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Quantitative Modelling at the Productivity Commission

Consultancy Paper

Philippa Dee
Australian National University

Background paper prepared for the 2004 Productivity Commission Conference.

The views expressed in this paper are those of the author and do not necessarily reflect those of the Productivity Commission.

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Publications Inquiries:
Media and Publications
Productivity Commission
Locked Bag 2 Collins Street East
Melbourne VIC 8003

Tel: (03) 9653 2244
Fax: (03) 9653 2303
Email: maps@pc.gov.au

General Inquiries:
Tel: (03) 9653 2100 or (02) 6240 3200

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Foreword

This publication was commissioned as a background paper for the Productivity Commission's conference 'Quantitative Tools for Microeconomic Policy Analysis' held in Canberra in November 2004.[1]

Policy modelling has played and continues to play an important role in the work of the Commission[2]. The objective of the conference was to provide an opportunity for the dissemination of new, data-related, modelling approaches, relevant to contemporary policy discussion. The conference participants comprised non-technical policy analysts and government advisors as well as economic modellers. Hence, the aim of the background paper was, as the author notes, 'to explain to a non-technical, policy audience, why modellers do what they do'.

The Commission is grateful to the author, Dr Philippa Dee, who is currently Visiting Fellow, Australia-Japan Research Centre at the Australian National University, and was previously an Assistant Commissioner at the Productivity Commission. Her unique combination of technical expertise and practical experience, is manifest in this insightful paper.

Gary Banks
Chairman

December 2005

[1] The conference proceedings are published in Productivity Commission 2005, *Quantitative Tools for Microeconomic Policy Analysis*, Conference Proceedings, 17–18 November 2004, Canberra.

[2] For a history of the Commission's activities over the last three decades see Productivity Commission 2003, *From Industry Assistance to Productivity: 30 Years of 'the Commission'*.

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Quantitative modelling at the Productivity Commission[1]

Tuesday 6 July 2004 was a typically fractious day for the members of the Senate Select Committee on the Free Trade Agreement between Australia and the United States of America. During the hearings, one of the Senators led one of the witnesses through the following line of argument.

The Senator distinguished three different types of evidence on the possible effects of the prospective agreement:

- modelling evidence;
- historical and comparative evidence; and
- pragmatic evidence — the opinions of the people who would actually be doing the trading under the agreement.

The Senator suggested that the modelling evidence could be discounted, because it was inconsistent — different modellers came up with different answers — and it was not based on fact, but rather a projection of what might happen in the future. Historical and comparative evidence was more powerful, because it was not a projection but had actually happened. And both the historical and pragmatic evidence pointed to the same conclusion — that AUSFTA was likely to be beneficial. The relevant historical evidence was that following NAFTA, trade and investment levels had increased between the partner countries. The relevant pragmatic evidence was that Australian business people were anticipating gains from AUSFTA.

Neither the Senator nor the witness acknowledged that, in reaching these conclusions, they were using a 'model' of their own. Their model was one that said that the growth of trade and investment flows between NAFTA partners had nothing to do with the growth in the size of the partner economies. Or if growth of the partner economies did matter, it was not enough to fully explain the growth of

1 The views expressed in this paper are those of the author and do not necessarily reflect those of APSEG or the Productivity Commission. This paper was commissioned as a background paper for the 2004 Productivity Commission conference *Quantitative Tools for Microeconomic Policy Analysis*. The conference papers are published in PC (2005).

trade and investment between them. Finally, the formation of NAFTA was the definitive explanation for this trade and investment growth, despite the availability of other explanations (eg proximity, reductions in trade costs), and despite aspects of the NAFTA agreement (eg its rules of origin) that could be expected to constrain trade growth and divert investment flows.

For the Senator, the facts spoke for themselves. But the relevant fact was not whether trade and investment flows had grown between NAFTA partners. It was whether they could have grown even more (including with non-NAFTA countries), had NAFTA not been formed. And this *counterfactual* was not observable.

What the modelling evidence (both econometric and computable general equilibrium) presented to the Committee had done was to *construct* a representation of the counterfactual.

When the Productivity Commission uses quantitative modelling, it is almost invariably doing the same thing — constructing a counterfactual. Modelling is the tool that economists use in the absence of being able to organise controlled experiments, in which two different real world outcomes would be generated — one with, and one without, the policy change in question.

The policy conclusions drawn from such modelling exercises often hinge on the sign and magnitude of the difference between the factual and counterfactual — that is, the *deviation from control*. The second section of this paper discusses the types of policy insights gained from the Commission's modelling exercises, and speculates on the extent to which they have influenced either the policy agenda, or policy outcomes.

The first half of the paper elaborates on some of the methodological issues to do with constructing the counterfactual. The intention is to explain to a non-technical, policy audience why modellers do what they do.

Throughout the paper, the examples are designed to be illustrative, rather than exhaustive.

1 How to construct the counterfactual

As hinted at above, the key difficulty with taking historical and comparative evidence at face value is that there is typically a multitude of reasons for those historical outcomes. To decide whether the policy change of interest had any role to play, it is necessary to *control for* the effects of all other influences.

The frustration for pragmatic, policy-oriented non-modellers is clear. The modellers spend an inordinate amount of time worrying about factors that are not of immediate policy interest. But the reason they do so is to avoid the possibility of a 'false positive' — attributing some efficacy to a policy when it was really some other factor at work.

1.1 Data-based techniques

Controlling for other factors does not always require techniques that would necessarily be called 'modelling'. The simplest way of controlling for other factors is to use *cross-classification*.

At the Commission, there has been ongoing interest in whether the recent acceleration in Australia's productivity growth is the outcome, at least in part, of microeconomic reforms. An early study looked at five case studies of industries that had undergone varying intensities of microeconomic reform, and compared productivity growth among industries of high and low reform intensity (PC 1999c).[2]

But Australia's measured productivity growth could have accelerated because of other factors. One alternative candidate was the greater use of higher skilled labour. Another candidate was the increasing use of information and communications technology (ICT).

In principle, one way of controlling for these factors would have been to split the sample of industries by skill use and ICT use, then to see how productivity growth varied with microeconomic reform among *sub-samples* that had the *same* intensity of skilled labour and ICT use. In this way, the influence of skill and ICT use would be controlled by cross-classification. But with only a small number of industries for which productivity growth could be computed, many cells in the cross-classification would have been empty. Even when using datasets as large as the Australian Census of Population and Housing, cross-classification can quickly come up against limits of small sub-sample size as the number of variables in the cross-tabulation increases.

So in this instance, other methods were used, which exploited variation over time, rather than cross-sectional variation at a point in time. Productivity growth was recalculated in a way that took account of the increasing use of skilled relative to unskilled labour over time. As expected, this adjusted productivity growth was

2 The Commission has disaggregated market sector productivity growth to the industry level, and the up-dated series are available on its website.

lower than unadjusted growth (Barnes and Kennard 2002). And an econometric approach was used to isolate the effect of ICT use on productivity growth, holding all else constant (PC 2004a). Together, the contributions of increasing skill and ICT intensity were found to account for some, but by no means all, of the acceleration of productivity growth. This stream of research, which includes Parham (1999), Barnes et al. (1999), Johnson et al. (2000) and Parham, Roberts and Sun (2001), is a good example of where a good deal of effort has gone into accounting for influences that are not necessarily of prime policy interest.

A related policy issue is whether the acceleration of Australia's productivity growth was the result of 'creative destruction' — the death of low-productivity firms and the birth and growth of higher productivity firms — or whether it was the result of improved productivity performance in ongoing firms. Here another data-based technique, *shift-share analysis,* was used to decompose changes in average firm-level labour productivity into:

- the contribution of changes in productivity within ongoing firms; and
- the contribution of changing shares of high- and low-productivity firms, arising from births and deaths.

The analysis by Bland and Will (2001), summarised in Parham (2002), found that the within-firm effects dominated net entry and exit effects.

Shift-share analysis can also be used to identify the effects of policy changes on economic outcomes, although it does not control for other factors in the way that cross-classification does. In PC (2003b), the Commission evaluated the effects of the Mutual Recognition Agreement and the Trans-Tasman Mutual Recognition Arrangement. One part of the evaluation was to see whether there had been an increase in the geographic mobility of registered occupations since the inception of the mutual recognition agreements. The analysis decomposed the changes in the number of arrivals in registered occupations into each State into (i) an effect due to changes at the national level, (ii) an effect due to changes at the State level for all occupations, and (iii) an effect due to changes at the occupational level for all States. If the joint contribution of the State effect and the occupational effect was positive for a particular State, it was taken as tentative evidence that mutual recognition boosted mobility. The approach did not correct for the influence of other factors, particularly age, that are known to have a strong impact on interstate mobility, and could have affected registered occupations over time.

1.2 Econometric analysis

Cross-classification is a particularly data-intensive way of guarding against ‘false positives’. Econometric analysis is a more parsimonious way of estimating the separate contributions of different factors to an outcome, and thus providing some protection against false attribution.

Econometric analysis estimates how much of the variation (over a cross-section, over time, or over both) in some outcome variable Y can be explained by variation in factors such as X_1 and X_2. A difficulty of attribution arises if there is some *common* variation between X_1 and X_2. Multiple regression analysis solves this difficulty by discarding the variation that X_1 and X_2 have in common. In attributing an influence of X_1 on Y, it uses only the variation in X_1 that is unique to X_1. Similarly, in attributing an influence to X_2, it uses only the variation in X_2 that is unique to X_2.

When trying to ascertain whether a policy has some discernable effect on an economic outcome, it is important to include both a measure of the policy (or a measure of the economic variable on which it has its first, most direct impact), as well as *all* the other possible candidate variables. If only the policy variable X_1 is included, then all of the variation in X_1 will be used in calculating the effect on Y, even if some of that variation is shared with some omitted alternative variable X_2. Thus some of the possible influence of X_2 on Y could be wrongly attributed to X_1 — a ‘false positive’.

If all potential influences are included in the analysis, however, then the estimated coefficients on each candidate variable measure the effects of that candidate on the outcome, holding the effects of all other candidates constant.[3] This is because they have been estimated using variation in a candidate variable that is unique to that variable. In this way, the coefficients from econometric analysis give a measure of the counterfactual (or can be used to compute one).

Some researchers point to the difficulty of obtaining data on all possible control factors X_2. But it is clear that exercises that make some attempt to do so will generally be significantly better than those that make no attempt at all, in that they will be more likely to avoid ‘false positives’.

3 In some techniques, such as Tobit analysis, the raw coefficients do not measure marginal effects, but the marginal effects can still be recovered through additional calculation.

Some examples

In the latest work on the determinants of productivity (PC 2004a), the labour productivity of firms in eight industry sectors was econometrically estimated to be a function of:

- the impact of ICT use, allowing for dynamics and lags[4];
- other factors that are conventionally regarded as influencing growth, including growth in fixed capital, lagged labour productivity (to allow for conditional convergence) and firm size; and
- complementarities between ICT use and firm characteristics.

What has yet to be done is to examine econometrically the determinants of productivity in a more comprehensive way, that takes account of all the possible influences — not just ICT use, but skills upgrading, some measure of microeconomic reform intensity, and also allowing for possible interactions between them. A challenge in doing so will be to come up with a numerical measure of microeconomic reform intensity. This issue is discussed in more detail later.

In another piece of econometric analysis, Commission researchers examined the effects of youth wages on youth employment (Daly et al. 1998), the context being a review by the Australian Industrial Relations Commission of whether junior rates (specified in many Federal and State awards) should be replaced by 'non-discriminatory' alternatives. Here, the econometric problems were the opposite to those above. Available data sources provided reasonable measures of the policy variable of interest — youth wages — but did not provide adequate data on all of the desired control variables, particularly the price of capital. The study came up with reasonably robust estimates of a negative relationship between youth wages (the policy variable) and youth employment (the outcome variable), but its findings on the degree of youth-adult labour substitution were less robust, because they could not correct for substitution between unskilled youth labour and capital.

One commentator on the youth wage analysis noted an additional problem — the lack of in-sample variation in the policy variable of interest. He suggested that in trying to draw conclusions about policy efficacy, the Commission should draw more on datasets from other countries, including developing countries, where variations in youth wages were much higher than in Australia. This would provide a

4 The predicted values of ICT use were included in the model, based on the characteristics of firms relevant for adoption. This lessens some of the endogeneity and causality problems discussed later.

much stronger econometric test. The point is more general than in just a youth wage context.

In examining the historical effects of preferential trading arrangements, Commission researchers had no choice but to use an international dataset (Adams et al. 2003). The analysis of the effects of preferential agreements such as NAFTA on trade and investment flows between partner countries corrected for a wide range of other possible influences on those trade flows, much more so than previous studies.

As a final example, a suite of studies by Commission researchers examined econometrically the determinants of non-traditional types of employment (Murtough and Waite 2000a, 2000b, Waite and Will 2001, 2002). The determinants were limited to the personal characteristics of the workers, and the industry in which they were employed. The econometric approach meant the analysis could identify the *independent* influence of factors such as gender — whether it mattered in itself, independently of other factors (such as occupation) with which it might have been correlated.

Correlation or causation?

The discussion so far suggests that to construct a counterfactual, the only requirement is to come up with an outcome variable, some candidate variables that might influence it, and regress one on the others. This approach can identify correlation. But a key question is whether it identifies causation. Finding a significant econometric relationship between Y and X_1 would be consistent with a change in factor X_1 *causing* a change in Y. But it might equally reflect that X_1 has *responded* to a change in Y.

There is no definitive *empirical* technique that will distinguish correlation from causation. Granger causality tests are routinely used in the literature. While helpful in many contexts, they rely on the logic of *post hoc, ergo propter hoc*. This logic can be misleading. It implies, for example, that Christmas cards cause Christmas.

Theory can be helpful in distinguishing correlation from causation, but again it will not be definitive. When economists build theoretical models, the behaviour of the *exogenous variables* (the things taken as given by the model) can be said to be *causing* the behaviour of the *endogenous variables* (the things explained within the model). So in a standard general equilibrium model, the behaviour of the prices and quantities of final goods is said to be *caused by* the behaviour of consumer tastes, production technologies, and factor endowments (the givens).

This means that in constructing a counterfactual, econometric modelling should be guided by economic theory, to ensure that the causal factors are truly exogenous —

taken as given, either to the economy as a whole (such as endowments, in a general equilibrium model), or to the economic agents whose behaviour is being explained (such as prices, in a model of consumer choice).

Theory can be helpful, but it will not be definitive. Theoretical models may also omit relevant factors, and there may be competing models with alternative views of causation.

In an economic model, two endogenous variables will vary together, not because one is causing the other, but because both are responding to variations in the exogenous variables. Econometrically, regressing one of these endogenous variable on the other will suffer from two problems. It will identify correlation, not causation. And the endogenous variable that is being treated as the explanatory variable will not be uncorrelated with the error term in the equation, leading to a biased estimate, not just of the relationship between them, but of the influence of any other explanatory variables in the equation.

This is not to say that in econometric analysis, one endogenous variable should never be regressed on another. Commission researchers routinely use economic theory to construct estimating equations where some endogenous economic outcome variable is a function of some exogenous policy measure, plus other endogenous variables. They are typically happy to accept that the policy measures are exogenous. What is required is to recognise whether other explanatory variables are endogenous, and use the appropriate estimating techniques to correct for the bias that would otherwise occur in the estimated relationship between the policy variable and the outcome variable.

Econometric estimation techniques

The Commission's econometric work has sometimes, but not always, made use of the appropriate econometric estimation techniques. It has generally used the appropriate techniques when the outcome variable of interest has been discontinuous — either discrete (as in the studies of non-traditional types of employment) or censored (as in the study of preferential trading arrangements). Commission researchers have also made use of the econometric techniques available to correct for *unobservable heterogeneity* — unobservable extraneous factors that might also account for the observed outcomes (for example Adams et al. 2003, Gabbitas and Gretton 2003). These techniques exploit the separate dimensions of variation across time and across cross-sections that are available in panel data. Commission researchers have not always made use of the techniques available to deal with selection bias (eg the Heckman two-step selection model — Gabbitas and Gretton 2003 would have been a suitable candidate). And

Commission researchers have rarely made use of available techniques (instrumental variables, systems estimation) to correct for two-way causality and the endogeneity of some of the explanatory variables. In productivity studies, for example, neither fixed capital quantities nor ICT use are strictly exogenous, and a common way to treat this problem is using instrumental variables.

Having said that, endogeneity may not be the only econometric problem, nor even the most important problem, that needs to be dealt with. And econometric software packages are limited in the number of econometric problems they can deal with at once. Thus, for example, it was not possible to estimate the dynamics of the relationship between the formation of preferential trade agreements and the resulting changes in trade flows, when the issues of censored data and unobserved heterogeneity also had to be dealt with. But instrumental variable estimation can be combined with a number of other estimation techniques, and should probably be used more in the econometric work of the Commission.

Econometrics versus 'structural modelling with behavioural parameters'

For a number of economic issues where the relevant theory is complicated (and hence issues of endogeneity are rife), the Commission will often construct the counterfactual by building a structural model with multiple equations (it may be either partial or general equilibrium), and choosing values of the behavioural parameters from a survey of the literature, rather than by estimating the full system econometrically.

There are two reasons for this. One is that it allows a bigger, more complex model system to be built than could be estimated in-house in the time available for a typical Commission study. Second, the outcome variable that is often of critical interest to the Commission — the change in overall economic well-being — is not directly observable, so cannot appear directly as the *Y* variable in an econometric model.

Instead, changes in economic well-being need to be measured as the combination of changes in:

- consumer surplus — the excess of a consumer's willingness to pay over the amount they actually have to pay for goods and services; and
- producer surplus — the excess of revenue received over the real resource cost of producing those goods and services.

So structural models of consumer and producer behaviour need to be constructed, and the results for changes in economic well-being imputed after further calculation. And the model has to be sufficiently structural, rather than reduced form, for this to occur. How such models are used to construct a counterfactual is discussed shortly.

What to do when the policy variable of interest is not readily quantified?

The single biggest modelling challenge faced by the Productivity Commission and its predecessors over the last decade has been that increasingly, the policy changes of interest do not come with a ready number attached, as they did with tariff changes.[5] Increasingly, the policy changes of interest are regulatory, and can be as subtle as bringing the unincorporated sector under the umbrella of the Trade Practices Act. For either econometric estimation or structural modelling purposes, the issue is how to conceive of the associated X_1 variable, and how to measure the magnitude of the policy change.

The exogenous policy variables that are traditionally included in economic models are of two types — tax-like instruments, and productivity shifters. So the approach overwhelmingly taken at the Commission has been to conceive regulatory policies in terms of their tax or productivity shifter equivalents. This approach has been criticised. Some think that our microeconomic modelling should get sufficiently ‘micro’ for regulatory instruments to be represented directly. To model the Trade Practices Act, for example, would require a model with an explicit concept of abuse of market power, and an explicit regulatory barrier preventing it — ideally one that captured whether the ban was *per se*, or required some burden of proof.

The techniques for converting regulatory changes into their tax and/or productivity shifter equivalents have become sufficiently sophisticated that they may yet provide a mechanism for eventually modelling the regulations directly.

Initially, the method used to compute tax or productivity shift equivalents was benchmark analysis. The prices or productivity of enterprises that had or had not undergone some regulatory reform was compared, and the difference was attributed to the reform process. The gap then became the amount by which prices or productivity could improve if reform were instituted elsewhere. This was the method used in the Industry Commission studies of the performance of major infrastructure industries in the early 1990s, which then fed into several studies of the effects of National Competition Policy reforms (IC 1995, PC 1999a).

The benchmarking exercises were criticised for comparing apples and oranges. In other words, the simple bivariate approach did not control for all the other factors

5 Continuing streams of work in the Commission have been the estimation of effective rates of protection, and of rates of budgetary assistance.

that might account for differences in price or productivity performance of enterprises in the reformed and non-reformed jurisdictions.

More recently, an econometric approach has been taken, both in the Commission and elsewhere, to undertake a more sophisticated version of benchmarking — one that corrects for other relevant factors that might affect performance. As before, not all possible control factors might be included, but including some is a significant improvement on including none.

The Commission’s work has been in the context of quantifying barriers to services trade. These barriers are overwhelmingly behind-the-border, non-price regulatory barriers. The methodology used to quantify their direct price or productivity effects at the sectoral level is spelt out in Findlay and Warren (2000). There are two key steps.

The *first step* is to convert qualitative information about regulatory restrictions into a quantitative index, using a priori judgements about the relative restrictiveness of different barriers.

The *second step* is to develop an econometric model of what determines economic performance in a sector, and use it to estimate the effect of the services trade restrictiveness index on some measure of economic performance (typically price, cost, price-cost margin, quantity or productivity), while controlling for all the other factors that might affect performance in that sector. The appropriate control variables obviously vary from one sector to the next. In fixed line telecommunications, they include household density, in mobile telecommunications they include population density, and in electricity generation they include the proportion of electricity generated from hydro and nuclear sources.

It is also possible to use the econometric stage to test the weights that were assigned a priori to different categories of restrictions in the first stage, essentially by reestimating them. This is done by entering the sub-index scores for the different categories of restrictions separately into the estimating equation.

Often this approach is precluded by one of two econometric problems — multicollinearity between the restrictiveness index components, or lack of in-sample variation in one or more of the components. The OECD’s evaluations of regulatory policy (Gonenc and Nicoletti 2000, Boylaud and Nicoletti 2000, Steiner 2000) pioneered the use of factor analysis to overcome these problems. This groups index components into linear combinations that are similar to each other, but different from (technically, orthogonal to) other groups, and examines the effects of these linear combinations on economic outcomes.

Once the econometric estimation is completed, the estimated coefficients give the 'on-average, per unit' effects of services trade restrictions. Total, country-specific measures of economic impact (ideally, equivalent to vertical shifts in supply or demand curves) can be calculated by multiplying the coefficient(s) by their associated restrictiveness index measures for that country. The latter measures can also be turned into 'tax equivalent' or 'productivity shift' equivalent measures for that country (depending on the exact performance measures chosen). These give the direct impact of services trade reform on the particular sector in question.

The restrictiveness indexes are essentially slightly more sophisticated versions of zero-one dummy variables, and should be given no more attention in their own right than dummy variables. What matters is the first round tax or productivity shift equivalents. To estimate these requires building detailed models of what determines performance *within* each sector. This provides tax or productivity shift equivalents of regulatory policy, akin to the tariff rates associated with tariff policy. These can then be used if necessary in a separate *intersectoral* model to trace spillover effects to other sectors and the economy as a whole. As the within-sector modelling gets more sophisticated, and more structural, it may yet be incorporated into the intersectoral models directly.

The suite of Commission work on services trade barriers includes McGuire (1998; on financial services), Holmes and Hardin (2000; service sector investment), McGuire and Schuele (2000; banking), McGuire, Schuele and Smith (2000; maritime services), Kalirajan et al. (2000; banking), Kalirajan (2000; distribution), Nguyen-Hong (2000; professional services), and Doove et al. (2001; international air passenger transport, telecommunications, electricity generation). Similar work by other Australian researchers is reported in Findlay and Warren (2000), including the work on telecommunications by Warren (2000). Similar work by the OECD (of which Doove et al. is an extension) is cited above. Fink, Mattoo and Neagu (2001), Clark, Dollar and Micco (2001) and Barth Caprio and Levine (2002) are three examples from the World Bank.

1.3 Structural modelling — partial equilibrium

The Commission's structural modelling is most commonly used to construct a *future* counterfactual — how different the world would look at some future point if a policy not yet in place were instituted, compared to how it would look at that same future point under a business-as-usual scenario. It can do this because, in a structural model, if not in the real world, it is possible to carry out a controlled experiment — to change just the policy variable of interest, while holding all other exogenous causal factors constant.

But the partial equilibrium modelling of Gregan and Johnson (1999), used to inform the Commission's inquiry into international air services (PC 1998b), was one example where structural modelling was used to generate an *historical* counterfactual.[6] The model of international airline networks was built at a time when Ansett had just entered competition on nine international routes. History was rewritten, and the counterfactual generated, by removing Ansett from those routes.

The model suggested that the entry of Ansett had generated a net benefit to Australia. While the producer surplus of Australian airlines had fallen, the consumer surplus of Australian consumers had increased. The finding was significant because, unlike in many other situations, the gain in consumer surplus was not a 'sure thing'. Consumers could benefit from lower prices, but consumers also had a preference for fewer airlines flying routes more frequently. The entry of Ansett put downward pressure on prices, but also led to more airlines flying routes less frequently. The model was sufficiently detailed and structural to pick up these tradeoffs, and to trace the implications through for overall economic well-being.

Earlier partial equilibrium modelling by Industry Commission researchers had similarly identified the net welfare gains from changes to the structure of domestic retail prices, and to international accounting rates, in telecommunications (IC 1997a, 1997b). It is instructive that by the time the international policy issue was referred to the Productivity Commission as a formal inquiry (PC 1999b), technology had changed sufficiently to render much of the previous policy concern about international accounting rates superfluous.

As a final example, partial equilibrium analysis was used by Commission researchers to quantify the net welfare cost of various forms of State taxation in Australia (Gabbitas and Eldridge 1998). The analysis went beyond many previous exercises by showing that the net welfare cost of some forms of State taxation was exacerbated because the State taxes were levied in conjunction with pre-existing Federal taxes.

1.4 Structural modelling — general equilibrium

Good partial equilibrium analysis is a prerequisite for understanding any microeconomic policy issue. Partial equilibrium modelling may be *all* that is required when the policy change of interest affects a relatively small sector of the economy — technically, where the income effects of the policy change are small. General equilibrium modelling may also be required when the policy change affects

6 Earlier, the Industry Commission assessed market power in the South Australian electricity market, using a similar method (IC 1996).

a large sector of the economy, or multiple sectors, and where income effects are likely to be significant. It is also sometimes used, as in Dee, Hanslow and Phamduc (2000), when inter-sectoral linkages are of direct interest in themselves. Sometimes the partial equilibrium models of sectoral behaviour embedded within general equilibrium models are sufficient to inform the general equilibrium analysis. Sometimes they are not detailed enough, so, as in the analysis of services trade barriers, it is helpful to build separate partial equilibrium models to inform the general equilibrium analysis.

Some economic phenomena of policy interest can start small but grow to be big. Foot and mouth disease is a good example. The epidemiology of the disease is such that it can spread widely from a single point source. To trace through the economic consequences of an outbreak, the Commission used a combination of partial and general equilibrium techniques (PC 2002a). It used a spreadsheet-based cash-flow model of livestock production over time to quantify the likely time profiles of production, domestic consumption and export supply changes for a number of cattle, sheep and pig products separately. This was essentially a 'poor person's' version of a partial equilibrium model of livestock production, consumption and trade. It then used a general equilibrium model to trace through the flow-on consequences for the regions of Australia and for the economy as a whole.[7]

The foot and mouth study was also an example where the Commission used modelling to compare the effects of several different policy responses to an outbreak. An extended 12 month outbreak was projected to be particularly costly to Australia, because Australia's agricultural exports would be locked out of disease-free foreign markets. A vaccination program was shown to reduce the costs somewhat. A zoning program, whereby disease-free regions of Australia would be quarantined and seek international acceptance to continue exporting, was shown to reduce the costs substantially. Thus the study provides some clear economic guidance should an outbreak occur.

One Commission study used a conventional *single-country* general equilibrium model to examine prospectively the likely effects of introducing a GST (PC 1998a). The modelling included a brave attempt to quantify the distributional impacts, by reconfiguring the model's results for returns to labour by occupation and industry into returns by income group. A referee of the modelling highlighted several important drawbacks of this approach. One was that a full evaluation of distributional impacts should account for the effects on the distribution of

7 Especially for computable general equilibrium models, the Commission continues mostly to use or adapt models owned or maintained outside the Commission, many of them developed with financial and other assistance from the Commission (see Powell and Lawson 1986); or it out-sources the modelling work.

consumption expenditure as well as on income. Indeed, the introduction of a GST was expected to have different distributional effects in these two dimensions. A second point was that working with groups rather than individuals had the disadvantage of averaging some of the most vulnerable individuals of interest into non-existence. The comments suggested that further research on distributional impacts should be done at the unit record level, combining both income and consumption data, as is done in microsimulation models.

Several more recent Commission reports used single-country general equilibrium modelling to examine the likely effects of prospective unilateral tariff changes (PC 2000, 2002c, 2003a). Here the economy-wide results highlighted how the gains from tariff reform are somewhat different in a generally low-tariff environment. The modelling also went further than previous tariff exercises in tracing through regional impacts. Finally, while the exercises did not quantify the full distributional impact, they did use a subsidiary module of gross labour market transitions to quantify possible labour market adjustment costs. The results accentuated the distinction between the 'deviation from control' results of most models and the 'absolute change' perspective that most people (including some Commissioners) carry in their heads. The results suggested that, even if employment levels in some industries were to be lower than otherwise at some future point as a result of tariff cuts, so long as the employment levels were still higher than they are now, then labour market adjustment costs would be minimal. The underlying policy message was that healthy rates of underlying economic growth could do a great deal to cushion the adjustment costs associated with structural change.

One general equilibrium modelling exercise has used a conventional *multi-country* modelling framework to quantify the effects on Australia of a preferential change in Australia's tariffs on imports from least developed countries (PC 2002b). The exercise was of policy interest by showing that the bulk of the adjustment would fall on countries, such as Fiji, with whom we currently have preferential arrangements, rather than on Australian producers. But this conclusion came most strongly, not from the general equilibrium analysis, but from the accompanying examination of trade patterns at the tariff line item level, evaluating the degree of similarity between the goods that the least developed countries would export to us, and the goods that Australia was currently producing or importing from existing preferential partners. This was one example where multi-country models, at their conventional level of commodity aggregation, are not sufficiently detailed to pick up the full impacts of preferential trade arrangements.

Another use of multi-country modelling was the examination by Commission staff of the impacts of Australia and/or other countries adopting genetically modified (GM) technologies in crop production (Stone, Matysek and Dolling 2002). The conclusion was that Australia would lose out if it did not adopt GM technologies while other countries such as the United States did, though this assumed no price premiums emerged for GM-free production. If Australia did also adopt GM technologies, the gains to Australia would be small.

This was one example of using a multi-country model to generate a payoff matrix of strategic interaction between countries. What was not done formally, but could be, was to use the payoffs to compute the Nash equilibrium of a non-cooperative game in which each country made a decision about its own GM adoption, taking account of the likely best response of its trading partners.

Another, similar example of using multi-country models to generate the cells of a payoff matrix was by Dee and Hanslow (2000), who used a multi-country model framework to examine the likely gains to each country from various combinations of partial or full liberalisation of services trade on a multilateral basis. The results were used to draw some general conclusions about the likely best sequencing of multilateral services trade negotiations, though again without a formal game-theoretic solution.

One innovation in the services trade modelling was to incorporate imperfect competition and firm-level product differentiation into the 'partial equilibrium' microeconomic foundations of the general equilibrium model. The treatment of imperfect competition was large-group monopolistic competition. A modelling challenge will be to incorporate oligopolistic behaviour where appropriate. Neary (2002) shows how this can be tractable.

Another innovation was to recognise that, because services trade negotiations now cover services delivered via commercial presence, the modelling framework had to include foreign direct investment as a mode of services trade delivery, and cover separately the production and trading activity of foreign multinationals. In other words, a conventional multi-country model had to be split out by ownership as well as location.

The exercise was still highly stylised, in at least two respects. First, it covered only a single aggregate services sector, although Verikios and Zhang (2001) is a first attempt at disaggregation. Second, it treated all services trade barriers as if they were tax-equivalent — that is, that they inflated price-cost margins. Subsequent research (including Kalirajan 2000, Nguyen-Hong 2000 and Doove et al. 2001) has hinted that at least some important services trade barriers may instead raise real resource costs, and so should be modelled via productivity shifters. The distinction matters a lot. First, in a unilateral or multilateral context, reducing barriers that escalate costs will deliver a much bigger 'bang for the buck' than reducing tax-like barriers. Second, in a preferential context, only with those trade barriers that are tax-like is there a danger of welfare losses from trade diversion (see also Adams et al. 2003).

A final example of general equilibrium modelling is by Laplagne, Marshall and Stone (2001). They used a single-country modelling framework to try to resolve the question of whether the observed increase in demand for skilled relative to unskilled workers was due to growing competition from unskilled-intensive imports from overseas, or due to skill-biased technical change at home. The findings were in favour of skill-biased technical change.

This use of general equilibrium modelling differs from the others, in that it is essentially running the model in reverse. Normally, some change is hypothesised in an exogenous variable, and the effects traced through to the endogenous variables. In this case, the hypothesised change in the exogenous variable is said to be *sufficient* to cause the resulting change in the endogenous variables. In plain language, this particular exogenous change will do the trick, though it does not rule out the possibility that some other exogenous change would also do the trick.

But sometimes, economists want to be able to say that some exogenous change is *necessary*. In other words, *only* this particular exogenous change will do the trick, and no other. To prove necessity, the model is run in reverse. The particular observed outcome for the endogenous variable is hard-wired into the model, and the model solved 'in reverse' to see which exogenous change is consistent with it.[8]

And this is what the last example of general equilibrium modelling did. Observed changes in economic variables, including employment by skill, were fed into the model, and a range of exogenous factors, including skill-biased technical change variables, were allowed to float freely until they reconciled with the observed outcomes.

The conceptual difficulty is that proofs of necessity only work if the resulting set of changes in exogenous variables is *unique*. The practical difficulty is that the various productivity shifters are not the only unobservable exogenous entities in the model that could have been allowed to adjust to reconcile with observed outcomes. In particular, the trade parameters could also have been varied. The standard values for the trade parameters in the forecasting version of the model that was used are relatively low (see also PC 2002c). With higher trade parameters, the trade explanation could have had more weight relative to the skill-biased technical change explanation. Indeed, other researchers are doing precisely this — adjusting the trade parameters in multi-country models to find out what values are required to reconcile

8 See also the historical simulations outlined in Dixon and Rimmer (2002), and the 'forces of history' method in PC 1999a.

with observed changes in bilateral trade patterns, while keeping most productivity shifters, or at least the biased ones, fixed (eg Gehlhar 1997, Hillberry et al. 2001). The broader policy message is that model-based proofs of necessity are no more bullet-proof than model-based proofs of sufficiency, unless the question of uniqueness is addressed.

2 Policy impacts

Modelling frameworks, whether they be data-based, econometric, partial equilibrium, or general equilibrium, are used by the Commission to construct the counterfactual. The above discussion outlines why modellers do what they do in order to achieve this.

An earlier paper (Dee 1994) discussed how to do it well. What can be said here is that the advantage of constructing something that is unobservable is that you can never be proven conclusively wrong by simple observation. This is why the Commission has always stressed that modelling is just one of many inputs into its deliberations. Considerable judgement is also required, including judgements about the congruence of the modelling results with ‘pragmatic evidence’. Often the two are not congruent because the pragmatic evidence takes a narrow sectional view, while the modelling is economy-wide. But sometimes the modelling could be just plain bad, or wrong. One innovation in the legislation that established the Productivity Commission was a requirement to either have modelling reviewed by an outside reviewer, or to use two models. Both types of discipline have been invaluable in improving the quality of what is done, if not always ensuring that the best *type* of modelling is done.

This section discusses the potential policy impact of the Commission’s modelling work. The next section concludes with some observations about fruitful new directions for future modelling efforts.

Some streams of the Commission’s research have been designed to influence the policy agenda, rather than policy outcomes.

The work on productivity and its links to microeconomic reform is in this category. A leading (or is it contemporaneous?) indicator of microeconomic reform fatigue was the scepticism expressed in some circles about whether Australia’s economic performance had improved, and a suspicion that microeconomic reform had contributed more ‘destruction’ than ‘creation’. The Australian economy’s resilience in the face of the Asian financial crisis was a powerful indicator to the contrary. The Commission’s careful analysis confirming an acceleration of productivity growth, and examining the factors driving it, has also be influential in shaping some sort of consensus.

The Commission's work on forms of non-traditional employment has also been agenda-setting. There has been a tendency among the Industrial Relations community to want to guard against unfortunate *individual* employment outcomes by maintaining constraints on industrial relations *institutions*, including the types of employment contracts that can be written. A conclusion of the Commission's research was that:

> … whether an employee has a casual contract provides little information about his or her welfare. Where the concern is about so-called 'precarious' employment, analysts need to identify such employment on the basis of work arrangements rather than the type of employment contract. (Murtough and Waite 2000a, p. ix)

Consistent with the aim of being agenda-setting, both strands of research have been widely and well-reported in the press on their release.

The stream of work on services trade reform is also designed to be agenda-setting, in highlighting to governments of the region how the economics and political economy of services trade reform differ from that of goods trade. When a summary of that work was presented to trade negotiators in Geneva, it was clear that their thinking on services was still heavily influenced by tariffs and goods trade, so much work has yet to be done. This should include 'selling' the results of the research to the individual governments of the region.

Other modelling research, while not being agenda-setting, may have helped to pre-empt unfortunate developments at an early stage. The analysis of APEC's early voluntary sectoral liberalisation (EVSL) initiative (Dee, Hardin and Schuele 1998) was undertaken shortly after the initiative was announced. The analysis highlighted significant problems with the proposals for chemicals, forest products and food. This may have come as a surprise to some, given that earlier research within the Industry Commission had indicated significant gains from achieving APEC's Bogor goals. Subsequent analysis by overseas researchers confirmed that in succumbing to the temptation to 'cherry-pick' the easy targets for liberalisation, the (EVSL) initiative risked worsening the dispersion in tariff rates up and down the production chains in which these sectors operated, worsening economic well-being. APEC's EVSL proposals were subsequently passed on to the WTO, seen by many as being a more appropriate forum for the actual process of trade negotiation, within the broader disciplines of non-discrimination, reciprocity and a 'single undertaking'.

In the Commission's traditional tariff inquiries into textiles and passenger motor vehicles (PC 2002c, 2003a), the less-than-spectacular modelled gains from further tariff reform contributed to reports to Government that were far mare nuanced than previously. The Government largely accepted the Commission's recommendations on the tariff front, but offered additional adjustment assistance.

The Commission's research (PC 2002b) into the effects of removing tariffs on imports from least developed economies was clearly a 'winner', with the Government announcing the immediate removal of tariffs and quotas on goods from 49 least developed countries and East Timor from 1 July 2003. The least developed countries gain at the expense of countries such as Fiji, with little impact on consumer or producer surplus in Australia.

The Government offered qualified acceptance of the Commission's recommendations on international air services (PC 1998b) in the areas where modelling had had some input. In addition to demonstrating the benefits from the entry of one airline into the international network of routes in the region, the modelling had also demonstrated net benefits from the formation of an 'open club', taking account of how airlines would reconfigure their regional networks after formation of the club. The Government accepted that Australia would seek to negotiate reciprocal open skies arrangements with like minded countries 'where this was in the national interest'.

The staff research into the costs of State taxation was published shortly before the GST was announced. The report had concluded:

> Broadening the current set of State taxes would offer scope to use taxes which are not only more efficient, but also more equitable. However, options that involve a broad expenditure or income base — allowing a reduction or replacement of the more distorting existing taxes — would require the cooperation of the Commonwealth and/or amendments to the Constitution. (Gabbitas and Eldridge 1998, p. xxxii)

Thus staff foreshadowed the necessity of Commonwealth involvement, without anticipating that the Commonwealth would pre-empt much of the concern about the inefficiency of some State taxes by offering to use revenue from the GST to replace them. The report's results on land tax raised interest in New South Wales at the time, with Commission staff being asked to make a presentation in Macquarie Street. And it is hard to imagine that the report was not waved in the corridors of Commonwealth Treasury during the formulation of the GST.

That the report on youth wages and employment had policy impact is evidenced by the fact that the research manager received a personally signed letter of thanks from the Minister for Employment, Workplace Relations and Small Business shortly afterwards.

May Australia never have to test the efficacy of the Commission's model-based findings on the costs of a foot and mouth disease outbreak and its containment.

3 Directions for further modelling research

Some of these have been flagged already. One is a more encompassing approach to the determinants of productivity growth. Another is greater attention to issue of endogeneity in the Commission's econometric analysis. A third is the possible use of formal game theory to help formulate the best policy strategies in light of the findings from multi-country modelling. These are essentially ways of improving on the modelling that is currently being done.

Of possibly more importance is the modelling work that is not being done but could be.

One area of policy concern to the Commission is the issue of adjustment costs. An avenue for further modelling research would be to parameterise properly the models of labour market adjustment costs that are currently in stylised form. Commission researchers have already done some of the necessary econometric work, examining what determines the probability of displaced workers finding reemployment (Murtough and Waite 2000c). Other relevant econometric work would be survival analysis of the determinants of the duration of unemployment. Such analysis may already be available. Surveying or undertaking this work would be of interest in its own right, but could also be used to improve the quality of the Commission's analysis of adjustment costs.

Related modelling would be to develop microsimulation modules using unit record data that could sit below existing general equilibrium models, to tell stories about distributional impacts. This would be complementary to, not a replacement for, the work that quantifies labour market adjustment costs. The reason is that microsimulation models can readily evaluate impacts on individuals, but tend to have few behavioural responses, so only evaluate individuals in their current employment state. By contrast, the labour market adjustment cost modules take account of labour market transitions across regions, across occupations, and between employment and unemployment.

Another major area of policy concern for the Commission is the costs of inappropriate regulation. This is an area where little empirical work has been done, save in the area of services trade reform.[9] It is telling, for example, that the Commission's recent report into the gas access regime (PC 2004b) was the third major report on access issues after PC (2001a) and PC (2001b) to conclude that, because the counterfactual could not be observed, nothing definitive could be said

9 A first step was taken in PC 2003c, producing a probability distribution of the estimates of the costs to general medical practices of administration of and compliance with government programs.

about whether the access regime was unduly deterring investment. It is not that the counterfactual scenarios need to be fed into a model. It is that the counterfactual needs to be *constructed using* a model.[10] And if the model has to be specific enough (as in the airline and foot and mouth examples) to capture the essentials of a particular jurisdiction or piece of infrastructure, then so be it.

The ongoing challenge is to recognise that counterfactuals can be constructed — that is what models are for — and to continue to grapple with how to characterise and quantify the exogenous policy input in a regulatory context.

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10 For example, in exploring the effects on rates of return, of regulation of charges for access to gas pipelines, the Commission (2004b) applied simulation techniques to the Capital Assets Pricing Model.

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