cost of the capital stock. The market valuation of equity should equal the discounted net present value of all future profits. If the present and future profits of the capital are worth more than the cost of that capital, then it is sensible to invest in more capital. This approach is used in Murphy, NIF and MSG. However it leads to serious problems in deriving the 'market value of equity'.

The first solution was to use Portfolio Demand Equations, a large set of equations for different types of assets demanded by different sectors - foreign, public, private and household. This approach was used in an earlier version of NIF called NIF10. Through these equations one can determine the interest rate, the price of equity, the exchange rate and many other
things. This approach has since been found to be unduly complicated and may lead to unstable equations. A method used now is to determine a key interest rate and from this determine others by arbitrage conditions as is done in NIF88 (see Simes, 1988). Also in MSG, "Exchange rates, long-term interest rates and equity prices are determined according to intertemporal arbitrage conditions based on rational expectations of the future path of the global economy."
(McKibbin, 1988)

3.3 Unemployment, Inflation and the NAIRU.

Another major theme has been the Phillips curve, originated in 1958. The trade-off between unemployment and inflation was not new. The shock was the level of unemployment at which inflation started, over 5%! This implied that if you wanted unemployment below 5% you had to accept some degree of wage inflation. Initially this was treated as a constraint and it was a political nightmare; the aim of policy soon became to shift the whole curve rather than just move along it.

This Phillips curve development was in fact a dubious one in the first place for it was purely a statistical result. In the late 1960's new data led to the derivation of families of curves and so the idea proliferated. In many if not by far the majority of models, the rate of unemployment was used in the causal determination of the rate of inflation whereas this
apparent causality was partly just a spurious effect of the simultaneous forces in the economy. For this reason, and partly the difficult political problems raised by the idea, it is pleasing to see that the rate of unemployment is used less now in determining inflation. For instance, in Ray Fair's Model (Fair, 1984), the labour supply is an intermediary function of much else such as taxes, real wages, interest rates and transfer payments, and so there is no clearly stable Phillips curve.

With the debate upon the Phillips curve, there arose the idea of the 'Natural Rate of Unemployment' (NRU) in possibly the most influential paper since Keynes, "The Role of Monetary Policy", given by Milton Friedman in his Presidential Address to the American Economic Association in 1968. The NRU is the rate at which the average real wage rate is held constant and any expansionary policy will just cause inflation in the long run. This led to the notorious vertical long-run Phillips curve. The form of this concept used today is the 'Non-Accelerating-Inflation-Rate-of-Unemployment'. This is known as the NAIRU, a name which is not much of an improvement. MSG, NIF and Murphy all make use of this concept though the effect is mollified by allowing some hysterisis; hysterisis is when the particular path taken towards the long-run solution affects that long-run solution.
3.4 Expectations

Friedman's paper talked of people's expectations of inflation. This led to the idea that the government had to reduce people's inflationary expectations to shift the curve. To do this they had publicly to espouse a long-term deflationary policy. Friedman assured the policy-makers that this would not take long and one could soon get back to a more publicly acceptable policy. Out of this arose the grand experiment, Margaret Thatcher's "Medium term financial strategy" in which her government announced a five-year slow reduction in the rate of growth of money and in the PSBR. The result? Unmitigated disaster. Not only did unemployment rise to incredibly high levels but so did inflation! It will be many years before Great Britain recovers from the scars (for further comments on this 'regime', see Buiter and Miller, 1983). The more recent reduction in inflation was a result of the reduction in global inflation levels and there are disturbing signs of galloping inflation again in Britain. One doubts whether the British government had read Friedman's later 1976 Noble Memorial lecture, in which he talks of slumpflation, positively sloped Phillips curves and much longer time periods.

People's expectations were not only discussed in Friedman's theory but had been a standard part of the debate for years, even in Keynes' work. However, in 1960, J.F. Muth laid the theoretical foundations of a new development, known as
'rational expectations'. The name is rather misleading for in at least one sense expectations had always been rational. The distinguishing idea is that the expectations are forward-looking, not adaptive and backward-looking. By this I mean that the expected values are the actual values predicted by the model, given all the information it has at this present point of time. Given this, a much better name would be 'model consistent expectations'. There is still much evidence for and against the hypothesis but, above all, it is a very parsimonious modelling strategy. The modeller does not have to explain how people derive their expected values; he simply equates them with the models expected values.

Early rational expectations models go back to Lucas (1973 and 1975), Sargent (1976), Sargent and Wallace (1976) and Barro (1976). In England, Patrick Minford has used rational expectations extensively in his Liverpool Model. In Australia, they are used in both Murphy and MSG but not in NIF. The debate for and against is at times surprisingly heated and vitriolic. The popular middle line is to use rational expectations not across the board but in specific areas such as in financial markets. The expectations debate goes on to discuss the different effects of anticipated and unanticipated changes in government policy and even the effectiveness altogether of government policy.

There is not time or space in this paper to describe the many other developments in macroeconomic theory, for developments in other ways in modelling must be mentioned. Here I can pay little more than lip-service to the dramatic developments in econometrics, starting with the work of Trygve Haavelmo (for example 1940, 1943 and 1947) and the Cowles Commission in the 1940's and 50's. Most estimation techniques were developed some while ago now and it is possibly surprising to see the lack of use today of instrumental variable methods and LIML (if not FIML) techniques. A major criticism of econometrics is possibly that too much effort has been put into hypothesis testing rather than estimation. Economics is not without its own major debates such as the procedural differences between David Hendry, Christopher Sims and Edward Leamer (see Pagan 1987). Curiously such issues, while vitally important, are commonly omitted from econometrics courses which concentrate on technique. For instance, it is rarely mentioned in student texts; it is not discussed at all in Gujarati's popular basic text (1988).

After going through a rather dry period full of asymptotic theory, there have been a number of exciting developments in econometrics in the last few years, notable amongst which are the specification tests which have been written about by a number of Australasians, such as David Giles, Max King, Mike
McAleer and Adrian Pagan (see references below). Also there has been the development of the methodologically more dubious diagnostic tests for heteroscedasticity, autocorrelation, non-normality, etc. Hardly a model is estimated without extensive use being made of these tests. Many models are still estimated with single equation techniques, and have to be for lack of data; this raises the risk of simultaneity bias and here the Hausman tests are very useful.

Finally the increased computing power available has permitted the development of computer-hungry techniques such as Jackknife and Bootstrap methods (see Miller 1974, Efron 1982 and Hinckley 1988), and the movement of computer-aided design (CAD) techniques into statistics with the development of exciting new graphical techniques. Further information on the development of econometrics can be gained from Epstein's (1987) 'History of Econometrics', which is particularly relevant to modelling as it concentrates especially upon structural estimation, the question of exogeneity, rational expectations and vector autoregressions.
5. Extensions of the Macroeconometric Model.

5.1 VAR Modelling.

One econometric technique deserves greater mention as it has led to a whole new field of macroeconometric modelling. The new models are Vector Auto-Regressive (Moving-Average) models known as VAR(MA) models. They are essentially just multivariate Box-Jenkins auto-regressive/moving-average (ARMA) models. As mentioned earlier, they arose because of fears that theoretical restrictions were too constrictive on the data, not allowing the data to 'speak'. The comments in Christopher Sims' critique of standard methods remind one of the work of Wesley Mitchell.

Since his 'Autoregressive index model for the U.S., 1948-75', published in 1981, many VAR models have been estimated including Sims own world model, and, here in Australia, one estimated by Trevor and Thorp of the Reserve Bank (1988). The main trouble with these models is that in the end they need as many arbitrary restrictions as the normal macroeconometric models and I prefer the normal model's theoretical rather than the VAR model's statistical justifications for these restrictions (see Doan et al, 1984, and Trevor & Thorpe). Although data-oriented, these models do not produce any better predictions although they may improve with the development of cointegration. A major use of VAR models might be to use them
as benchmarks for other theoretical models.

5.2 International Models.

Aside from the econometric developments, mention must be made of the development of other new types of model. In the early 1600's it was forbidden to export gold from England as it was thought that this would reduce the wealth of England and hence its strength to fight Spain and Holland. When an East India Company boat sank with a large cargo of gold bullion soon after leaving an English port, it raised a furor of public consternation. The director of the East India Company, Thomas Mun, sprang to its defence with his tract "England's Treasure by Forraign Trade" in 1630. Possibly from this arose the mercantilist theories in economics. Given this and England's large entrepot trade, it is surprising that there are few British international models.

Now there are many types of international model with different geographical coverage and country groupings. Another distinction is whether they use a common model structure for each country or combine differing sub-models of each country. The Project Link uses 79 different models developed in their original countries (Waelbroeck, 1976). The Japanese EPA world econometric model uses different models for each country, constructed however by the EPA itself (Yoshitomi et al, 1984). MSG uses similarly structured models for each sector of the
world but the Japanese labour market in particular has to be modelled differently. These models are now used extensively by the IMF and others to help devise international policy. This is possibly the greatest area of development in modelling today (for example, see Bryant et al, 1988).

5.3 Multi-Regional Modelling.

Of a similar nature in a way to international models are the multi-regional models of a single country. Here two distinct approaches abound. Firstly there is the top-down approach (TD) where some national model is used to create some aggregate forecasts which are then broken down into regional forecasts in some consistent fashion. An example is the model of Milne, Adams and Glickman (1980) which uses the Wharton model's aggregate forecasts. The alternative approach is of course the bottom-up approach (BU) which builds up from individual sets of equations for each region, adding the results together in some consistent manner to obtain national aggregates. An example is the National Regional Impact Evaluation System (NRIES) of Ballard, Glickman and Gustely (1980). Here there are 51 state models with approximately 230 equations each plus a 50 equation national model; there are some 4000 behavioural equations in some 11,000 equations all told! Given the lack of good state-based statistical data, the TD approach is probably more suitable to Australia.
The final development that I will discuss is General Equilibrium Modelling. Schumpeter writes "few sequences in the history of economic analysis are so important for us to see, to understand, and to fix in our minds, as is the sequence: Petty-Cantillon-Quesnay" (p218). While Richard Cantillon (1680-1734), a Parisian banker of Irish extraction, was clearly inspired by the work of Petty, his achievement stands out clearly in its own right. Most outstanding of all was his understanding of the circular flow of the economic process as the payments of each sector of society become the incomes of other sectors. In all its bare essentials, Cantillon really created the 'Tableau economique' that was developed by the surgeon-physician to Madame Pompadour, Francois Quesnay (1694-1774).

Quesnay was a member of the physiocrats who tried to find valid criteria for judging particular policy proposals. While the mercantilists had aimed at increasing wealth by 'forraign' trade, the physiocrats aimed at increasing wealth by increasing production, particularly agriculture. Quesnay's work lies directly in the tradition, since Petty, of 'describing the facts'. Amongst his many treatises on economic theory, the most famous is the 'Tableau Economique' of 1758.
He followed Cantillon's categorisation of people into three classes, the landowners (classe proprietaire), the farmers (classe productive), and anyone not involved in agriculture, the merchantmen, which he called the 'classe sterile'. The Tableau depicts the flows through the economy of funds from one sector (classe) to another.

Apart from the great simplification provided by the Tableau it lays the way open for statistical analysis; Quesnay was fully aware of the possibilities here. Like Petty he also tried to estimate the national income. Schumpeter wrote "the Cantillon-Quesnay tableau was the first method ever devised in order to convey an explicit conception of the nature of general equilibrium. It would seem impossible to exaggerate the importance of this achievement if admiring disciples had not actually succeeded in doing so". (op.cit. p242). However this approach has led a checkered history. It lay essentially undeveloped until Walras took it up over a hundred years later and even then, because of the mathematical complexity, it was not further developed until the 1930's and 50's.

6.2 Input-Output Analysis.

The essential concept of interchanging flows was developed by Wassily Leontief in his Input-Output analysis (Leontief, 1941 and 1964). This led in particular to Richard Stone's Input-Output model of the UK economy, which has developed into the
massive present-day Cambridge Growth Project model. In
Australia the first I-O tables were produced by Cameron in the
late 1950's. In 1964 the Australian Bureau of Statistics (ABS)
under Cameron produced its first table for 1958-9. While
initially such tables were infrequent, dependent on censuses,
more recently the ABS has produced tables for consecutive
years in the early 1980's and even a state breakdown for 1985-
6. For further information on Australian Input-Output Tables,
see the article by Barbetti (1987) in the new Australian
Journal of Regional Studies; for a computer package to use
these tables, there is the GRIMP package, described in Jensen
and West (1986) and distributed by the Department of
Immigration, Local Government and Ethnic Affairs.

6.3 The Johnsen and Scarf Approaches.

If you add some neo-classical production functions and some
price-sensitive demand equations to the basic I-O table, you
have the essence of a highly non-linear Walrasian general
equilibrium model. This was developed by two different groups.
One group stems from the mathematical developments of
whole stream of Applied General Equilibrium models. In the
U.K., one has the models of Whalley (1975), Miller and Spencer
(1977) and Piggott and Whalley (1977). In the US, one has
Fullerton et al (1978) and in Australia, Piggott (1980). Much
of this work is described in the book 'New Developments in AGE
analysis', edited by John Piggott (1985). Note that Warwick McKibbin describes his MSG model as 'a dynamic general equilibrium model of a multi-regional world economy'.

Most general equilibrium Scarf-type models were developed to study particular policy changes. The other group to develop the Walrasian scheme have tended to develop more long-lasting models of the whole economy. These stem from the pioneering work of L. Johansen with his 1960 model of Norway. Essentially this is based on the idea of taking logs and differentiating to create a linear model. Strangely the Scarf and Johansen groups appeared initially to be totally unaware of each other's work.

The Australian example of a Johansen type model is ORANI developed mainly by Peter Dixon in the IMPACT Project directed by Alan Powell. Now it is developed by Peter Dixon and Brian Parmenter at the Institute of Applied Economic and Social Research in Melbourne (see Dixon et al, 1982). This approach has developed greatly over the last ten years, partly through the mathematical expertise of Ken Pearson and the development of the GEMPACK set of computer programs for running models. Peter Dixon and Brian Parmenter have also now produced a forecasting version of ORANI simply called ORANI-F. These lie directly in the tradition stemming from Quesnay of a macroanalytic description of the economy based on a microanalytic theory of exchange and, as such, they are often called, rather confusingly, microeconomic models of the
Such models should be contrasted with models that use a microeconomic input-output core as a foundation for a macroeconomic model. An Australian example of this is the Institute Multi-Purpose model (IMP), developed largely by Peter Brain of the National Institute for Economic and Industrial Research. This is a highly detailed, largely Keynesian, demand-driven econometric model containing some 6000 equations in ten modules; apart from the main module, other modules cover demography, finance, energy transport, industrial activity, agriculture, international trade and telecommunications. There are two further modules, a linear programming module to determine patterns of demand for new energy types and a module splitting key aggregates by state. For further information see Peter Brain (1986).
7. The Value of Models.

Let me conclude quickly with some brief comments on the value of these various types of models. Firstly, modelling forces an open expression of theory in a logically consistent way. Great analysts may have magnificent subconscious models in their heads but they are of little use to other people and die with them. Models also help the analysis of the economy and the effects of policies. And, however much criticism they have received, they are also helpful in understanding the future. As Samuelson wrote 'However good is the qualitative judgment ... our judgment is kept tuned up by looking at computer forecasts.' One should not believe one model's forecast wholeheartedly. Rather the analysis of many different models' forecasts, and other people's personal judgements, help create better judgements in the on-going decision-making processes of government and private industry.

Different models reveal different aspects of the economic system. The aim of conferences on the models, and of modelling Bureaux, is not to produce one grand supermodel. It would probably be as bland as the well-known cartoon and now film super-hero. Different models implicitly summarise the implications of different theories and hence comparative analysis leads to greater understanding of these theories and inevitably to their development. One should not think of it as the 'War of the Models' but rather construe it as the
construction of a well-informed debate. And it is precisely this debate which I hope to enhance by the establishment of an economy-wide modelling Bureau to be called the Economic Modelling Bureau of Australia (EMBA).
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