Using CBA and CGE in Investment and Policy Evaluation: a Synthesis

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Abstract

Using CBA and CGE in Investment and Policy Evaluation: a Synthesis

The traditional way of evaluating investments has been that of Cost Benefit Analysis (CBA) - however, in recent years there has been a growing use of Computable General Equilibrium (CGE) models in investment evaluation. At one level, they have been regarded as different techniques, addressing different aspects of the evaluation problem. At a second level, the two can be complements, each providing an assessment of the investment. At the third level, they can be integrated into a general equilibrium evaluation of the investment. The current practice is at the first level- but the view put forward here and we can go beyond this, and that they are best seen as complements, and potentially, integrated. By using both, it is possible to gain more accurate measures of how much better off the economy will be as a result of implementing the project. This paper analyses the different advantages and limitations of the two techniques. One issue which needs to be addressed if CGE models are to be used in assessing whether an economy is better off as a result of the project is that of welfare measurements. Some CGE models have a welfare measure, while others do not- however welfare measures can be built into models. CBA has problems in handling what are essentially general equilibrium problems. By addressing the limitations of the two techniques it is possible to develop much more reliable measures of the net benefits of investments.

1 Introduction[1]

Cost Benefit Analysis (CBA) has long been the standard technique of project evaluation, though there have been some use of alternative approaches, such the use of Input Output (IO) models. More recently, there has been a growing use of computable general equilibrium (CGE) models as a technique of project evaluation- CGE models have been used extensively in economic policy evaluation, in some countries more than others, though their use in project evaluation is becoming more widespread. In Australia, for example, most major infrastructure projects are now subjected to a CGE evaluation, often in addition to a CBA. CGE models are now used in this way in the UK. This this use poses the question of what the roles of the different techniques are, and should be.

We can distinguish three levels at which the two can be used:

- Firstly, there is the use of the two techniques to analyse different aspects of the evaluation problem. For example, a CGE model might be used to measure the impact of the project on GDP, while the CBA might be used to measure the impact on net social benefit or welfare. Currently, this is the way most CGE studies are used in the investment evaluation problem.

- Secondly, the two techniques can both be used to estimate how much better off the economy is as a result of the investment. Typically this is not done at present, but there is no reason why it cannot be done. The two would have different limitations and hence will give different results- this means that there is an interpretation issue to be solved. Use of the two will result in more information about uncertain magnitudes being available to the decision maker.

- Thirdly, in principle, a third level, of integration of the two techniques, is feasible. This may require a high level of disaggregation of the CGE model used, and the use of more sophisticated benefit measures than is common with current CGE models (feasible using the theory of CBA). The result will be a single, general equilibrium, evaluation of the project.

In this paper, it is argued that the CGE approach is an important advance in project evaluation which should be used, where possible. CGE models are currently used to examine different aspects of the project evaluation- the first level. However there is no reason why they cannot be used to estimate the net effect of the project on welfare or net social benefit- the second level.

Both CBA and CGE models do have limitations, but these are (currently) complementary, and thus they can be used together to gain a more accurate evaluation of the project. There are several ways in which CBA and CGE models can be used together. At a basic level, a

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CGE model can be used to estimate key shadow prices. It can also be used to estimate aspects of the project which CBA has difficulty with, such as income distributional effects and measurement of greenhouse gas emissions. A CGE model can be used to be the primary evaluation tool- one which can assess general equilibrium (GE) effects (in theory, CBA takes account of GE aspects of a project (Dreze and Stern,1987) - but in reality, most CBAs are partial equilibrium (perhaps with an estimate of some indirect effects). With current limitations, the best approach may be to produce both a CBA and a CGE simulation, and compare the two to gain a more accurate estimate.

This paper addresses several issues:

- Firstly, the roles of CBE and CGE models in investment evaluation are set out;
- Next the characteristics of CBA and CGE are explored- this covers how the two measure welfare, issues of disaggregation with CGE models, the partial and general equilibrium evaluation, how the two handle externalities and non-market goods, macro and regional effects, and how employment issues are handed;
- Thirdly, the paper discusses how net social benefit or welfare can be measured- CGE models can (but not always do) provide welfare measures identical to those of CBA;
- Fourthly, the ways in which the two techniques can complement one another to improve evaluation are explored- these include handling difficult-to-value aspects such as inbound tourism, distribution, and key shadow prices;
- Practicalities such as cost, disaggregation and data requirements are important and are discussed; and
- Finally the ways in which the two can be used together is discussed. When estimating an uncertain variable, such as the net social benefit of a project, it is always better to have two estimates rather than one.

2 Cost Benefit Analysis, Computable General Equilibrium Analysis and Investment Evaluation

For many years, the traditional and widely used technique of assessing whether an investment was worth doing, at least in the public sector, was Cost Benefit Analysis (CBA) (see the following surveys of CBA- Boardman et al (2011); Perkins, (1994); de Rus, 2010; CEDEX, (2010)- see also Jorge-Calderon (2014) for its application to Aviation investment). Thus CBA has been applied to infrastructure investments such as airports, railways, roads, broadband networks, dams and power stations. It has been used to assess education investments and health and welfare reforms. It has been used to assess policy reforms, such as airline deregulation and clean air regulations, as well as measures to reduce greenhouse gas emissions. While the main use of CBA has been the public sector, the private sector has used

it when it seeks to gain approval for large, and perhaps controversial, projects, and sometimes in the context of Public Private Partnerships.

CBA has been the dominant technique of investment evaluation. It is very widespread and adaptable and most micro economists would say that it is the best and most rigorous technique available. At the same time, there are several limitations to it, most of which are known. Thus there are some problems in measuring specific benefits or costs, there are problems in handling general equilibrium (GE) aspects (the theory of CBA tells us that we should use a GE framework- see Dreze and Stern, 1987; Dinwoody and Teal, 1996), yet invariably, only a partial framework is used, with attendant inaccuracies. It has problems in handling distribution (studies usually provide initial incidence of changes, but what is required is the ultimate incidence). In spite of these limitations, it is regarded as very useful.

Over time, several other techniques of investment assessment have been developed. One approach has been to develop techniques which are intended to be broader than CBA- these include multi criteria analysis (see Quinet (2010) on the relationship between the two). These approaches can be seen as broadening the scope of CBA to include additional aspects, such as spatial and environmental aspects - CBA would not be replaced by them but rather CBA would form part of a more comprehensive assessment.

Other techniques are more in the nature of substitutes for CBA. One of these is the use of Input Output (IO) models. IO has an established role in analysing the structure of industries. However it has also been used to develop impact models, (such as multiplier models) which purport to enable the measurement of the impact on a target variable (such as output or GDP) of a change, such as a tariff or an investment. Such multiplier models are now being used as a means of assessing investment projects). Typically, an investment which costs $X will give rise to a multiplier effect, and the impact on the target variable, such as output or GDP, will be in excess of the injected investment, and the impact may be, for example, $2X.

These models are used as an investment assessment tool in many cases- for example, there are widely used in Germany in airport assessment (Forsyth, Njoya and Niemeier, 2014). This approach always makes the investment look good, but is should come as no surprise that they fail the test of rigour. Additional factors of production will be needed to add to output, but they have no cost, according to IO. There is no rigorous welfare measurement, as there is with CBA. In a sense, an IO model could be thought of as a poor man's CGE model- except that one would have to be destitute to use them. There are popular in some quarters because they make poor projects look good.

The types of problems identified with IO models are rectified with CGE models. These are complete models of the economy, or of the sectors that are of interest. Intentionally there are no loose ends- thus all inputs and outputs are accounted for, and the sources of all factors are accounted for. Incomes are sufficient to cover the costs of factors, and the external account balances (though of course there can be borrowing from abroad). A CGE model may be either small (say, two sectors) or large (say 500 industries). They may be very detailed, or quite simple. An issue with CGE models is often the level of aggregation. There might be a

"transport" industry, or there might be a transport sector covering many industries, such as long distance rail, high speed rail, freight rail and urban rail. A model may be a national model, or a regional model, or a model which covers all regions in a country.

CGE models are now becoming widely used in many countries, especially for policy analysis. Models are being used for the analysis of tax reforms, changes in industry policy, welfare reforms and labour market reforms. They are also being used to assess the impacts of shocks, such as the effects of mining booms on other sectors, the impact of the SARS epidemic on tourism and the impact of climatic events such as droughts. Recently they have been used to gauge the impacts of climate change, as well as mitigation measures (such as carbon taxes). They are very adaptable and can show light on a wide range of changes affecting economies and policy actions. CGE models are available for most countries of the world, and for many countries, there are many different models available. The use of CGE models differs from country to country- there has been widespread use of them in Australia, where just about every major shock to the economy or policy change is analysed using them, while in other countries there seems to be less use made of them- for example, in Germany there is rather less used made of the models which are available.

Of particular interest is the growing use of CGE models as a tool for assessing investments, rather like CBA (see also the comments on CGE by Boardman et al, 2011, p124). One of the earliest studies was that of the CityLink Motorway in Melbourne in 1996 (Allen et al,1996). This has been followed by many studies of major transport investments, such as roads, railways and airports. For most major projects in Australia which are subjected to economic analysis, most would be evaluated using a CGE analysis (not all major projects are subjected to economic analysis- controversial projects are often reserved for political decisions). Other countries, such as the UK and Japan, have used CGE models to evaluate infrastructure projects (UK Airports Commission, 2013; Ueda et al, 2006).

In Australia and elsewhere, non-infrastructure investments have also been evaluated using CGE models- an interesting case is with Major Events, such as the Sydney Olympics (Madden and Gieseke, 2011). (CGE models have also been used in the evaluation of the Beijing, London and Rio de Janeiro Olympics). There has been a change in assessment of major events in Australia- in 2000, most major events were evaluated using IO models, but by 2010, most studies on major events were evaluated using CGE models. CGE models have long been used to evaluate policy changes. A good example of this is the use of CGE models to evaluate whether a country gains from imposing a tax on air transport (Tourism Research Australia, 2011; PwC (UK), 2013; Forsyth et al, 2014). Most studies of aviation taxes have used the IO approach and all of these conclude that the country loses, in GDP terms, from doing this. However, there have been CGE analyses done of aviation taxes in Australia and the UK- and in the Australian case, the conclusion was that the country did gain from imposing the tax (Forsyth, 2014).

There have been a number of cases of studies done using *both* CGE and CBA. Most of these are from Australia. Thus the Melbourne CityLink road was evaluated using both in 1995, the 2005 Melbourne F1 Grand Prix was evaluated using both (Abelson, 2011); the Eddington

Report of 2008 into Melbourne transport (Meyrick, 2008) also used both. Recently, the proposal for a High Speed Train was evaluated using both. The 2012 report on a new airport for Sydney (Joint Study, 2012) employed both- CBA to assess whether (and where) it was worthwhile to build the airport, and CGE models were used (in a different part of the report) to assess the cost of not building the airport (as well as the best time to build).

This tandem approach, or use of two evaluation techniques, poses a fundamental question- which (if either) is correct if the two methods come to different answers? This is not an idle question- at least in some cases, the two techniques have given what at least *appear* to be, contradictory answers. This was the case in the evaluation of the Melbourne Grand Prix- the CBA seems to say that the investment was not worthwhile, while the CGE model seemed to suggest that the investment was worthwhile (Abelson, 2011;Victorian Auditor-General, 2007).

Ultimately, there could be two main reasons why the evaluations differ. The first is that the evaluations differ because they are using different criteria for how the economy is affected by the investment- for example, the CBA might be yielding results in terms of welfare or NSB, and the CGE model might be yielding results in terms of GDP or similar measures (see Abelson, 2011). The two might agree perfectly if the results of both are expressed in welfare terms. The issue then is how can the different measures be render consistent- for example, how can the results of the CGE model be expressed in welfare terms?

The second reason is that the two evaluations may be indeed different. Thus the CBA may tell us that the project reduces welfare by $1bn, while the CGE model tells us that the welfare rises by $100m. There is nothing surprising about this result- both techniques rely on approximations. Two estimates of an uncertain variable are better than one. As long as both are done well, this can be valuable information. To know more about the results of the project, it is necessary to probe further into the assumptions, data limitations and approximations to gain a more reliable estimate.

In using both CBA and CGE, we have two ways of answering the same question- for example, whether a country gains from investing in a road or railway. Both of these ways have limitations, and in some cases these are quite substantial. The argument here is that it is possible to combine them, and as a result, derive a much more reliable evaluation. The next step is to outline what the differences in CBA and CGE are, which will enable us to recognise the limitations there are and point out how two approaches can be combined to get a better overall evaluation.

3 The Characteristics of CBA and CGE

There are several ways in which CBA's and CGE models differ- in terms of their outputs, the ways in which they analyse problems, and in the types of issues which they can handle. Thus it is not surprising that might come up with different answers. Some key aspects are outlined here, and then are analysed in greater detail in subsequent sections.

Model Output and Welfare Results

CBA and CGE models often come up with apparently different results in terms of the bottom line. However it is a misconception that they yield inherently different results. Thus, with CBA analyses, the result is normally an evaluation in terms of the impact on the net social benefit (NSB) to the economy. By contrast, CGE results are often (though not always) expressed in terms of the impact on GDP, consumption or other macroeconomic variables in the economy. As a result, people think of a CGE analysis as measuring the impact on GDP, and CBA as measuring the net social benefit, of the investment- i.e., two different measures which are unrelated.

In reality, this need not be the case. CBA does present results in terms of the impact on NSB, but a CGE model can also present results in terms of impacts on NSB. Many CGE models already can provide results in terms of impact on NSB, and also impacts on GDP, consumption, employment and other variables which may be of interest. Those models which cannot can readily be adapted to do so, in most cases. The types of inputs which CBA draws upon in measuring NSB, such as consumers' and producers' surplus, and impacts on government budgets, can also be measured using a CGE model. After all, the CGE model will typically have demand and production functions and government budget changes, (in other words, the building blocks of CBAs) embodied in it and thus it is a straightforward matter to measure consumers' and producers' surplus (sometimes with greater rigor than with typical CBAs). Examples of CGE simulations using welfare measures include Blake (2009) and Dixon (2009).

The upshot is that what appears to be a major difference, in terms of measuring the impacts of welfare of making an investment, is illusory. In fact, a CGE model is a more flexible form of investment assessment in that it can yield a welfare measure, but also measures on many impacts of the investment, such as those on GDP or output, employment, and more.

What is difficult to explain is the fact that when used to assess investments or policy interventions, in many cases, CGE modellers use GDP, consumption and other measures rather than NSB, as a measure of how much better off the economy is as a result of undertaking the investment or implementing the policy. These measures mean that the CGE results cannot be compared to those of a CBA study. This means that there are two competing answers to the same question. It means that the full potential of the CGE model is not being reassessed.

The key question is not whether a CGE model can yield welfare measures comparable to those of a CBA, but how best this can be done. This is examined in section 4.

Model Structure and Disaggregation

With CBA there is no set model structure, and the level of disaggregation is not an issue. A CBA can be applied at whatever level needed- it can handle small or large benefits and costs. The objective in doing an analysis is to measure and record all costs and benefits no matter how large or small.

This is a contrast with a CGE model. There is a specific model structure, and evaluation of the investment takes place in the terms set by the model. The model may be sufficiently disaggregated to capture all of the key features of the investment. On the other hand, it may be too aggregated. As an example, there are problems in using a model which has only one transport industry in evaluating an investment which aims to shift freight from road to rail.

If there are no constraints in terms of time, data and money, these problems can be solved by building a sub model, with road and rail freight industries. This is often done - using a more aggregate model as the basis, and a more detailed sub model is built which has enough detail to explore the industries of interest. Some models are designed to make the construction of sub models quite easy, and software advances are also making this easier. Sometimes this is not possible within the constraints, and the results of model simulations using a more aggregate model than desired may have to be used- if so, there will be a cost in terms of accuracy in results. Some models now make it very easy to disaggregate and develop sub models such that the CGE approach can become much more precise in terms of its results.

Partial and General Equilibrium Evaluation

General equilibrium studies, such as those done by using a CGE model, are, by definition general equilibrium studies. A CBA is usually a partial equilibrium study. This will mean that the markets directly affected by the investment will be analysed and direct benefits and costs will be assessed. However, a partial equilibrium study such as a CBA will not take into account any, or most of, the indirect effects. There are many cases where CBA which are basically partial take some indirect effects into account. Thus a CBA of a road may take into account benefits and costs on competing railways. A good study will attempt to assess whether there are any substantive indirect effects present, and will then value them. Normally, there will be only a few indirect effects taken into account, and most of the costs and benefits will be direct.

There is no presumption that this should be the case. Indeed, the theory of CBA is that it should be a general equilibrium study- for example, the theory of CBA enunciated by Dreze and Stern in the Handbook of Public Economic Economics (1987) supposes a GE framework. In their view, CBA should include all costs and benefits, regardless of whether they occur directly or indirectly. Most actual CBAs fall short of this ideal, and in practice, CBAs are partial equilibrium assessments, though many make an attempt to take account of obvious and substantial indirect effects.

This means that, in effect, most CBA are inaccurate- though we do not know to what extent they are so. It may well be that most of the costs and benefits which matter are captured by a partial CBA, especially if key indirect effects are measured and counted. However, it is also quite possible that a partial CBA misses out on important indirect or GE effects- this can come about partly because the analyst is unaware of effects which will prove critical, and partly because these effects are lost in the complexities which are inherent in an economy. In some of these cases, the analyst may be well aware of them but lack the ability to measure

them. One of these is measuring the benefits of inbound tourism (which will be discussed in section 5) – an important source of benefits for airports and some road and rail investments.

In short, we know that CBA is inaccurate - but we do not know by how much. Indeed, users of CBAs tend to *assume* that there are very accurate- but this may be a dangerous assumption. On the other hand, we can assess how inaccurate a CBA is by using a CGE model to evaluate the same project. This is a good example of where the two techniques are complements.

Externalities and Non Market Goods

A typical CBA will attempt to measure, value and include externalities and non market goods. Thus, for example, a CBA of a road project will include the noise externality from the road, and it will include benefits of the road in terms of saving leisure time, which would be a benefit which does not go through markets. A CGE evaluation would not initially include these effects. However, it is a straightforward matter to include them as an add-on to the evaluation, and this is what often is done. The costs of noise and the benefits from leisure time savings are added in as part of the evaluation, so that a complete assessment is made.

This is essentially a partial equilibrium approach since the direct cost or benefit is the only one considered. However some externalities are essentially general equilibrium in nature. A good example is greenhouse gas emissions. A road and its traffic may generate emissions, but it will have impacts on emissions of substitute modes such as rail, and on the emissions on the inputs to the road, such as the production of concrete and energy- and there may be further impacts which are not easy to measure. The initial or partial equilibrium measure of the impact on emissions could be quite different from the ultimate effect, taking into account GE effects. The road investment could ultimately lead to a reduction on emissions.

Macro and Regional Impacts

Even when there is a fully employed economy, there may be macro effects which may be of interest to policymakers. Thus a project will have impacts on macro indicators such as GDP, National Income, exports and imports and investment. Even though these need not form a component of the bottom line, which is measured by NSB, they may be of interest. A CGE model can estimate the impacts on these, as well as the impact on NSB.

Of particular importance are the impacts on regional magnitudes, because these will form part of the assessment of NSB at the regional level. Consider a study of a project in a region- there will be macro effects in this region. Thus, a road in a region can result in additional employment in the region, additional use of investment, and tourism. There will be additional income in the region- though of course some of the additional resources and income will be at the expense of other regions in the economy. If one is doing an assessment of the NSB from the perspective of the region, rather than the economy as a whole, these regional benefits and costs need to be taken into account. This is something which users of CBA recognise as a problem, though CBA does not have an answer.

These effects can be measured using a CGE model - regional IO models have been used (for a discussion, see West, 1995), though normally these models do not have a welfare measure. Thus a road in a region may produce a NSB of $500m in the region, including macro effects in the region evaluated at $600m. The road is worthwhile from a regional perspective. In this situation there will be negative effects on other regions- these might be -$600m. On balance the gains from the investment are positive for the region, but not for the economy as a whole. Since it is often governments of regions which make the decision to investment, it is important to have a measure of how much better off the region will be as a result of making the investment.

Employment and Unemployment

Arguably, one of the most difficult problems in investment evaluation comes about when there is unemployment in the economy. It is easy to set out, in theoretical terms, what should be done- shadow wages can be substituted for market wages. The difficulty is measuring shadow wages. Shadow wage issues have been discussed in great detail in the context of developing economies with underemployment, and there has been some analysis of where there is unemployment, for example, in high income economies.

Often in these economies there is unemployment, and it is difficult to handle this in an evaluation- whether or not a CBA or a CGE approach is used. A project may lead to more direct employment, but to what intent will this lead to reduced unemployment? It could be more than the increase in direct employment, less than the increase, or zero, depending on how labour markets work. Often analysts will opt for an arbitrary rule of thumb- for example, by assuming that shadow wages are 80% of market wages.

The problem with CBA is that it is essentially a partial equilibrium solution to a general equilibrium problem. It is very difficult to know what the indirect effects of a project are. On the other hand, a CGE model can tell us what the effects of making the investment will be, if we know how the labour market will respond (and with additional information, we can value the changes using shadow wages). The limitation is that we do not know how labour markets really work. There are many theories about how labour markets work, and corresponding to each or these is an estimate of how the investment will affect employment. Thus if a CGE model embodies a Keynesian assumption of sticky wages, it would project a large change on employment, while if the model embodies flexible wages, it may project low or zero changes in employment. Thus the CGE model can be of great use in tell us what will be the effects on employment under different labour market assumptions, and this can be very useful. However, it does not tell us which are the right assumption to use.

4 Measuring Net Social Benefit or Welfare Changes

As noted in section 3, there is considerable confusion about measuring welfare changes in CGE modelling. With CBA, there is a rigorous and well established theory about welfare measurement – in simple terms, it involves measuring consumers' and producers' surplus,

along with surpluses accrued by governments (which ultimately will accrue to households and workers as surpluses) (Dreze and Stern, 1987). A CBA will measure the net social benefit from an investment or a policy action. Exactly the same measure can be used in a CGE model simulation. However, in practice, this is often not the case- hence, there is confusion.

Putting a welfare or NSB calculation is into a CGE model is a straightforward exercise. A CGE model will normally have a set of demand functions, and production functions, which serve as the basis for measuring consumers' and producers' surplus. If there is a government sector, it is possible to determine government deficits or surpluses. Where capital or labour supply is flexible (this is not always the case with widely used CGE models), there will be rates of return and wage rates which form the basis of estimating the factor supply rents. The model will embody information about distortions such as tax rates, which will be used in estimating NSB. A model for a country will have information about export and import prices, along with distortions, which are used to measure terms of trade effects. For regional models, information about inter regional migration will be present. For most CGE models, measuring NSB is a matter of setting out some additional relationships using data which are already in the model.

Some CGE models already have a welfare measure, and some do not. The might be several reasons for the lack of a welfare measure in a model, but one prominent reason is that a welfare measure is not needed in many cases, since that the model has been designed to answer questions which do not need a welfare measure. For example, if the model is used to estimate the impact of a mining boom on the output of the motor vehicle industry, a welfare measure is superfluous. This said, models designed to explore this type of question are increasingly used to analyse different questions, some of which do require a welfare measure, such as whether a country gains from investing in a particular project.

In some cases, what analysts have done is develop approximate measures of welfare. In some circumstances, GDP will be equal to NSB. If all factors are fixed, (e.g. in the short run), and there are no terms of trade effects, and there are no externalities and non-priced goods, welfare or NSB will be equal to GDP (subject to the conventions used by statistical agencies in measuring GDP- see Blake, 2009). This exact situation is likely to be quite rare- most likely there will be some changes to factor inputs, or a change in the terms of trade, or some change in externalities. In these situations an approximate welfare measure can be derived by adjusting the GDP (or national income) measure to take into account the costs of factors or terms of trade or externalities. Thus when using a model based on MMRF, a widely used Australian model which does not have a welfare measure, Dwyer et al (2005) adjusted GDP to take account of the costs of labour and capital when analysing tourism changes. In a similar way, Dixon (2009), who also used the MMRF model, adjusted GDP by taking into account the cost of capital when evaluating the welfare gains from lowering motor vehicle tariffs in Australia (previous work had not taken in account the fact that additional output was achieved using additional capital inputs).

Thus the widespread perception that CBA measures NSB, which is the rigorous measure of welfare, and that CGE models measure indicators such as GDP, does not stand up. NSB and GDP are related, though usually quite different, and many CGE models explicitly set out this relationship, and they can be used to measure a range of indicators such as welfare and macro or national account variables such as GDP. Where a CGE model is being used to measure how much better off a country is as a result of a change such as an investment, a welfare measure is needed, but an approximate measure can be developed readily from variables already in the model. It is not necessary to fall back the common practice of using variables such as unadjusted GDP or consumption as the proxy for welfare- these are likely to be very inaccurate.

5 Taking Advantages of Complementarities

Both CBA and CGE can be used for investment and policy evaluation, but both have distinct limitations. In most cases, neither one nor the other is sufficient on its own to yield an accurate measure of how much better off the economy is as a result of making the investment or instituting the policy. However, together the two can be used to gain a far more reliable and accurate assessment. Here we look at the ways the two can be used together.

CGE and the Aggregation Issue

Possibly the most severe limitation of a CGE simulation as an investment evaluation tool is that most CGE models are much more aggregated than the analyst would need or want. This is a particular problem when small investments are being considered, but to is also a problem with large investments. While there are some very large models (e.g. of 500 industries), the model available to the analyst may be much smaller. Even with a large project, such as a High Speed Train or a major airport investment, the level of aggregation of the model may preclude much useful analysis. It is not easy to analyse when the only relevant industry is a single “transport” industry.

If resources permit, the solution will be to build a sub model which is sufficiently disaggregated to capture the industries of interest. Thus “transport” can be disaggregated into smaller industries, such as ordinary rail, high speed rail, local rail, urban roads, urban motorways, and non-urban roads. Inevitably, there will be a higher level of aggregation than desired, but this will be sufficient to enable useful analysis to be done. For a larger evaluation project, or an evaluation which is to be repeated frequently (such as for many smaller rail or road links), a sub model would be a worthwhile investment. Some models nowadays make it easy to create sub models.

It is possible to make good use of the complementarities between CBA and CGE in looking at this problem. If there is already a CBA of the project (which tells some of the story, but not all of it), this can be used to design the sub model of the CGE model- to highlight what markets are important to capture and what ones do not matter. If there has not yet been a

CBA, then it is possible to develop a simple "back or the envelope" CBA which highlights the important relationships which the CGE sub model should cover.

CGE and the Externalities and Non-Market Goods Issues

There are several costs and benefits which a normal CGE model would not pick up. Some of these would be externalities and non-market goods. Some of these do not have any significant GE aspects. Road noise may be localised and not likely to impact on other markets, and recreational benefits from a dam may have little (but not zero) impacts on other markets. These costs and benefits would not be included in a CGE model, and they are best handed in the same way as done in a CBA- they are measured and valued and added in once the model simulations have been done. This is often done when effects outside the model are included in a comprehensive evaluation.

However some externalities and non-market goods can have an important GE dimension- for example, greenhouse gas emissions. This externality is tailor made for a CGE approach. More generally, it is a straightforward matter to incorporate externalities in a CGE model. A good example of this is the incorporation of greenhouse gas emissions into CGE models- there are several examples of these, such as Adams et al, (2000). These models include the measurement of the production of greenhouse gasses along with the production of normal outputs- for example, additional transport output also comes with additional emissions, additional steel output comes with additional emissions, and so forth. Thus when a project produces more transport output, the model calculates the change in emissions, both directly from the production transport output, and indirectly, from the production of all the other industries affected. The outcome is an estimate of the net change on emissions. This could be higher than the direct estimate, or it could be even negative.

Another example would be leisure time savings. Typical CBAs measure and value the gain or loss in leisure time as a result of a project. Normally the analysis stops there. However, one of the responses to an increase in leisure time is likely to be, at least to some extent, an increase in work hours- travellers are unlikely to spend all of their increase in real income as a result of time savings as additional leisure time. This has implications for production, wage income, taxes and consumption. Since there are several distortions present (e.g. through wage taxation), the initial measure of the benefits as a result of a leisure time saving could be quite different from the ultimate evaluation. Some of these effects were analysed in a partial equilibrium framework in Forsyth (1980), and more recently, they have been analysed in a specific CGE model of a city by Venables (2007).

Obviously some externalities will be more amenable to measurement using a CGE framework than others. However the results of using a CGE framework to measure externalities suggest that partial equilibrium measures may be quite inaccurate. At this stage, with relatively low prices for carbon, greenhouse gas emissions are not likely to be a large proportion of the costs of a project- though this may change significantly in the future. However, the other examples are of more immediate importance. Leisure time savings can be a very high proportion (e.g. 90%) of a transport project's benefits, and any improvement in

the measurement of their value could make a large difference to the overall result of an evaluation.

There is little difficulty in measuring externalities and non-market goods and adding these on to a CGE assessment of an investment. This is where the usual CBA stops. However, CGE models can do a lot more. An externality such as emissions or a non-market good such as leisure time can be incorporated into the model. This means that the relations between the externality or good and other goods can be explored. The result will be a more accurate measure of the benefits and costs or the investment.

CBA and the General Equilibrium Issue

With CBA being a mainly PE approach, it does not capture GE aspects of the evaluation problem. In principle, all costs and benefits could be changed by replacing a PE evaluation by a GE evaluation- i.e., a CGE approach which would be more accurate than a PE CBA. Thus a real option would be to undertake a CBA and a CGE simulation, and analyse the differences between the two. Neither one would be perfect, since neither one will measure all costs nor benefits- there will be an issue of interpretation to choose the evaluation.

It may be the case that some aspects of the CBA evaluation are less reliable than others. For example, several costs and benefits of the investment may be regarded as reliable e.g. construction cost measures, though some others may not be. Fuel costs are often a problem- should pre-tax or post tax prices be used? Work time saving may be easy to measure, but the appropriate value of them depends on taxes and how these affect the economy. In short, a GE perspective could be very useful in measuring costs and benefits. Even though a CGE model is not used to carry out a full evaluation of the investment, it can be used to cast light on difficult areas.

The best way of illustrating a point is through an example. One of these difficult areas is the measurement of the benefits and costs of inbound and outbound tourism- something which CBA has had big problems in coming to grips with.

CBA and Measuring the Benefits of Tourism

When a country plays host to inbound tourism, it may gain. On the other hand, when it generates outbound tourism, it may lose. For some airport projects, most of the benefits are in the form of inbound tourism benefits, and is some cases, tourism benefits will be a significant proportion of benefits for road and rail projects. For many years, at least from the 1960s, there have been CBAs which have sought to measure the gains or losses to countries and regions. Most of these measures have been decidedly ad hoc, and they have ranged from zero to 100% on tourism expenditure. Some studies are more analytical, and provide reasons for their valuation. An example is a study by Ody (1969) of an airport on Cyprus - this argues that most of the cost of servicing the tourists would be zero since there was high unemployment. A recent (thorough) study of an airport in Sydney (Joint Study, 2012)

assumes that inbound tourism benefits are equal to 25% of tourism expenditure (it also implicitly assumes that there is no cost from outbound tourism).

It is not surprising that there are problems in valuing tourism for use in a CBA. The gains and losses that inbound tourism creates are wide and not specific- they include profits from a wide range of small enterprises, and a wide range of tax effects, and other things (perhaps a terms of trade effect, and possible an impact on employment). This is the sort of problem which a CGE model can handle very effectively. Normally, one would not expect that there would be a large (relative to expenditure) effect on welfare as a result of additional tourism exports or imports, because additional spending by inbound tourists requires goods and resources- labour, accommodation, transport and the like. A normal assumption would be that the tourists pay for the goods and services which they consume, and that there no net surplus or profit (other than normal profit) as a result of exporting tourism goods and services.

However, there can be reasons why the cost of $100 worth of tourism services may be greater or less than $100. There are no economies which are totally free from distortions, such as taxes and excess profits. In the case of tourism, the latter is not likely to be significant. However, given the way tax systems work, tourism is a relatively highly taxed export industry. Tourists pay VAT/GST on much of what they buy, and they also pay fuel taxes when they use motor vehicles. This is in contrast to most exports, where buyers pay no tax. Thus some of the $100 which the tourist spends goes to the government, and the resource costs of the tourism spending are less than $100. Put another way, additional spending will give rise to a net benefit. This effect will not likely to be very large, but it will be positive.

One can use a CGE approach to measure these benefits. There have been a small but growing number of studies which have either explicitly or implicitly put a value on tourism benefits. In Australia there have been a number of related studies which explicitly estimate the value of tourism to the Australian economy (see Dwyer et al, 2005; Forsyth et al 2014). Depending on the model and assumptions used, these measure the benefits of inbound tourism at between 5% and 10% of expenditure. Using a different model, for the UK, Blake (2009) concludes that the value of tourism is about 6% of expenditure. The UK and Australia have similar tax systems, though indirect taxes are slightly higher in the UK than in Australia. A recent discussion of the measurement of tourism benefits in an airport context occurs in the UK Airports Commission's recent report (Airports Commission, 2013, Interim Report, Appendix 3: Technical Appendix, P22).

There has been much less interest in measuring the costs or benefits of outbound tourism. Very often assessments of the benefits of airports or liberalisation proposals are made which highlight the benefits of inbound tourism but ignore totally the effects of outbound tourism. As it turns out, additional outbound tourism has a cost, but the mechanisms are similar to, not the same as for inbound tourism. Typically, outbound tourism attracts no taxes in the outbound country, while other imports are taxed, for example by VAT/GST taxes, and domestic goods are taxed. The results depend on whether domestic tourism (which is taxed) is a substitute for outbound tourism, or whether the substitute for outbound tourism is

goods in general. In a recent study, Forsyth et al (2014) estimated the cost of outbound tourism to be around 5%, slightly less than the gain from inbound tourism.

The upshot of this is that the benefits from inbound tourism, and the costs of outbound tourism, can be estimated using CGE approaches. The results so far suggests there are small but positive benefits from inbound tourism, and small costs from outbound tourism.

The gains from tourism can be an important element of a CBA. In a recent study of a new airport for Sydney, (Joint Study, 2012), total tourism benefits were slightly less than $3bn, out of a total benefits of around $7bn. These benefits were estimated (arbitrarily) as 25% of tourism expenditure. If instead there were valued at 7.5% of expenditure, benefits would be around 0.9bn. The CBA does not include any costs from outbound tourism. Given that outbound tourism is slightly greater than inbound tourism, the net tourism benefits from the project could be small, or even negative.

CBA and Handling Distribution

Handling distribution is something which has had a chequered history in CBA. At different stages the preference has been to include an analysis of equity aspects, and at other stages the preference has been to ignore them. Thus, in the 1970s and 1980s several writers (especially those associated with the World Bank) argued for the inclusion of equity results, and showed ways of how this could be done. Since then there has been a much lesser emphasis on equity (including at the World Bank) and the recommendation has been to conduct CBA without including distributional assessments, and to leave the assessment of equity to the final policymakers.

There are several reasons for this ambivalence. One reason is that it is more difficult to include distribution than ignore it- allowing for distribution requires a lot more data than not allowing for it. But another potent reason is that it is difficult to handle distribution in a partial equilibrium manner. Even when the direct distributional aspects of an investment can be estimated, the ultimate incidence could be quite different. The working of markets means that the initial beneficiaries from an investment are not those who ultimately gain- the gains are diffused across the whole economy. Calculating the ultimate incidence is an essentially general equilibrium problem.

As a result, a CGE approach can be very useful in working out the incidence of the benefits and costs of an investment. If the CGE model being used has distinct groups or workers or households, it is a straightforward matter to determine how the different groups are affected by an investment. The model can give information about, not just the overall welfare gain or loss to the economy, but also the gains and losses which accrue to the different groups. Thus information could be used by the decision maker. In the extreme, welfare weights could be given to the different groups to measure social welfare, as suggested by the writers of the 1970s and 1980s.

The CGE approach does have some costs. Getting information about diverse groups of householders or workers could be a data intensive exercise. The model will become more

complex and slower to run. Another aspect is that the model may be too aggregate to capture the gains and losses accurately. A partial equilibrium approach is likely to be more accurate the detail of the gainers and losers. On the other hand, it will fail to measure the ultimate incidence of the changes brought about by the investment- and the initial and ultimate incidence can be quite different (and it is the ultimate incidence which is what is needed).

This is a good example of where both the partial equilibrium CBA and the GE CGE approaches are complementary. By using both we can gain a more accurate assessment of the distributional aspects of the investment.

CBA and Shadow Prices

It may be the case that the preferred way of estimating NSB of a project is CBA. However one might use a CGE approach to analyse specific aspects of the valuation problem. One way in which a CGE model can be useful if one is using a CBA is through shadow pricing. Two shadow pricing problems are considered here.

The Marginal Welfare Cost of Taxation

In recent years analysts have given more attention to the welfare costs of raising taxes. If a project requires tax funding, the cost of this needs to be taken into account when calculating its total cost. The marginal welfare cost of taxation (MWC) was analysed by Ramsey, and optimal commodity taxation was analysed in detail by Diamond and Mirrlees (1971). In 1976 Browning developed a partial equilibrium measure of the welfare cost of taxation based on income taxes in the US. Since then, much of the discussion has followed Browning's lead, and mostly it has followed the partial equilibrium framework he analysed.

However there are good reasons for believing that the partial equilibrium approach does not capture the full complexity of the problem. While most analysts focus in on income taxes, other important taxes exist, and the distortions they create are affected by what is going on with income tax. The welfare cost depends on the overall tax wedge, not just the wedge created by the tax being altered (usually income tax). Stuart (1984) measured the MWC using a CGE model (see also a CGE approach by Ballard, Shoven and Whalley, 1985). He came up with considerably higher estimates of the MWC- this was partly due to the fact that he used a CGE approach, but also he used different elasticities (Browning, 1987).

In theory, CGE models should be an ideal way of measuring the MWC of taxation. In practice they have not been used as much as they might be. This may be because many models have a quite simple labour market- and measuring the MWC requires that the labour market, and in particular, labour supply functions, be set out in detail (see Freebairn, 1995). Since there is no "correct" way of charactering the labour market and labour supply, there can be many answers to the question "what is the MWC of Tax". This is an issue which will be resolved in the future.

The Shadow Price of Foreign Exchange

The shadow price of foreign exchange used to be an important parameter in CBA. Interest in it has fallen, largely because there are relatively few trade distortions in industrial countries, though it can still be relevant in developing countries, some of which still have large trade distortions. There have been important partial equilibrium approaches to measuring this shadow price, the best known of which is the Harberger Sydlowsky-Fontaine formula (see Fane, 1991). Several of the theoretical approaches take a GE approach to the problem, such as Dinwiddy and Teal (1996), and CGE models have been used in making empirical estimates. A CGE estimate of the shadow price of foreign exchange for Canada was done by Jenkins and Kuo (1985). This estimates the shadow price as 6.5% above the official rate. Shadow prices would have become closer to the official rate as trade distortions have fallen, and thus correcting for this shadow price would not be worthwhile for industrial countries such as Canada.

6 Practicalities

There are several practical issues to be resolved when evaluating projects or policies using CBA or CGE. However, it should be noted that the recommendation here is that both techniques be used to evaluate a project or policy- it should not be a matter of which is preferable, as the two are essentially complements not substitutes. It may be the case that is some cases, only one is feasible- however this should not be the case in most situations, especially those involving medium to larger projects. Some aspects which need to be considered are as follows.

Cost

There should not be any problem about the cost of an analysis with a CBA- a CBA can be as large or small as needed. Very small projects warrant very small or basic CBAs. Often agencies which are making large numbers of small investments, such as road improvements have standardised CBA models. The cost of evaluation will be very small. Large and more detailed projects such as motorways or hub airports warrant more detailed scrutiny.

Undertaking a CGE simulation is a more involved process, though it is becoming much less so over time (some people will remember that in the 1970s running a simple regression or performing a simple econometric test took much time and effort- nowadays it can be done very simply and cheaply. The same is true for CGE models now). Firstly there is a question of model availability. Models are becoming much more available- for industrialised countries there are several models available from university research centres, government agencies and major consulting firms. If models are available they can be run very cheaply. This said, the available model may not be ideal for assessing the project at hand- as a result, approximations will need to be made. Building a new model to analyse a specific project may be an expensive business, but for a major investment (such as a new London airport or a High Speed Rail line in Italy) it may be worth investing in. Most studies can be done using an existing, off-the-peg model. For larger projects it will often be worthwhile to adjust the model to making it more accurate, and this will have a cost.

Data

Both CBA and CGE analyses are data intensive. A CBA will require a considerable amount of specific data about the project or policy. Building a CGE model is usually very data intensive, as it requires data about a whole range of markets across an economy, not just those directly affects by the project. But as noted above, the CGE evaluation approach usually requires using an existing model, and perhaps making adjustments to it, not building a whole new model. Basically, the CGE approach involves using a broader data base, and less detail about specific aspects of it.

Disaggregation and Detail

A CBA can be as detailed as required, subject to the cost of the evaluation process. The CGE model will always be more aggregated than the analyst would like. The model available to the analyst may be too aggregated capture the detail of the project. In this case, it is always possible to disaggregate the model, and build sub-models to capture the detail which is needed- though this will have a cost.

This highlights the reason why the two techniques are complementary. The advantage of the CBA is that it can be more detailed than the CGE simulation. On the other hand, it does not capture several aspects of the evaluation problem, including the GE aspect. Thus the way to get an accurate assessment of the project is to do a CBA, which is good on detail but which is essentially partial equilibrium, and a CGE simulation which is less detailed but which evaluates the project taking into account the GE aspects which could be important (and we can only tell where or not they are by doing an evaluation).

7 The Way Forward

A problem arises in that there are two and different techniques to evaluate an investment or a policy- CBA and CGE. They will, or are likely to, give rise to different evaluations, or in other words, different answers to the question of “how much better off will the economy be if it makes the investment or institutes the policy”? Currently, CBA and CGE are often seen as different techniques for different evaluation problems. However, this is changing, and so the two are both used to answer what seem to be very similar questions. The two are clearly getting closer. Both tools have distinct limitations, and there is the possibility of using both together to gain a more accurate evaluation of investments or policies.

The State of Play

There has been a distinct coming together of the two techniques over the past 20 or so years. In the past, the space of investment evaluation was occupied by CBA, which is a technique specifically designed for investment evaluation. Recently there have been CGE studies of major investments. There have been several studies which set out two evaluations, though typically, they focus in on different aspects- thus a CBA may be used to evaluate the Net Social Benefits from making an investment, and the CGE study may focus in on other, but

related, aspects, such as the effect on GDP. An example of this is the analysis of the Second Sydney Airport- the CBA measures the benefits from making the investment, while the CGE study measures the cost to the economy of not making the investment. Having a tandem approach can be confusing- several times they are apparently saying different things, posing the question of which is right and which is wrong? At present, most of the use of CGE models in investment evaluation is at the first level of analysis (as described in part 1), but moving to the second level is feasible and desirable.

There is a confusion about the outputs of (most) CGE evaluation (indicators such as GDP or consumption) and the outputs of CBAs, the effect on NSB. GDP is quite different from NSB, but is related to it. As a result, most CGE models can give as outputs, either directly or indirectly with little adjustment, a measure of NSB, which is the output of a CBA (the CGE simulation can also provide a range on many other useful measures such as GDP, consumption and employment). Thus CGE models *can* be used to give a direct answer to the question "how much better off is the economy as a result of making the investment"? Both techniques can be used to measure welfare. This is so for investment evaluation, as well as policy evaluation- with the latter, CGE models are sometimes used with a welfare or NSB or welfare measure, not just a measure in terms of GDP.

Arguably, both should be used. Both have limitations, some of which are significant- by using both, a more accurate answer can be given.

Another way in which CBA and CGE are linked is through the use of shadow prices measured using a CGE model in CBAs. This has been done for almost 30 years. Arguably there could have been more use of CGE models in generating shadow prices for CBAs.

Filling the Gaps

One way in which the complementarities between the two techniques can be made use of is through using CBA to fill in the gaps in a CGE simulation, and vice versa. There is some use of this already. Thus some CBA approaches are used to fill in gaps which are present with using the more aggregate CGE modelling studies. For example, a CGE study of a road investment would not take into account the road noise or other externalities. However, it is simple to measure the noise cost and add it to the CGE evaluation. This out-of-the model in-filling is quite common. Use of CGE results to measure effects which CBA finds difficult has been done, (such as measuring the benefits to an economy of inbound tourism) though it is not as common. As noted before, there are several ways in which CBA has difficulty in measuring particular costs and benefits, and more use could be made of this (possibly lack of access to a suitable CGE model may have been a reason, but with the proliferation of CGE models, this will be less of a problem in future).

Explaining the Differences

Investments or policy proposals can be evaluated in terms of their effects on the economy using either CBA or CGE models, or both. If they are evaluated using both, it would be very unlikely that they would come up with the same answer. The two techniques are different,

and both of them have limitations. The next stage would be to document and explain, as far as possible, why they differ.

There have now been a small number of examples of where the two techniques have been applied to evaluate the same projects. Unfortunately, side-by-side comparisons are not currently possible, because the results of the evaluations are set in different terms- the CBAs give results in terms of NSB, and the CGE modelling gives results in terms of GDP and similar accounting measures. However, as emphasised before, there is no particular reason why this has to be the case- a CGE study can give results in terms of NSB as well as the other variables of interest (though the CBA cannot give results in other than NSB terms). All that is needed is that the CGE model is adapted to produce results in terms of NSB (many models already do, so no adaptation is needed), and this can be done systematically in the modelling, or in an ad hoc way by adjusting the existing results of the model. The result will be two measures of how much better off the economy will be as a result of the investment.

Normally there will be significant differences in the results of the evaluations. Neither one nor the other is likely to be the "correct" answer. The next stage is to analyse why they are different. Several of the explanations will be simple. Thus, a CBA may measure externalities such as noise from a road, while the CGE study does not. The CGE study will make an estimate of the general equilibrium aspects of the road, which the CBA will not. A CBA will make an estimate of the direct cost of greenhouse gas emissions, but the CGE model will produce an estimate of the direct and indirect emissions if it has a greenhouse gas emissions capability, which some do these days. Where there is an identified source of difference, it is possible to work out why the two results are different. Thus if there is an airport being evaluated, and if the benefits from inbound tourism are specifically identified in a model which has a tourism sector, it will be possible to estimate these benefits in a CGE study (this is something which cannot be done at all accurately in a CBA). However, if there is no specifically identified tourism sector in the CGE model, it will probably not be feasible to estimate how much difference the inclusion of tourism benefits make to the overall difference in the results (which is why researchers interested in tourism build tourism sectors into their models).

It is unlikely to be the case that every difference can be explained fully. Unless a detailed forensic study of why the results of a CBA and a CGE study is done, it will not be feasible to track down everything which causes the two approaches to differ. The CBA will be fairly straightforward, but the CGE model will be picking up effects which give rise to the effect on NSB to be smaller or larger. However, it is possible and desirable for the analyst to set out the different factors which cause the evaluations to differ, and how big the quantitative significance of these is- that is, a concordance between the evaluations. This will produce a pair of evaluations which are closer together, even though they might not be identical. This will be of value to the decision maker- two estimates of an uncertain magnitude are better than one. This can be done readily with current knowledge- all that one needs is the two evaluations expressed in the same terms.

Integrating CBA and CGE

Ideally, we would like move to the third level, as identified in part 1 above, and to have an integrated evaluation, which covers and measures every cost and every benefit, both indirect and indirect. Hopefully this will yield the most accurate assessment of the project or policy. This might be a general equilibrium evaluation which is sufficiently disaggregated to ensure accuracy, can handle economy wide aspects such as employment and macro impacts, and which is able to encompasses detail. This is the idea of cost benefit analysis as set out in theoretical work. In reality we are not at this stage yet, though in the past few years we have moved closer to it.

Does it make a difference?

Does it make a difference having two evaluations of the same project or policy? If the two evaluations can be reliably be expected to produce very similar results in terms of the bottom line, in the effect on NSB, then only one will suffice. Given that a CGE study provides information on a range or outputs, while a CBA provides results on only one, NSB, this would suggest that CBA could well be redundant. One would need to test this suggestion empirically- this could be done by examining the results of a large number of projects which have been evaluated using both techniques.

There are good reasons for expecting this to not be the case, at least in the present. There are too many differences between the approaches which have been identified and could be important. CBAs have problems in measuring key benefits and costs, they do not take into account GE aspects, which can be important is some cases (we do not know how many), and they have difficulty in coping with economy wide effects, such as the impact on employment. On the other hand, a CGE study may be too aggregate to yield accurate results, and it may not include externalities and non-market goods. The example of measuring tourism benefits in the Sydney Airport CBA indicates that the estimate of NSB could be as much as 40% too high as a result of using arbitrary assumptions about tourism benefits, something which is necessitated by the inability of CBA to measure tourism benefits.

8 Conclusions

The development and use of CGE models is giving rise to an advance in investment evaluation. CBA has been the standard technique in evaluating investments, but CGE models are now being used in this area and their use is growing. There are a number of limitations to CBA which CGE models can address. These include:

- The essentially partial nature of CBA (we do know that CBA is inaccurate, but we do not know how inaccurate it is);
- The inability of CBA to handle more complex costs and benefits, such as, for example tourism benefits;
- Its inability to go beyond direct measures of externality costs and benefits and measure ultimate impacts;

- Its inability to measure ultimate distributional measures; and
- Its difficulty in handling economy wide or macro effects, including unemployment.

The CGE approach to investment evaluation has great promise is addressing many of these limitations- this promise is already fulfilled in part.

This paper has explored a wide range of issues involving the relationship of CBA and CGE models, especially in their role as tools for investment assessment. The similarities and differences have been noted, and it has been argued that some of the differences are not as fundamental as often suggested. This is particularly true of the investment criterion- CGE models can produce results in terms of the impact on welfare or net social benefit, in the same way as CBAs do. A CGE model can handle general equilibrium aspects of an investment, which is a limitation of CBA. There are particular measurement problems which CBA has great difficulty in handling, but which can easily be handled using a CGE model. A limitation of a CGE model is that it is usually very aggregative- however this limitation is being addressed by using sub models. A CGE approach can be useful in measuring key shadow prices, such as the marginal welfare cost of taxation. A number of practical problems with both approaches have been noted.

The extent to which CBA and CGE models can be integrated can usefully be summarised in terms of three levels.

The first level sums up what is currently being done. CBAs and CGE models are used to evaluate investments, but they are being used to shed light on different aspects of the valuation problem. This is useful, but it can be confusing- are the two techniques potentially resulting in inconsistent results?

The second level is not often or ever achieved, but it is perfectly feasible. It is possible to use a CGE model to answer the question- does the economy gain, in welfare or net social benefit terms, from an investment? There is the likelihood that a CBA and a CGE model will produce different answers to the question. However, this should not regard as a problem- the two techniques both have limitations, and two estimates of an uncertain magnitude (i.e. the impact on welfare of the project) are preferable to one.

The third is in the future (though this may not be very far off). This is the level of complete integration of the techniques. This would be feasible of CGE models can be disaggregated readily, and thus the accuracy of a CBA can be achieved using a CGE model. Such an inetegration would mean that the goal of the theory of CBA, that of a general equilibrium CBA, becomes a reality.

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