Tools for Measuring the Full Impacts of Agricultural Interventions

IFPRI-MCC Series: Prioritizing Agricultural Investments for Income, Poverty Reduction, and Nutrition

Technical Paper 2

Will Martin
International Food Policy Research Institute

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

MILLENNIUM CHALLENGE CORPORATION
UNITED STATES OF AMERICA

ACRONYMS AND ABBREVIATIONS

BCA	Benefit-cost analysis
BCR	Benefit-cost ratio
CEA	Cost-effectiveness analysis
CV	Compensating variation
ERR	Economic rate of return
EV	Equivalent variation
FAO	Food and Agriculture Organization
IE	Impact evaluation
HRV	Hausmann, Rodrik and Velasquez approach
IRR	Internal Rate of Return
MAFAP	Monitoring and Analyzing Food and Agricultural Policies
MCC	Millennium Challenge Corporation
MCF	Money Metric Marginal Cost of Funds
MMCF	Marginal Value of Public Funds
MVPF	Quality Adjusted Life Years
QALYs	Quality Adjusted Life Years
R&D	Research and Development
RCT	Randomized Control Trials
WTP	Willingness to Pay

EXECUTIVE SUMMARY

A first step in evaluating the effects of agricultural investments in developing countries to recognize that policy makers will almost certainly have multiple objectives. Even policy makers like those at the Millennium Challenge Corporation, with a strong focus on ensuring that interventions contribute to growth, also have a keen interest in poverty reduction and other goals such as enhancing gender equity. This presence of multiple goals has profound impacts on the choice of policies and mean it is likely that more than one policy instrument will be needed to best achieve those goals.

Once the goals of policy have been identified, the next step is to identify possible policy instruments to help in achieving these goals. These potential policy instruments will likely include some policy reforms like adjustments to trade policies that are relatively easy to implement, whose impacts are relatively easy to analyze and whose implications for fiscal revenues may be slight. They may also include reforms to the ways that policies are identified and implemented, such as moves from centralized policy making to community driven development, designed to align policies more strongly with needs in the communities affected. They are also likely to include investment projects with substantial revenue requirements that seek to rectify market failures in areas such as the provision of public goods or the internalization of externalities.

Constraints Analyses are an important part of the MCC approach to identifying and evaluating interventions using the Hausmann, Rodrik and Velasco growth diagnostic approach (HRV). This seeks to identify areas in which substantial progress can be made at limited cost by identifying key omissions in current policies. Their famous, and useful, analogy to a barrel with a short stave whose lengthening can increase the water level in the barrel at minimum cost helps grasp the essence of this approach. It deals with situations where inefficiencies in past policy making, and/or changes in circumstances mean that disproportionately large benefits are obtainable at low cost.

A key question is whether the current economy-wide Constraints Analyses go far enough into the details of the agricultural sector to help identify the best interventions. Should a similar approach be used to focus on problems within the agricultural sector and help identify the most pressing needs for intervention. Could such studies help to identify key challenges such as limited adoption of modern, high productivity crop varieties, oppressive taxation or wasted subsidization of key agricultural commodities? Might such analyses also provide key parameters for subsequent project assessment?

Even if a highly detailed Constraints Analysis is available, Benefit-cost Analysis (BCA) is needed even when marginal costs are unusually low because the net benefit needs to be assessed and there are many circumstances where this may not be high. It may, for example, be better to move to an entirely new intervention than to repair an existing measure. Consider, for example, the case common in transition economies where an irrigation scheme could be rehabilitated at lower cost than a new irrigation system could be constructed, but the existing scheme remains uneconomic because of bad location or a change in market circumstances.

A key conclusion of this review of tools is that the basic building block for assessing potential policy evaluations should continue to be benefit cost analysis (BCA) of alternative proposals. BCA allows projects of different sizes and with different objectives to be assessed using a common metric that provides vitally important information for policy makers. Alternatives such as cost-effectiveness analysis (CEA) are often attractive because of difficulties in evaluating the value of their benefits but provide no basis for comparing across different types of project.

Impact evaluation (IE) is a vitally important potential source of information on the effects of interventions. The focus of IE on identifying causal impacts is invaluable in identifying approaches that work and in rejecting approaches that only appear to achieve their goals. Unfortunately, much impact evaluation stops with identifying statistically significant impacts on outputs, without going the necessary extra mile of identifying the benefits of those outputs or the costs of the inputs needed to bring them about. Just as careful design is needed to identify causal impacts, careful design and implementation are needed to measure the benefits and costs associated with projects undergoing impact evaluation.

The paper shows that benefit cost analysis is a special case of a prototypical model in which welfare impacts are evaluated using their impacts on consumers' costs of expenditure and on firm profits. This demonstration makes clear that many familiar forms of analysis—such as graphical supply and demand curve analysis—are special cases of a general model that can be used for graphical analysis in simple cases and for evaluation of potentially large numbers of interventions when a formal model is available. Where necessary, this unifying framework can be extended to incorporate taxes and other distortions, nontraded goods and general equilibrium implications.

Much can be achieved using traditional trade-focused approaches to benefit-cost analysis, of the type proposed by Little and Mirrlees (1974) and Squire and van der Tak (1975). Impacts of intervention may be measured using simple engineering data or results from impact evaluation and values assigned to benefits and costs using shadow prices that reflect the impacts of the project on economic welfare. For traded goods, shadow prices can be implemented very simply using the border price rule, rather than by pricing at distorted domestic prices. Not doing so risks making decisions that reduce national welfare by ignoring the revenue losses associated with stimulating production of inefficient import-competing production and ignoring the benefits not reflected in domestic prices of goods subject to export taxation.

One important omission from most applications of benefit-cost analysis is the costs of raising the revenues needed for interventions that provide public goods and must be financed using distorting taxation. It appears that this may have arisen because early applications of cost-benefit analysis at the World Bank and other development agencies focused on interventions such as building steel plants where there was potential for projects satisfying the benefit-cost criterion to break even or make a financial profit. With the modern focus of government interventions on rectifying market failures such as inadequate provision of public goods, there is much less expectation that projects will break even. The costs of raising public funds can be captured simply using the marginal cost of public funds (MCF) to incorporate the very real costs of raising public funds, or the real benefits of reforms that generate scarce public funds. By raising the hurdle for investments requiring public resources, use of the MCF helps to distinguish between competing uses for public funds and to allocate these funds to the projects yielding the highest social returns.

A widely used alternative approach to rationing scarce public funds is applying discount rates far above the social discount rate, such as the 10 percent discount rate used by MCC. This approach has the disadvantage of discriminating against investments, such as improvements in agricultural technology, that generate benefits over very long periods. Incorporating the MCF in the evaluation of benefits and costs would avoid this bias against long-lasting interventions. By allowing use of a more economically realistic discount rate, it would also make it feasible to use Benefit-Cost or Net Present Value criteria rather than the Economic Rate of Return. While convenient, the ERR approach does not always have a unique solution and involves the very strong assumption that project beneficiaries can invest at the rate of return achieved by the project overall—an assumption that has come under strong criticism in agricultural

R&D, where the rates of return on investment are far above the likely rates of return on investments available to individual beneficiaries.

Where interventions affect the prices of factors or nontraded goods, traditional trade-focused approaches encounter severe difficulties. Suggested approaches such as identifying the shadow prices of nontraded goods by repeatedly decomposing them into the traded goods they embody are not very transparent or satisfactory. A much simpler approach in this situation would be to use general equilibrium models to assess the impacts of the intervention. A wide range of approaches is available, ranging from global models to simple national models solved on spreadsheets.

Standard money measures of welfare change such as Compensating Variation and Equivalent Variation provide valuable indicators of the welfare impacts of interventions. In the textbook case of a consumer facing a change in prices, the welfare impact can be identified either as a compensation measure—the external transfer needed to compensate for the change— or as a money metric—the amount of money equivalent to the change. Considerable care is needed in the presence of distortions, where the two types of measure may become very different because of revenues resulting from income effects on taxed goods. Unfortunately, choosing to use just one measure is probably not a satisfactory solution because some approaches to evaluation—such as standard approaches to benefit-cost analysis—naturally yield compensated welfare measures while other approaches—and especially model-based analyses—tend to produce money metric measures of welfare change. Fortunately, relatively easy adjustments are available to transform from one approach to the other.

Cost effectiveness analysis is widely used as a substitute for benefit cost analysis when the benefits of the project—such as savings in Quality-Adjusted Life Years (QALYs)—are believed to be too difficult to price. While such reticence is understandable, failing to put such a value on the project goal greatly reduces the value of the analysis to policy makers who must decide how to allocate resources across wide ranges of policies—such as interventions in health and in agriculture. Where possible, it seems desirable to attempt, in a manner as transparent and well-grounded as possible, to put indicative values of different goals.

The biggest challenge for policy makers arises when decisions about resource allocation across multiple projects must be made with partial information on goals and impacts. Recent work suggests that considerable progress can be made in solving these problems. Multiple goals can frequently be aggregated into a manageable objective function, and the optimal set of policies identified by solving either a constrained or unconstrained programming model that builds on existing modeling tools.

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1 INTRODUCTION

Differences in the share of employment in agriculture and in labor productivity in agriculture can explain most of the differences in income between poor and rich countries (Restuccia, Yang and Zhu 2008). Given that the agricultural sector of developing countries provides employment to most of the world's poor, reducing the gap between incomes in agriculture and in the rest of the economy has great potential to increase incomes (Martin 2021). Policy makers are concerned not just with raising incomes, but also with reducing income and gender inequality, improving nutritional outcomes and enhancing sustainability. These multiple goals will clearly require multiple policy interventions. The key question is how to identify ex ante and verify ex post the combination of interventions that can most effectively achieve these goals.

Given the importance placed on Constraints Analysis in the MCC approach to evaluating projects, it seems important to begin any analysis of possible interventions in the agricultural sector with an examination of the situation in the agricultural sector, and rural areas more generally. Done carefully, this approach may help, like the economy-wide Constraints Analyses, to identify areas in which interventions in agricultural may have the greatest impact for the lowest possible cost.

Once the key market failures affecting agriculture have been identified, careful, consistent approaches are needed to evaluate specific approaches to improving the situation. A wide and seemingly diverse range of approaches has been suggested for evaluation of policy reforms in development programs. These include Impact Evaluation (eg Khandker, Koolwal and Samad 2010; White and Raitzer 2017); Benefit-cost analysis (BCA) (Boardman et al 2018); Marginal Value of Public Funds (MVPF) (Hendren 2016; Hendren and Sprung-Keyser 2019); Cost-effectiveness Analysis (CEA), and the Hausmann, Rodrik and Velasquez (2005) growth diagnostics approach. Many of these approaches focus on aggregate outcomes such as the overall benefit-cost ratio for an intervention but meeting many goals—such as reducing income and gender inequality and improving nutrition—requires analysis at the level of households and/or individuals. Once individual interventions have been identified and evaluated the key challenge is to provide guidance for policy makers on the best combination of measures to achieve those goals.

What appears to be needed is a framework that encompasses these approaches, allows their strengths and weaknesses to be clarified and the best approach to be identified. To do this, we begin with a simple, stylized representation of Impact Evaluation, showing its important contribution, and what is needed in addition for project evaluation. Then the discussion turns to a simple general-equilibrium model that can be simplified for analysis of some interventions and augmented to deal with the complexities that arise in others. The simplifications are useful in themselves and have the pedagogical advantage of helping to build confidence in what, to many, may initially seem to be an unfamiliar approach. Both the simplifications and augmentations are designed to identify the simplest possible approach to evaluation, and to avoid the errors that have frequently been made by analysts not laying out a sufficiently comprehensive model to evaluate the intervention under investigation.

A key question is what types of intervention need to be analyzed. The first type of intervention to be considered is those that seek to generate new knowledge. A second is implementation of public projects that use existing knowledge to provide public goods that would otherwise be under-supplied in the market. A third involves design of regulatory policies or of policy making processes to achieve better policies affecting agriculture. A fourth involves dissemination of knowledge to potential users who might not currently have access to it and/or “nudging” producers towards actions that are in their own best interests (Duflo, Kremer and Robinson 2011).

Agricultural research and innovation systems are a classic example of new knowledge interventions. Nobel Prize Winner TW Schultz (1964) did much to highlight the importance of this type of intervention, arguing that traditional agriculture was “poor but efficient” and that the only way incomes could be sustainably raised was through innovations that raise agricultural productivity. Finding new crop varieties that increased yields and were more robust to weather conditions was at the heart of the green revolution. Clearly, a continuing stream of innovations is needed, not just to increase yields but also to offset the adverse impacts of continually evolving insects, diseases and weeds (Olmstead and Rhodes 2002).

Public good provision includes a wide range of interventions. Some of the more basic government interventions include the maintenance of law and order, the design and enforcement of weights and measures and laws on land tenure. Also important are infrastructure interventions such as dam-based irrigation projects and local roads that require a degree of coordination not feasible for individual producers and so will be under-provided by the market. With infrastructure projects, government or other development partners invest budget resources in public (or other externality-generating) goods that raise agricultural productivity or lower the cost to households of achieving any given level of economic welfare. The frequently large budget costs associated with these projects require attention to the costs of raising taxpayer funds, a cost that is ideally including in the analysis. Even if it is not, it will almost certainly raise its head through constraints on the amounts of funding governments are willing to provide even for high-return projects.

Interventions for better policies include reforms of agricultural support or taxation and regulations on product quality. These interventions frequently do not require outlays of government funds—and some interventions such as import tariffs sometimes may even raise substantial revenues—although they can have substantial economic costs by distorting production or consumption decisions. A related set of interventions such as government provision of crop insurance and/or price stabilization focuses on challenges related to production or price volatility. Policy interventions also include changes to the policy formulation process such as Community Driven Development approaches (Mansuri and Rao 2013) that shift decision making to the local level. Delegation of irrigation water management to water users’ groups is another indirect approach sometimes used with the aim of achieving better policy choices (Fishbein and Haile 2012).

Dissemination of knowledge interventions involves identifying information needs for producers and/or consumers and providing the needed information in ways that will improve economic welfare. This set of interventions includes agricultural extension and training, information about market prices (Goyal 2010) and market prospects. Behaviorally focused interventions that seek to improve outcomes by “nudging” farmers to make better decisions (see, for example, Duflo, Kremer and Robinson 2011) assume that policy makers have better information than private agents but go beyond provision of that information, by encouraging them to make the “right” decisions.

The distinction between approaches that raise productivity with existing technology and those involving development of new technologies that raise productivity is an important one for agricultural development. If we fully accept the Schultz (1964) hypothesis that subsistence farmers are “poor but efficient” then there is no need to consider approaches to raising productivity with existing technology. While this proposition is widely accepted among agricultural economists—who tend to focus more on developing new knowledge than extending available knowledge—it remains deeply controversial among development practitioners.

One possible explanation for this difference of view is that most farmers in most developing countries have moved away from purely traditional agricultural practices to systems that involve at least some use of modern technologies (Abler and Sukhatme 2006). Given this, much modern analysis focusses on questions like whether subsistence farmers are using economically optimal amounts of fertilizer or are operating inside the production possibility frontier for this reason or due to lack of awareness of currently available technologies (Duflo, Kremer and Robinson 2011). Duflo, Kremer and Robinson (2011) argue that there may also be cognitive biases that explain sub-optimal purchases of fertilizer, creating opportunities for "nudge" policies to have an impact. The production frontier approach of Maruyama et al (2018) involves both identifying the scope for interventions to raise farm productivity with current technology and the opportunities to use new technologies that expand the available production possibilities.

The broad goal of this paper is to provide an integrated framework for evaluating interventions and to identify ways in which this broad approach may be adapted to specific needs. Throughout the paper the focus is on approaches that seek to put monetary values on benefits and costs, while recognizing that this may be challenging and that it may sometimes be necessary to use simpler approaches such as Cost Effectiveness Analysis when there is unlikely to be sufficient agreement on the value of the gains from the intervention to make Benefit-Cost analysis helpful in reaching agreement (JPAL 2020, p8). The approaches considered include impact evaluation, trade-based benefit-cost analysis, welfare-based benefit-cost analysis, money-metric and compensated welfare measures.

The approaches considered are quite general in allowing assessment of both the overall social benefits and the gains or losses to individual beneficiaries, as suggested by Londero (1996). The frameworks used can be applied both at national level and at the individual or household level to allow assessment of the overall economic returns from an intervention and its distributional impacts. Distributional impacts can, in turn be examined economy wide and for individuals stratified by income level, by gender and/or by region. Other important objectives, such as nutritional impacts and impacts on sustainability can also be incorporated to some degree by extending the type of household model used in Laborde et al (2019).

The effects of some interventions—such as improvements in access that raise producer prices and lower prices of inputs and consumer goods—can be examined using simplifications of the basic approach. The economic returns from investments that involve substantial budgetary expenditures funded through taxation require extensions to the basic approach if the costs of raising public funds are to be adequately considered.

The paper introduces a critically-important distinction between two alternative measures of the welfare impacts of interventions—the compensation approach and the money-metric approach. In distorted economies, these measures may be quite different and mixing them up may result in serious errors. This problem can't be overcome by simply choosing to use one type of measure, because one or the other is frequently much more convenient to use and or available from earlier work. What turns out to be necessary is to understand how to move from one to the other and to use only comparable measures when evaluating projects.

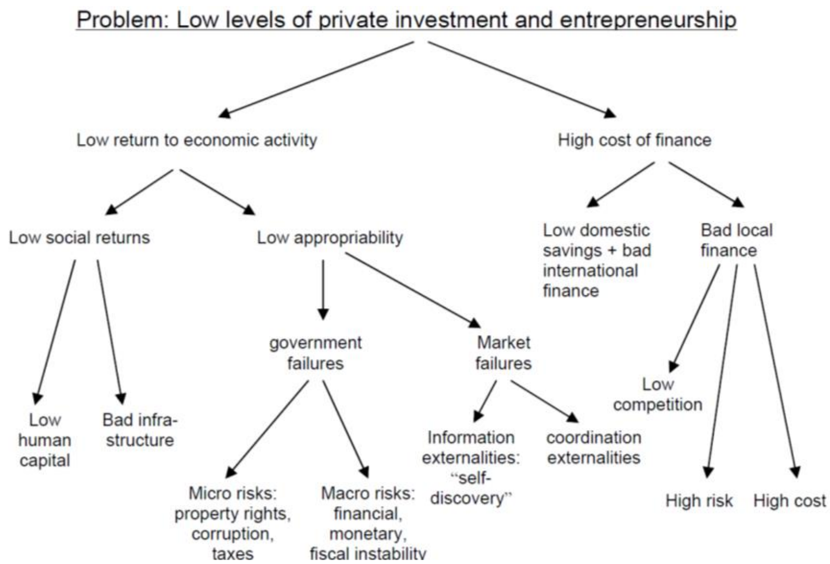
The next section of the paper deals with the Constraints Analysis that the MCC typically uses as a first step in design and analysis of its program of interventions. The second deals with assessing the impacts of investment—a vitally important source of rigorously-based information on whether the intervention achieves its immediate goals, but one that could be harnessed more strongly to estimating the economic benefits and costs of interventions. The third lays out a simple general equilibrium approach to the economy that underlies most approaches to economic evaluation. The fourth section shows how this can be used to assess the economic impacts of changes in prices. This leads into a discussion of the situations in which partial equilibrium approaches will be useful. The next two sections introduce price distortions and factor taxes. With this as background, the eighth section lays out the key elements of the computable general equilibrium models now widely used to analyze the impacts of interventions. The ninth section considers discount rates and economic rates of return.

With the background laid out in the first nine sections, the tenth section turns to the Benefit-Cost evaluation that is central to MCC's approach to assessing the desirability of potential interventions. It highlights that there are two potential approaches to evaluating policy changes—the money metric approach and the compensation approach—and shows how results from both these approaches can be compared. The eleventh section extends the analysis to situations with nontraded goods and/or factors whose prices may change in response to income and/or substitution effects arising from the intervention, and for which a general equilibrium treatment is therefore required. The twelfth section examines the implications when prices respond to interventions. The thirteenth section considers alternatives to benefit-cost measures, such as the marginal value of public funds (MVPF) and cost-effectiveness approaches. The fourteenth section considers distributional impacts and the beneficiary analyses used by MCC. The fifteenth section considers the tradeoff between efficiency improvements and poverty reduction, considering both the overall benefits, and the extent to which these benefits accrue to low-income groups—the question of identifying benefits and beneficiaries highlighted by Londero (1996). Conclusions are presented in the sixteenth section.

2 CONSTRAINTS ANALYSIS

The Constraints Analysis approach used by MCC seeks to identify the most profound sources of economic loss in the economy and to allow policy makers to focus on those, rather than on areas where returns may be lower and/or more uncertain. This approach is based on Hausmann, Rodrik and Velasco (HRV) (2005) and Hausmann, Klinger and Wagner (2008) and involves identification of symptoms that indicate fundamental problems in the economy. The approach recognizes that a problem like low levels of private investment that results in low levels of economic growth may have many different causes, as shown in the Hausmann, Klinger and Wagner (2008) Growth Diagnostics decision tree reproduced in Figure 1.

Figure 1: Growth Diagnostics Decision Tree



Source: Hausmann, Klinger and Wagner (2008, p21)

While Millennium Challenge Corporation (MCC) growth diagnostics studies (eg MCC 2015, 2017) do a good job of identifying key features of the economy and key constraints to growth performance, they do not appear to delve far into the details of the agricultural sector to identify why agricultural outcomes might be unsatisfactory. If agricultural development projects are to make the greatest contribution to economic development, there remain many challenges in identifying why the agricultural sector generates unhappy outcomes, such as low output per person, low output per acre of land, volatile output and low incomes for farmers.

The Constraints Analysis approach outlined in Figure 1 is just as relevant for the agricultural sector as for the overall economy. The agricultural sector may perform poorly because of low returns to economic activity, or because of high costs of the finance needed for a modern agricultural sector. Low returns may, in turn, arise because of policies that reduce agricultural prices either directly by taxation of agriculture or indirectly by providing high protection to the industrial sector, or through exchange rate distortions that lower returns to producers (Anderson and Martin 2009). Another potential source of low returns may be a failure to increase agricultural productivity, perhaps because farmers don't adopt higher-productivity modern varieties; perhaps because those varieties are not available to them; or perhaps because they still find high labor productivity traditional procedures better than modern alternatives at current availability of land per person (Boserup 1965).

The agricultural sector in growing economies is also influenced by barriers to movement of labor between sectors. As economies grow, the agricultural sector inexorably declines as a share of the economy (Martin and Warr 1993). If there are barriers to mobility of resources out of agriculture returns to labor in agriculture may be substantially below those in other sectors. But agricultural incomes also depend heavily on the availability of employment opportunities outside agriculture. If the rest of the economy is generating good employment opportunities in export-oriented industries, and workers have opportunities to move then returns to labor in agriculture are likely to increase over time. If, by contrast, the traded goods sector in the rest of the economy is focused on limited markets for import substitution and workers are unable to move out of agriculture, returns per worker may remain low even if the resources and technology used in agriculture are quite good.

In this situation, it seems likely that a first approach to identifying the best investment opportunities in agriculture might involve a supplement to the national Constraints Analysis that focuses on the constraints facing the agricultural sector. A non-exhaustive list of issues to consider might include:

- Farm incomes relative to non-farm incomes
- Crop yields per hectare
- Share of land under shifting cultivation
- Output per worker in agriculture
- Share of agricultural output that is consumed on-farm
- Shares of crop area sown to improved varieties
- Distortions to agricultural incentives such as export taxes, tariffs on products & inputs
- Policies inhibiting movement of labor out of agriculture
- Quality of property rights in land and constraints on those rights
- Irrigated area relative to assessed irrigation potential
- Proximity of farmers to urban centers

These measures can rapidly build an assessment of where the agricultural sector of a country is on the transition from traditional agriculture of the type considered by Schultz (1964) through the transformation process (World Bank 2008) towards a modern high-productivity agricultural sector. It may help to avoid traps of the type identified by Boserup (1965) in which development specialists were confused by the reluctance of farmers to accept modern technologies because simple slash-and-burn agriculture has high labor productivity when population pressure is low.

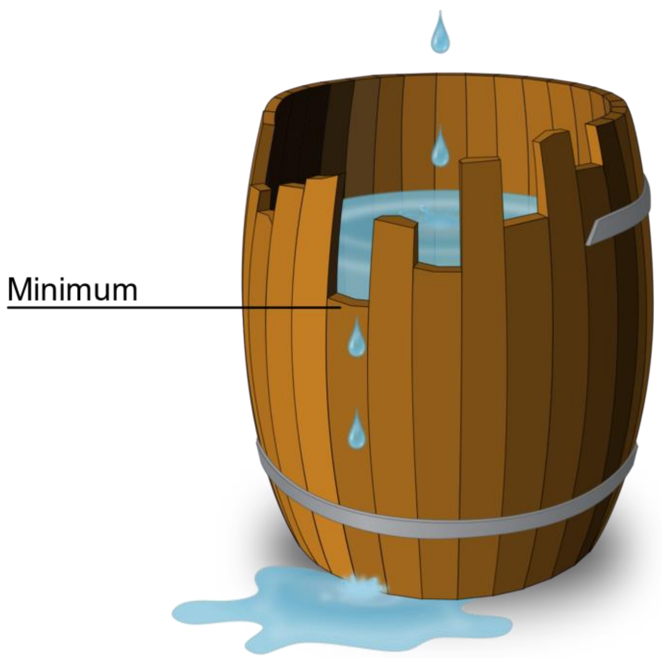
The Constraints Analysis approach looks rather different from Benefit-Cost analysis but can be seen an approach to identifying areas in which the benefits are likely to be disproportionately large and/or the costs unusually small. The essence of this approach is to look for situations where policy outcomes are sharply curtailed by one or a few limiting constraints and a large improvement can be brought about by relaxing those constraints.

The barrel shown in Figure 2 provides a useful analogy for this approach to policy analysis. If raising the water level in the barrel is the policy goal, then raising the height of the lowest stave will be much more cost-effective than raising all of the staves. Raising the height of any other stave will generate costs but provide no benefit. After the water has reached the second-lowest stave, it will be necessary to raise the height of the two lowest staves simultaneously, increasing the cost per unit of deepening achieved. As the water becomes deeper and more and more staves need to be augmented, the marginal cost will continue to rise until, perhaps, the marginal cost exceeds the marginal gain.

A situation where one stave in the barrel is disproportionately low reflects either past policy failures or a change in circumstances. Considering first the case of past policy failures, the uneven staves in Figure 2 reflect wasteful use of the timber incorporated in the (n-1) unnecessarily long staves. Efficient barrel-building would have involved making all the staves the same length. A change in circumstances that would result in an outcome like Figure 2 would be deterioration of one of the staves, resulting in it becoming much shorter than the others.

Identifying such binding constraints is potentially a very important approach to identifying highly prospective interventions. However, an HRV analysis needs to be accompanied by benefit-cost analysis. Consider, for example, a proposal to rehabilitate a currently non-functioning irrigation scheme. If the interventions needed to rehabilitate the scheme are quite minor—perhaps repairing a broken canal —then the cost of rehabilitating the scheme will clearly be much lower than building a new scheme of the same specifications. But the scheme may have fallen into disrepair for good reason. Perhaps it was built under an economic regime where relative prices were distorted, or perhaps it no longer makes economic sense. Only an updated benefit-cost analysis using the marginal costs and benefits of the rehabilitation project will ensure that it makes sense today.

Figure 2: Policy Choices for Raising the Water Level in the Barrel



3 ASSESSING THE IMPACT OF INTERVENTIONS

Prior to undertaking any economic evaluation of a proposed intervention, it is critical to be sure that the intervention has a favorable causal impact on economic outcomes of concern. This is surprisingly difficult to objectively verify because of reverse causality. Deaton and Cartwright (2018) provide a useful description of the key element of impact evaluation using the equation:

$$(1)\ Y_i = \beta_i . T_i + \sum_j \gamma_j x_{ij}$$

where Y_i indicates the outcome(s) for unit i; β_i is the effect of the treatment on unit i; T_i is the treatment being considered and the x_{ij} s are observable control variables.

A key question is whether the assessment is being undertaken is ex ante or ex post. Clearly, initiation of any new project requires an ex ante assessment based on the information available to decision makers at the time. Ex ante assessments are particularly challenging because they must depend on information such as engineering “guesstimates”; experimental evidence that may require adjustment (such as use of experiment station yields as a proxy for farm yields) or empirical analysis of previously implemented projects. Where projects are implemented in stages, ex post information can become available if efforts are made to collect and assess such information as the project proceeds. While much is not known at this point, we do know a lot about how to organize ex ante assessments. Kaufmann et al (2000) provide a framework that examines both the technical match between the outputs of the intervention and the needs of users, and the cost-effectiveness of the intervention.

Even ex post analysis involves many challenges. Much of the enormous impact evaluation literature is focused on ensuring that the coefficient β_i is statistically significant and that this measured effect is not due to a confounding effect such as a common determinant of both the treatment and the outcome. As noted by Ravallion (2001), simply comparing outcomes for treated and untreated units may either result in spurious indications of efficacy, as when investments in rural roads are associated with high economic growth precisely because roads were placed in areas of anticipated demand growth; or in spurious indications of ineffectiveness, as when death rates are higher than average in hospitals because people admitted to hospital are unusually sick.

Enormous progress has been made in recent years in identifying the causal impacts of interventions on outcomes. One key recent development in development economics has been the widespread adoption of Randomized Controlled Trials (RCTs), which reduce the risk of making incorrect inferences and the probability of identifying true causal impacts. While this approach first entered agricultural economics as a way of assessing the efficacy of innovations such as new crop varieties (Fisher 1935), it has more recently re-emerged with a focus on assessing the impact of changes resulting from policy reform (Duflo, Glennerster and Kremer, 2007).

The rise to prominence of RCTs has not been without controversy. Card (2019) identifies an ongoing controversy between those who view causality as demonstrated only when there is a clear theory linking cause and effect (eg Heckman 2008) and those who see causality demonstrated through experimental designs that allow causal effects to be identified without a precisely-specified behavioral model (eg Holland 1986). Deaton (2010) challenges the use of purely design-based approaches and argues that they contribute only when they help to identify and test the implications of relationships for which theoretical models provide a causal path. Ravallion (2012) argues that a focus on problems for which randomization is feasible may have shifted attention to small interventions and away from dealing with the big challenges to development. Peters, Langbein and Roberts (2018) highlight concerns about the validity of RCT findings outside their specific context and suggest ways to improve their external validity.

There has also been great progress with other identification strategies, such as those involving “natural experiments” where the treatment was administered in a random manner; regression discontinuity designs; double-difference approaches; and use of instrumental variables to avoid spurious correlations. Whatever approach is used, good analytical work must carefully confront the challenges of identifying the true effect and testing for its significance. Deaton and Cartwright (2018) argue for a carefully thought-through approach to identifying the best approach to the problem at hand, rather than seeking to use

RCTs in all cases. There is, however, universal agreement that the increase in focus by development economists on identifying true causal impacts and avoiding spurious results is highly desirable.

Khandker, Koolwal and Samad (2010) and Gertler et al (2016) provide valuable summaries of techniques for impact evaluation in development economics. These range from the use of structural models that potentially allow ex ante assessments of the impacts of interventions, through a range of econometric techniques—such as Regression Discontinuity designs, Propensity Score Matching, Double-Difference and Instrumental Variable models— designed to deal with problems of selection bias; through to RCTs.

Whatever approach is taken to identifying true causal effects, it is important that the assessments used be as rigorous as possible in identifying the impacts of the intervention. Inevitably, the less formal sources of information, such as preliminary trials in the region of the intervention and expert opinion are likely to suffer from biases due, for instance, to selection of the most promising areas or individuals for preliminary assessments. Quite frequently, monitoring and evaluation during the project can allow more informed and rigorous assessments that, in turn, provide the basis for mid-course corrections and enhancements.

Initial ex ante assessments of the likely impact of an intervention, such as a transition to high-value agriculture (Borkum, Fortson and Miller 2015) are particularly challenging. How can a project designer be sure that a project will result in the desired increase in productivity? Clearly, the initial design of such projects is more an art than a science. But if evaluation steps are built into the design—perhaps by rolling out the project in a way that permits randomized assessments of outcomes—then the margin for error in this project, and other projects for which the lessons from this project are relevant, can be reduced.

A surprising feature of the literature on impact evaluation has been a strong focus on the challenges of identifying unbiased and significant impact effects on an outcome variable such as Y_i in equation (1), rather than on identification and economic analysis of proposed interventions. Studies of impact evaluation, such as Gertler et al 2016), frequently include no discussion of approaches to measuring economic benefits or costs, although Dhaliwal et al (2012) do provide guidance on approaches that might be used for cost-effectiveness analysis and Gertler et al (2010) recognize benefit-cost analysis as a complementary analytical tool. Adams et al (1992) found that only 121 of 50,000 RCTs included economic analysis of the impacts under consideration, as well as the significance of the impacts. While this study referred to medical analyses—where RCTs have been used for much longer—it seems clear that, even today, very few development-oriented impact evaluations, with honorable exceptions such as de Brauw et al (2018), are accompanied by economic analyses that allow the benefits and costs interventions to be rigorously evaluated and ranked against alternatives.

Clearly, it is highly desirable to focus development interventions on those that can be shown to have statistically significant, favorable impacts on development outcomes. But this is only a necessary condition for development impact. Many interventions with positive and statistically significant impacts on desired outcomes may be economically inferior to other interventions. The tools for evaluating projects would ideally ensure both that there is an impact and that this impact has benefits that exceed its costs. Sometimes, it will be challenging to value outcomes. Where this is not believed to be possible, the intervention cannot be evaluated against a wide range of alternatives. It may still be helpful to evaluate it against alternative approaches to achieving the same goal, as discussed in the section on Cost-Effectiveness Analysis, but this is much more limited value to development policy makers than being able to assess the intervention against a wide range of alternative interventions. As argued by Harrison (2014), findings that an intervention causes outcomes such as changes in fertilizer use are not substitutes for rigorous measures of the welfare impacts of the policy, such as changes in the equivalent variation resulting from the policy.

Ensuring that the best program of interventions is implemented requires viewing impact evaluation not as the end of the evaluation process, but as perhaps the end of the beginning. The economic evaluation of interventions involves several issues about modeling and measurement that have received disproportionately little attention in the literature and are therefore considered in the following sections.

4 A SIMPLE GENERAL EQUILIBRIUM MODEL APPROACH

Approaches to assessing the impact of interventions on economic welfare are often thought of as existing in silos. Benefit-cost analysis is often seen as a very simple technique, implemented using spreadsheets, that simply adds up benefits and costs, to calculate a measure such as a Benefit-Cost ratio or an Economic Rate of Return. Partial equilibrium models of market behavior are often seen as occupying a different place, perhaps estimated econometrically at national level and using simple simulation software. Beneficiary analysis clearly needs data at a much finer level than either of these approaches, such as household survey data, but typically involves much less detail on the responses of producers and consumers. General equilibrium modeling is usually undertaken in a way that looks very different from the other approaches, using calibrated models built to exactly fit a baseline dataset (eg Laborde et al 2013). But, in fact, all these approaches have much more in common than might at first appear to be the case. At the same time, however, they differ in subtle ways that need to be understood if their results are to be compared. To help see the similarities between these approaches, it is helpful to begin with a very simple framework and to add and/or subtract features as needed.

Almost all these approaches have, as a common underpinning, a simple general-equilibrium model with a representative consumer and producer like those found in Dixit and Norman (1980). Many development projects also involve government-provided goods (see Anderson and Martin 2011). Producer profits can be represented by $\pi(p,G)$ where the vector p includes prices of both outputs and intermediate inputs, and G is included to capture the impacts of government-provided goods—such as, for example, public roads—on the profitability of private production. In a model of this type, consumer behavior can be represented by an expenditure function that shows the amount of expenditure $e(p,G,u)$ needed to reach a level of utility, u, given a vector of domestic prices, p, and a vector of government-provided goods and services, G.

Within the expenditure function, an increase in prices raises the expenditure required to achieve any given level of utility. Within the profit function, an increase in output prices raises producer profits while an increase in intermediate input prices reduces them. A productive increase in the supply of government-provided goods, G, should either increase producer profits at given prices, and/or lower the expenditure needed to achieve a given utility level. Examples of the former include government investments in productivity-increasing research and development, or in irrigation facilities, or efficient water allocation legislation, that allow farm firms to increase their output. An example of the former is where government provision of a legal and policing system reduces households' need to employ private security guards (or soldiers).

Since the government chooses the quantity of the good to be supplied, the marginal value of the good can be represented using virtual prices, e_G or π_G (Neary and Roberts 1980), that adjust in response to the quantities of the government good provided and other determinants such as wage rates and the prices of consumer goods. The virtual price πG is the increase in producer profits associated with an increase in provision of the government good. Virtual price e_G shows the reduction in private expenditures needed to maintain utility following provision of an additional unit of the government good.

These virtual price measures of the marginal impact of a change in the quantity of a good provided by government may be inferred in many ways. If the good is a perfect substitute for a good available in the market, the marginal benefit to the consumer or producer receiving the good is simply the market price. If it is not, then procedures such as elicitation of willingness to pay may be used to infer them (Hardie and Strand 1979). Other widely used approaches involve estimating the impact on the supply of or the demand for other goods—such as the increase in output from a yield-increasing production technology or the reduction in travel costs needed following provision of a better road (see Boardman et al 2018 for a wide range of approaches).

These two functions can be turned into a measure of the welfare impacts of changes in prices, p, and G by embedding them in an income-expenditure condition:

$$B = \pi(p,G) - e(p,G,u) + \gamma \qquad (2)$$

Where γ is an exogenous transfer from outside the country under consideration. If we continue to hold utility constant, then B is initially zero and changes in B provide a measure of the compensation required to hold utility at its initial level following a change in G. If utility is held constant at its initial level, the result is a Compensating Variation measure of utility change. If utility is held constant at its final level, the result is an Equivalent Variation measure of the welfare change.

The function B may seem unfamiliar at first but is reasonably straightforward. The first expression, π(p,G) captures the impact of changes in p or in G on producer profits. The second term, e(p,G,u), captures the impacts of price changes on the cost of living (a concept familiar from the Consumer Price Index), and the effect of changes in G on private costs of living (as when provision of policing services reduces personal costs for self-defense). In the trade literature, it is a simplification of the balance of trade function of Anderson and Neary (1991) used to measure the impacts of changes in world prices on national economic welfare and extended to analyze the implications of changes in trade policies. As we will see, it underlies Deaton’s (1989) net-sales criterion for measuring the impact of a commodity price change on any household.

The first derivatives of these functions with respect to prices are the quantities of these goods supplied, π_p, and demanded, ep (Varian 1992). The derivatives of these functions with respect to G indicate the marginal return to an increase in G, and hence the marginal value (or willingness to pay) for additional investments in G. The derivative properties of these functions have important implications for the use of this function in evaluating the impacts of policy interventions.

The model may be applied at the national, regional or individual/household level. If it is applied at the national level, the profit function is a GDP function representing the maximum potential value added in the country given the available resources, the current level of productivity and the level of government-provided goods, while the expenditure function is based on a representative household. If the model is applied at the household level, the expenditure and profit functions for individual households can be distinguished, and the model can be used to track the implications of interventions for each household, and hence to assess implications of interventions on poverty and income distribution.

5 WELFARE IMPLICATIONS OF CHANGES IN PRICES

Many development projects result in changes in prices that have important implications for producers and consumers and may result in large welfare implications. A simplified version of equation (2) allows us to obtain rigorous estimates of the implications of changes in prices for economic welfare. For individual countries/households and commodities these estimates have a very intuitive interpretation for small shocks, and familiar implications for larger shocks. They also provide a path to estimating the implications of larger shocks using either evaluations of the non-linear expenditure and revenue functions, or second-order approximations to these functions.

A first order estimate of the impacts of a set of price changes on the welfare of the household or country under consideration is given by the first-order differential of equation (1) with respect to the price of the good. Thus

$$(3) \qquad dB = \pi_p . dp - e_p . dp$$

where πp is a vector of the quantities of goods supplied and ep is the quantities demanded.

For an individual good, given that the first derivatives of the expenditure function are the supply and (compensated) demand functions for that good, equation (3) can be written as:

$$dB = (S - D).dp$$

Where S is the supply of the good and D the demand, and hence (S - D) is the country or household's net sales of the good. This is the Deaton (1989) measure of the welfare impact of a change in the price of a commodity produced or consumed on household welfare. If the application is to a country, equation (2) estimates the impact of a change in the price of a traded commodity on national economic welfare—a measure known in this context as the income effect of a terms-of-trade change.

This non-parametric first-order effect provides adequate estimates of the impact of a change in prices on welfare if:

1. The change in price is small, or
2. The change in price allows insufficient time for the quantities demanded and/or supplied to change or,
3. Supply and demand responses are small enough to be ignored.

These conditions are very strong, and especially likely to be misleading for price changes that are relatively large and sustained. However, such simple measures may be very useful for providing quick estimates of the impacts of short-lived price shocks on welfare. They have, for instance, proved very useful in assessing the impacts of short-run food price shocks on the welfare of vulnerable households (see, for example, Ivanic and Martin 2008). They may also be very useful in simple, structured assessments of the impacts of development projects that change prices on the income levels of beneficiaries.

When price changes are large and sustained, and supply and demand responses are potentially large, there are two approaches to consider. The first involves specifying the revenue and expenditure functions using information from econometric evidence. This is highly desirable when there are multiple price shocks, because it can be difficult, in this context, to track the movements in supply and demand curves associated with multiple price changes. It is not necessary that the expenditure and profit functions be spelled out in a single equation. Larger systems of equations in partial or general equilibrium models, such as MIRAGRODEP (Laborde, Robichaud and Tokgoz 2013), may be used to represent these relationships and others needed for welfare evaluation. Where representing these revenue and expenditure functions explicitly is not possible, it may be helpful to use second-order approximations to the impacts of price changes on the realizations of these functions.

For a single price change, second-order approximations to equation (2) can be very helpful aids in interpreting these measures. A second-order approximation for the welfare effects of a price change is given by the Taylor Series:

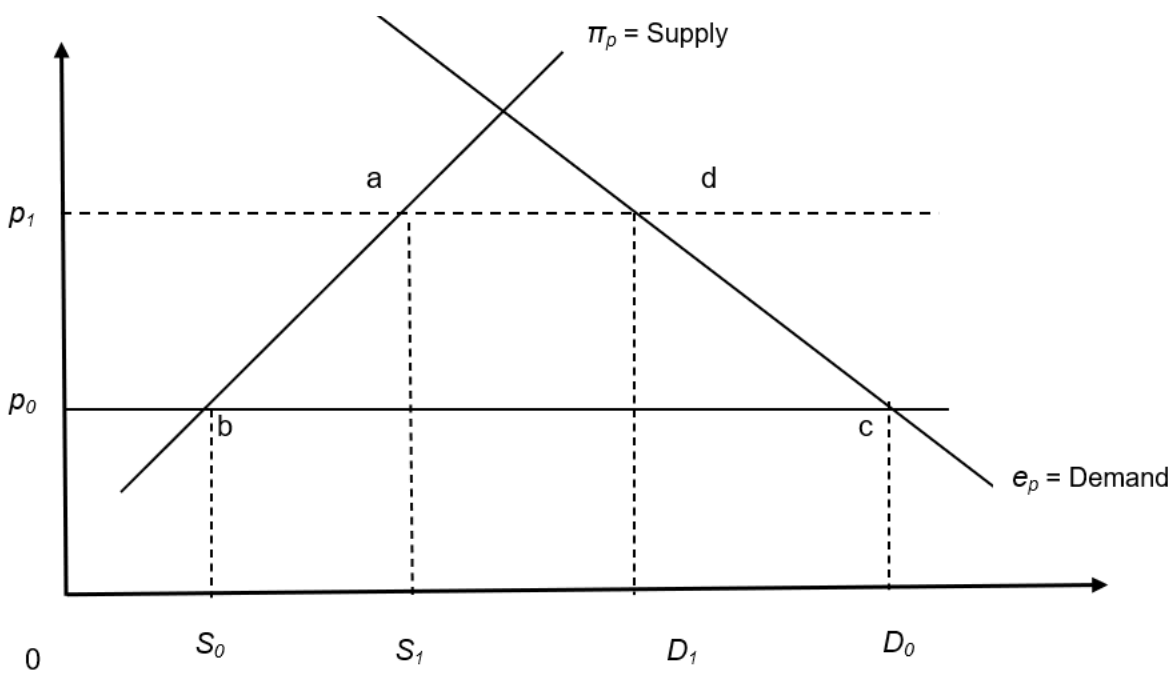
$$(4) \qquad \Delta B = (\pi_p - e_p).\Delta p + \frac{1}{2}.(\pi_{pp} - e_{pp})\Delta p^2$$

The first derivatives π_p and e_p are, as previously discussed, the supply and demand for the good in the initial situation; the second derivatives π_{pp} and e_{pp} are the slopes of supply curve and the compensated demand curve for the good under consideration. Thus, equation (4) can be rewritten as:

$$\Delta B = (S - D).\Delta p + \frac{1}{2}.\left(\frac{\partial S}{\partial p} - \frac{\partial D}{\partial p}\right)\Delta p^2$$

Equation (4) has a simple, graphical interpretation represented in Figure 3 by the area (abcd). This is smaller than the area $(S_0 - D_0).\Delta p$ that would be implied by a first-order approximation. The intuition for the reduction in this loss is that producers respond by producing more and consumers by cutting their consumption. The producer response increases their gain from the increase in price, while the consumer response reduces their loss from the price increase. Both adjustments reduce the net cost associated with the price increase.

Figure 3: Welfare impacts of a large price change



It is unnecessary to introduce the profit and expenditure functions in equation (2) when the effect can be captured graphically as in Figure 3. However, the more formal approach outlined here has a major advantage when we begin to consider multiple price changes, which are extremely difficult to track using diagrammatic approaches such as consumer and producer surplus. The demonstration that the two approaches are equivalent is also a useful step towards approaches that generalize the model beyond equation (2) and allow issues not amenable to a graphical treatment to be addressed.

6 PARTIAL EQUILIBRIUM ANALYSIS

The similarity of Figure 3 and figures based on ad hoc representations of supply and demand suggests a role for partial equilibrium analysis. One situation where partial equilibrium analysis will provide a reasonable approximation of impacts is when the income effects of the change under consideration are relatively small, so that there is little income-induced movement in the demand curve. Partial equilibrium analysis may also be useful when the time frame for analysis is short, making it more difficult to develop more rigorously-based models, where the commodities are small in revenues and expenditures, and price changes are more important than in typical cost-benefit analyses.

Partial equilibrium modeling has been widely used in analyzing agricultural problems, such as the impacts of global agricultural trade distortions on food prices (eg Tyers and Anderson 1992). Partial equilibrium approaches continue to be widely used for problems involving volatility, where sustained income effects are typically small (eg Gouel, Gautam and Martin 2016; Anderson, Ivanic and Martin 2014; Minot, Valera and Balíe 2021). However, advances in the technology for solving large, static or dynamically recursive models having allowed many more of these problems to be solved using computable general equilibrium models.

7 INTRODUCING PRICE DISTORTIONS

The model in equation (2) can easily be extended to include price distortions created by trade or domestic taxes. To incorporate these distortions, we introduce a distinction between domestic and world prices to represent trade taxes and between producer and consumer prices to represent production or consumption taxes. We also add a revenue term that we initially assume is redistributed to the household without creating any additional economic distortions and therefore augments the revenue from production given by π(p,G). We begin by considering the imposition of tariffs on imports at the national level. The resulting model is based on the balance of trade function of Anderson and Neary (1991):

$$(5) \qquad B = \pi(p,G) - e(p,G,u) - (p-p_w)' z_p(p,G,u) + \gamma$$

Where p is a vector of domestic prices; p_w is a vector of world prices; z_p is a vector of net exports when positive or net imports when negative ($\pi_p - e_p$) and all other terms are as previously defined. Note that for an import, z_p is negative and the import duty ($p-p_w$) is positive so - $(p-p_w)' z_p$ is a positive contribution to the income of the representative household. For an export tax ($p-p_w$) is negative and z_p is positive so - $(p-p_w)' z_p$ is again positive. When utility is endogenously determined, the balance-of-trade function expresses the balance of trade as income from production, tariff revenues recycled to consumers and-transfers less the expenditure required to achieve a specified level of utility. When utility is held constant, this generalization of the expenditure function indicates the increase in transfers from the rest of the world needed to compensate for any change in policy or external prices.

With utility held constant, the first derivative of B with respect to p is $(p-p_w).z_{pp}$ so the impact of a small change in tariffs on economic welfare is given by:

$$(6) \quad dB = -(p-p_w).z_{pp}dp$$

Where z_{pp} is the slope of the export supply/import demand function. This measure of welfare change is the impact of the change in the tariff rate on tariff revenues resulting from the change in the quantity imported over the existing tariff barrier given by ($p-p_w$), the measure of welfare change emphasized by Harberger (1971, p796). It is also a compensation measure of the welfare impact of an increase in the tariff. A decline in B is the amount of compensation that must be provided from the rest of the world if utility is to stay at its initial level following this tariff increase.

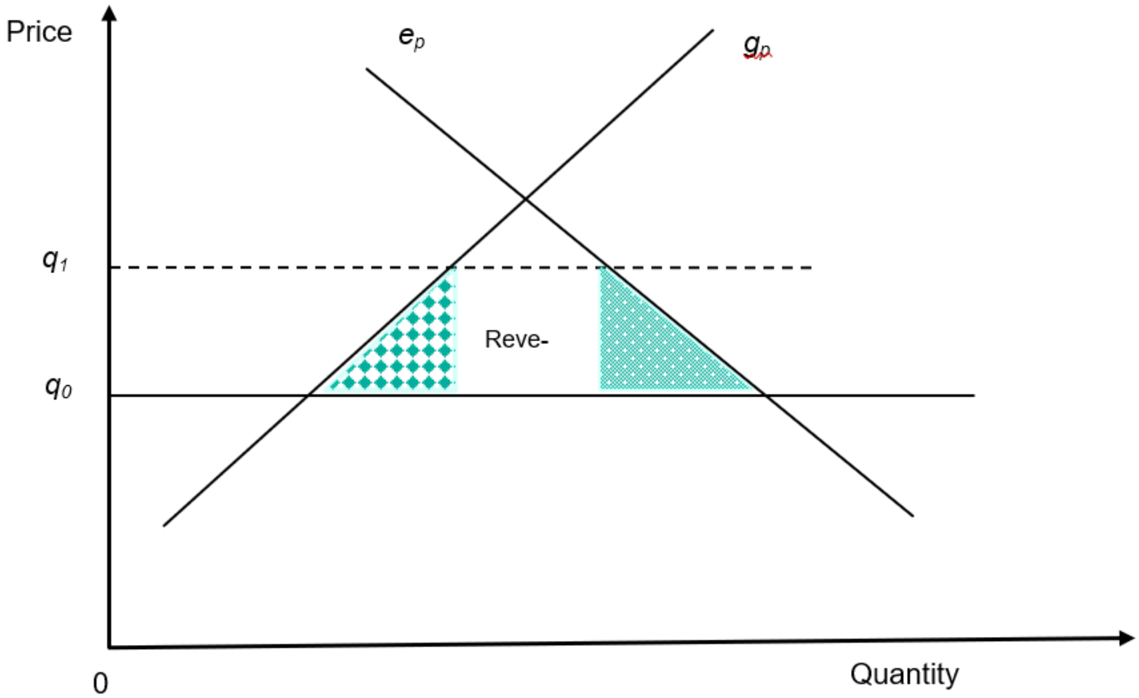
An important implication of equation (6) is that an incremental increase in a tariff from an initial level of zero has no impact on welfare. Another important implication is that the marginal welfare cost of an increase in a tariff rises with the tariff. A second-order Taylor series expansion about an initial tariff of zero, ignoring higher-order terms involving z_{ppp} by assuming the expenditure and revenue functions are quadratic, indicates that the welfare cost of a tariff regime is quadratic in the tariff rate and equal to:

$$(7) \qquad \Delta B = -\Delta p.z_{pp}\,\Delta p = -\,\Delta p.(\pi_{pp} - e_{pp})\Delta p$$

For a change in a single distortion, this is the familiar Harberger Triangle measure of welfare change. Since z_{pp} is positive, the introduction of a non-trivial tariff reduces welfare and requires an increase in transfers from the rest of the world if utility is to be held constant. In line with the trade-focused approach to Cost-Benefit analysis, this approach measures the change in welfare in terms of the foreign exchange equivalent of the intervention (Ward 2019) and yet is clearly consistent with Harberger's public finance approach.

Equation (7) has a simple graphical interpretation for a single tariff, as depicted in Figure 4. The social costs of this intervention are given by the two shaded areas in the Figure, with the checked area representing excess production costs and the dotted area the social costs of sub-optimal consumption of the good. The clear rectangle between these two areas is the tariff revenue received. Again, the second-order approximation—which is exact for quadratic expenditure and revenue functions and hence for linear supply and compensated demand functions—corresponds with the diagrammatic treatment in the single commodity case, except that this formulation makes explicit that the demand curve should be a compensated demand curve. And, of course, equation (7) can represent the impacts of changes in multiple tariffs if its elements are generalized to include vectors of tariff changes and the associated matrices of own and cross price effects in production and demand.

Figure 4: Welfare impacts of an increase in a tariff



The welfare measures discussed above are compensated measures, under which domestic consumers are compensated for the income change resulting from the policy change so that u remains constant and can be ignored in calculating the welfare impact. A source of major confusion in the public finance literature is that there are two distinct measures of the welfare costs of policy change in the presence of distortions—the compensation approach and the money metric approach. The distinction between these two approaches is quite different from the more widely understood difference between equivalent variation and compensating variation. That the compensation/money-metric difference is distinct from the CV-EV difference is very clear where the policy change is an infinitesimally small change in prices. In this case, there is no difference between equivalent and compensating variation measures, yet—as we shall see—there is a difference between the compensation and the money-metric approaches. A simple explanation of the difference between money metric and compensation measures is given in Appendix 1.

An alternative welfare measure, a first-order money metric measure of welfare change for a price change resulting from a tariff barrier can be obtained by differentiating equation (5) with respect to p and u.

(8) $(p-p_w).z_{pp}dp + e_u du - (p-p_w).e_{pu}du = (p-p_w).z_{pp}dp + e_u du - (p-p_w).\frac{e_{pu}}{e_u} e_u du$

Recalling that $\chi_I = \frac{e_{pu}}{e_u}$ is the Marshallian income effect in demand (see Dixit and Norman 1980), equation (8) can be rewritten as:

(9) $e_u du = -\frac{1}{(1-(p-p_w)\chi_I)}(p-p_w)z_{pp}\,dp$

The term $\frac{1}{(1-(p-p_w)\chi_I)}$ is sometimes known as a foreign exchange multiplier[1] and is known to be positive in stable markets. This means that the sign of the welfare impact can always be determined by the right-hand side of (6) which, as we have seen, is a compensation measure of welfare change—the transfer from the rest of the world that would leave utility at the same level as if the policy had not changed. This result is consistent with Hatta's (1977) demonstration that the welfare effects of policy change do not depend on income effects. If we have a complete model, the foreign exchange multiplier can be evaluated either using knowledge of the income effects and distortions, or by comparing the money metric measure of welfare change from a foreign transfer with the value of the transfer.

For a national model with a uniform commodity tax such as a Value-Added Tax (VAT), we can work with a single, composite commodity, x, and p, p_w and χ_I are scalars. To get some indication of the potential magnitude of this multiplier, consider a VAT levied at a uniform 25 percent on all final consumption. In this case $(p\text{-}p_w).\ \chi_I$ may be reorganized to

$$\left(\frac{px}{e}\right).\left(\frac{p-p_w}{p}\right).\left(\frac{dx}{de}.\frac{e}{x}\right)$$

Since all income is spent on the one good, $\left(\frac{px}{e}\right)=1$ and the income elasticity of demand is one, so $\left(\frac{dx}{de}.\frac{e}{x}\right)=1$. Since the VAT marks up the price of all final goods by 25 percent, $\left(\frac{p-p_w}{p}\right)$=0.2, making the foreign exchange multiplier 1.25. For this simple case, with a plausible VAT rate, the money metric measure of welfare change is 25 percent greater than the compensation measure. As we will see when we have a model with labor and other factors, the money metric welfare measure may be considerably smaller than the compensation measure.

Unfortunately, Hatta's finding has frequently been forgotten. Repeatedly, authors using incomplete models have argued that the money-metric measures are the "right" ones because they use actual measures of tariff or tax revenues and have gone on to conclude that using the money metric measures has important policy implications (see, for example, Ballard and Fullerton 1992). As shown by Anderson and Martin (2011), both money metric and compensation measures are acceptable, and give the same results as long as they are used consistently. What creates errors is mixing the two—such as using a money metric measure for the costs of raising revenues and a compensation measure to evaluate the benefits from a policy intervention.

One solution might seem to be to use only one or other measure, but this is harder than it might appear. Compensation measures are much more convenient when using a diagrammatic approach to welfare evaluation like the one reported in Figure 2 or spreadsheet-based benefit-cost analyses. The money metric versions of Figures 3 and 4 involve continuous movements in the demand curve as real income changes, making graphical interpretation very unclear (see Martin 1997). But when using a general equilibrium model to measure welfare changes, it is frequently much more convenient to use a money metric measure in which changes in utility impact demands and tax revenues. Either approach is fine as long as it is used consistently, or adjustments between the two types of measures are made (Anderson and Martin 2011).

[1] This name has been used because, it can be used to calculate the burden on a country of making a transfer to the rest of the world. The increase, or decrease, in the burden comes from the interaction of the payment with the distortions created by the donor country's tax system.

8 INTRODUCING FACTORS AND FACTOR TAXES

Deaton and Muellbauer's (1981) full expenditure function, which represents household decisions to supply factors of production, and particularly labor, as well as making consumption choices is very useful for extending the analysis to include factor supply, demand and taxes. The profit function can readily be extended to allow it to represent firms' demands for factors as well as their commodity output supply and demands for intermediate inputs. The resulting model is a modification of equation (5) to focus on factor taxes such as income taxes, where the tax creates a gap between the factor returns received by the household, wh, and the factor returns paid by the firm, w:

(10) $B = \pi(p,w,G) - e(p,w_h,G,u) + (w_h - w)' e_w(p,w_h,G,u) + \gamma$

Factor demand by firms, π_w, is negative because payments to labor reduce firms' profits. Labor supply by households, e_w, is negative because the household's ability to supply factors reduces the income from outside the household needed to sustain a given standard of living. Frequently, only labor is considered, but income taxes are levied on all factor income and so it will sometimes be useful to consider the broader supply of factors that generate taxable income suggested by Feldstein (1999). When considering poverty impacts, changes in wage rates for unskilled labor are frequently of interest since income from this source is particularly important for many poor households.

When focused on national level questions, the representative expenditure and profit functions refer to all households and firms in the country. For simplicity, it is usually assumed that the revenues from taxes are distributed directly to the household. When considering individual households, it is frequently useful to focus only on enterprises directly managed by the household, as in the farm household models pioneered by Singh, Squire and Strauss (1986). In this case, $(\pi_w - e_w)$ is the household's sales of labor outside the farm firm, a direct analogy to the Deaton (1989) net-seller/net-buyer criterion for whether a household gains or losses from a change in the price of a commodity.

9 COMPUTABLE GENERAL EQUILIBRIUM MODELS

Computable general equilibrium (CGE) models at national level (Dixon et al 1982; Lofgren, Harris and Robinson 2002) and at global level (Hertel 1997; Laborde, Robichaud and Tokgoz 2013) are extremely powerful tools for assessing the impacts of many shocks and policy changes. The national modules of these models all contain three core elements consistent with those discussed above:

(i) Income-expenditure condition: $\pi(p,v) - e(p,u) - (p-p_w)' z_p(p,v,u) = \gamma$

(ii) Product markets: $x = \pi_p - e_p$

(iii) Factor markets: $l = e_w - \pi_w$

The income-expenditure condition is consistent with equation (5) in including producer profits, $\pi(p,v)$; consumer expenditure, $e(p,u)$; and revenues from trade and potentially other taxes, $(p-p_w)' z_p(p,v,u)$; subject to an external financing constraint, γ. The product market equations simply express a vector of net trade, x, as the difference between domestic supply, π_p and domestic demand, e_p. The factor market equations represent differences between factor supply from households, e_w and demands by firms, π_w. The utility level, u, is typically endogenous. The product market conditions determine net trade for tradeable goods and allow the model to solve for prices of nontraded goods. The factor market conditions are often used to solve for factor prices such as wage rates.

In addition to the core blocks of equations identified above, trade-focused models tend to include considerable detail about trade policy measures, and their impacts, including approaches to assessing the impacts of highly disparate rates of protection on different products (Laborde, Martin and van der Mensbrugghe 2017). Other models have included relatively more detail on domestic taxation (Shoven and Whalley 1984). All CGE models contain many other equations for a wide range of purposes, such as to manage intermediate input use or to distinguish between domestic and imported goods, and a wide range of accounting identities to calculate useful summary statistics.

One key thing that CGE models typically do not include is the direct impact of government interventions on producer profits or the cost to households of achieving their initial level of utility. While this impact must be evaluated for benefit-cost analysis and could potentially be added to the expenditure and revenue functions in CGE models, it has never, to my knowledge, been done in practical applications. Doing so would be enormously valuable because it would allow the marginal benefit of a government-supplied good to be not just a scalar value, but a function of the level of the intervention, z_G. This would allow a suitably augmented model to capture the reality that provision of one lighthouse has a potentially enormous value, while a second has close to zero value. More generally, it could capture high or low initial levels of return and the declining marginal product of public investment, just as for private investment in other parts of the model.

Absent an explicit representation of the benefits of government-provided goods, CGE modelers focused on analyzing the impacts of government investments tend to focus heavily on measures such as changes in productivity, which are relatively tractable approaches to capturing the direct welfare impacts of some government-provided goods, such as new product varieties resulting from public research and development. The ORANI model of the Australian economy (Dixon et al 1982) includes variables for both product-augmenting and process-enhancing technological change throughout. The impacts of many government-provided goods can be captured in this way, but the process of translating the government-provided output into such a product or process-enhancing productivity change is more an art than a science.

One potentially useful simplification of standard CGE models is the 123 model originated by Devarajan, Lewis and Robinson (1993). This model focusses only on the income-expenditure condition and product markets, which allows it to be solved using simpler software, including Microsoft Excel (see Fukase and Martin 2001). It is useful when resources are very limited and particularly when key information such as an input-output table is not available. Because models of this type contain a market clearing condition for domestic goods, they are potentially very useful for estimating the price changes associated with major policy reforms such as the elimination of exchange rate distortions.

10 DISCOUNT RATES AND ECONOMIC RATES OF RETURN

Almost all investment projects involve a difference in timing between inputs and outputs. Textbook treatments of Cost-Benefit analysis consider several possible approaches to the choice of discount rate—such as the Social Opportunity Cost of Capital; the Social Time Preference Rate and the Shadow Price of Capital considered by Boardman et al (2018). These approaches yield discount rates that are quite low, even for relatively short-term projects, with Boardman et al (2018) suggesting rates ranging from 2.2 percent to 4.7 percent.

The rate chosen by any government is probably less important than being consistent across projects. Typically, governments provide guidance on discount rates for their entities conducting Cost Benefit Analysis. The US Office of Management and Budget (OMB 2018, p9) recommends a real discount rate of 7 percent based on the marginal pretax rate of return in the private sector, as does the Australian Government (2016). The UK Treasury advocates a rate of 3.5 percent (UK Treasury 2018, p103) based on the Shadow Price of Capital. Freeman, Groom and Spackman (2018) compare this rate with the standard French rate of 2.5 percent and conclude that 3.5 percent is in the middle of the range based on the literature available, although they also note that it is much higher than current real interest rates. The European Commission recommends a rate of 4 percent.

For development projects, the Asian Development Bank uses a 9 percent discount rate for most projects, but a 6 percent discount rate for projects with strong environmental or poverty reduction benefits (ADB 2017). The Inter-American Development Bank imposes a 12 percent rate of return hurdle for its projects . The World Bank has generally used a discount rate of 10 to 12 percent, not because this is seen as a correct measure of the social cost of capital, but as a device for rationing World Bank funds (Belli et al 1998, p179). However, project analysts are permitted to use lower discount rates if they justify this choice and discount rates of 6 percent appear to have been quite widely used (eg World Bank 2017). The 10 percent discount rate currently used by the Millennium Challenge Corporation (MCC) is clearly well above the standard rates used for investments in high-income countries themselves, but within the range used by multilateral donors.

To the extent that the 10 percent discount rate chosen by the MCC is intended to serve as a rationing device, it is instructive to consider how large an effect this increase in the interest rate has relative to an increase in the cost of government funds that takes into account the marginal cost of raising public funds (MCF). Of particular interest is the effect of moving from the 7 percent rate used for US government domestic investments to the 10 percent used in MCC investments. A simple Excel calculation for a project with a 20-year life suggests that using the higher interest rate has the same impact as raising the threshold for investments by 20 percent. The disadvantage of raising the threshold by raising the discount rate is that this approach discriminates against projects which yield longer streams of benefits.

The Economic Rate of Return (ERR) measure calculated by MCC for its candidate projects has the advantage relative to estimating a Benefit-Cost ratio of not requiring the analyst to specify a discount rate. This is particularly important when an extremely high discount rate might otherwise be employed. This approach has, however, been seriously criticized. One concern is that, if the time profile of benefits and costs is somewhat complex, there may be more than one value of this discount rate, more commonly called an internal rate of return (IRR), that equates benefits and costs (Dinwiddy and Teal 1996, p94).

Another point of concern is that the IRR approach assumes that the recipients of benefits from the project will be able to reinvest the funds generated by the project at the same rate of return as the original investment. This assumption is problematic when there is serious under-investment and consequently high returns in an area, such as agricultural research and development. Alston et al (2000) reported an average IRR of 81.3 percent in studies of US agricultural research and development. Alston et al (2011) point out that it is unrealistic to expect that beneficiaries could continue to invest at such a high rate of return. They therefore propose using a modified IRR that assumes beneficiaries of the investment can re-invest at a lower, externally determined rate of return. In their examples, this roughly halved the estimated IRR on long-lived investments in R&D.

11 BENEFIT-COST EVALUATION

This section focusses on evaluation at the national level, since Benefit-Cost Analysis (BCA) focusses on finding the aggregate welfare impact of an intervention, which must consider not just the benefits and financial costs of the intervention, but also induced impacts on government revenues associated with changes in the quantities flowing over policy distortions (Harberger 1971). Evaluation of impacts on individuals will involve distributional impacts resulting from price changes and changes in transfers of revenues to individual households as well as the changes considered under BCA.

If the government can provide goods without any cost to itself, then equation (2) can easily be used to provide a compensation measure of the welfare implications of providing this good.

(11) $dB = (z_G - (p\text{-}p_w).z_{pG})dG$

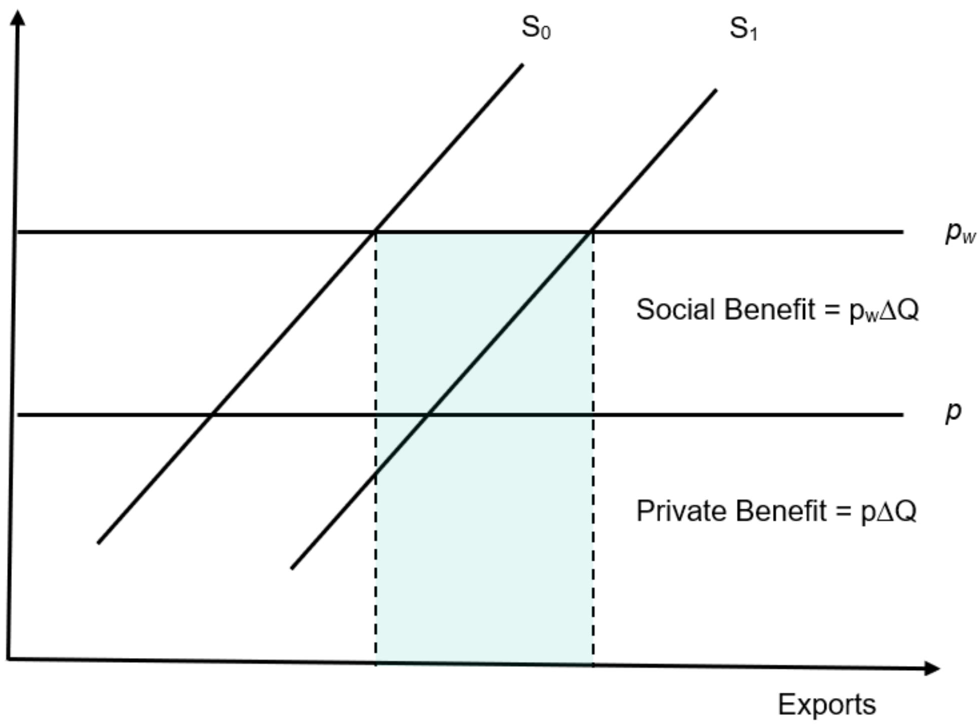
Where z_G is the direct benefit (eg an increase in revenues from production or a reduction in the costs of achieving a given level of utility) of a change in the publicly provided good. While analysts frequently compute the marginal benefits of a particular intervention, they are rarely incorporated in formal models, except in the case of interventions such as research and development that increase productivity or consumer benefits. Where the goods provided by government have perfect substitutes in the market, as in the case of pure food aid, $z_G = p.\Delta z$ where Δz is the increase in private availability of the good resulting from the intervention, and the reduction in the quantity that households must purchase to meet their consumption needs.

The $(p\text{-}p_w).z_{pG}$ term on the right hand side of equation (11) deserves particular attention. It adjusts for the fiscal revenue impact of changes in the outputs provided by government and the inputs used in their production. In the simple case of purely private goods (such as food) provided by government, z_{pG} is 1 and the effect of this adjustment would simply be to move to border pricing, as suggested by Little and Mirrlees (1974), since equation (11) becomes $dB = (p - (p\text{-}p_w).z_{pG})dG = p_w dG$. If government-provided goods are imperfect substitutes for privately provided goods z_{pG} is no longer precisely 1 but can be estimated to allow evaluation of the intervention.

Shadow pricing of traded goods using border prices was strongly recommended by Little and Mirrlees (1974) and widely used in World Bank project evaluation in the 1970s and 1980s (World Bank 1992), when trade distortions in developing countries—including tariffs, export taxes, quotas and foreign exchange distortions—were extremely high. As these distortions declined, it appears that formal use of shadow pricing also declined. While the average rate of taxation of agriculture in developing countries has declined substantially (Martin 2019), important distortions remain on the export side and many developing countries have moved to protect their import competing sectors.

A simple graphical illustration of the rationale for shadow pricing is given in Figure 5 for the case where an exportable good is subject to an export tax. A project that increases output of this product by ΔQ has a value at domestic prices of p. ΔQ. Once we allow for the fact that this increase in output is associated with an increase in export tax revenues of (pw - p). ΔQ, we see that the social return from this increase in output is pw ΔQ. When we consider the impact of a project that increases output of a good that is protected by a tariff, moving to border pricing has the opposite effect on social returns. Increasing production of import substituting products lowers government revenues by replacing imports that pay a tariff with locally produced goods that do not. Shadow pricing at world prices therefore reduces the measured social benefit associated with import-competing commodities.

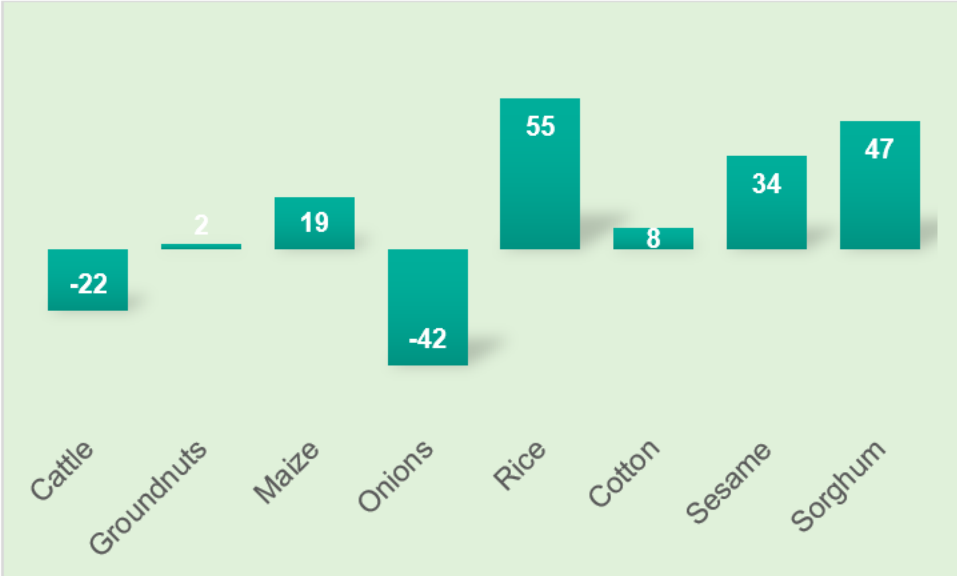
Figure 5: Impact of Shadow Pricing a Good Subject to an Export Tax



A simple example shows how important shadow pricing of traded agricultural products can be. The Di Irrigation component of MCC's Burkina Faso Agricultural Development Project had an estimated close-out Economic Rate of Return of 3.8 percent based on domestic market prices[2]. The very transparent spreadsheet used for this evaluation provides details of farm costs and prices and provision for sensitivity analysis. The FAO's MAFAP monitoring website provides estimates of the nominal rate of protection at farm gate for agricultural commodities in Burkina Faso over the 2009-14 reference period used in the analysis, as presented in Figure 6. This Figure makes clear the very large variation across commodities, the heavy protection for rice, sorghum and sesame, and the heavy taxation of onions and cattle. Using the estimated revenues in 2030, after the project has been fully implemented, it is clear that onions are expected to dominate output of the scheme, with 82 percent of the value of output at domestic prices, and 91 percent at the world prices implied by the Nominal Rates of Protection presented in Figure 6. Because of the importance of onions, the value of output rises by 58 percent when valued at border, rather than domestic prices, and this change more than doubles the economic rate of return for the project—taking it from 3.8 percent to 8.8 percent.

[2] Downloaded from https://assets.mcc.gov/content/uploads/2017/04/mcc-err-burkina-di-irrigation-close.xls on 25 May 2020

Figure 6: Nominal Rates of Protection by Commodity, 2009-14 Average: Burkina Faso



Note: Data downloaded from http://www.fao.org/in-action/mafap/data/en/ on 5/27/2020

Little and Mirrlees (1990), argue for estimating the public and private parts of project costs and benefits separately so that the costs of raising public funds through distortionary taxation can be incorporated in the analysis. To assess the implications for benefit-cost analysis of these costs, we need a model with a government budget constraint. Anderson and Martin (2011) develop such a model with the real-world feature of multiple domestic taxes but without external trade distortions. Here, we specialize to a single domestic tax, a tax on labor earnings[3], but add a range of external trade barriers. The resulting model has two equations: a private budget constraint and a government budget constraint. Satisfaction of both these equations ensures that the national budget constraint is satisfied. The equations are:

Private Budget Constraint

$$\pi(p,w,G) - e(p,w_h,G,u) = \beta \qquad (12)$$

Government Budget Constraint

$$c(p,w,G) - (w_h - w).e_w + (p-p_w).z_p(p,w,w_h,G,u) = \alpha \qquad (13)$$

In equation (12), the w_h variable is the post-tax wage rate received by the labor-supplying household. Since the quantity of labor supplied is negative (as distinct from the positive quantities of commodities consumed), a higher wage rate reduces the net expenditure that the household needs to achieve a given level of utility. The market wage rate, w, enters the profit function π(p,w,G) representing producer behavior. Because wages are a cost to business, profits are decreasing in w. For simplicity in this conceptual model, we assume that the market wage rate is fixed, either by free international movement of labor or by the presence of a numeraire commodity produced only with labor under constant returns to scale.

[3] Generalization to include taxes on consumption or production of goods, as in Anderson and Martin (2011) is possible, but adds complexity and obscures the link with the literature on the marginal cost of raising funds through taxation such as Ballard and Fullerton (1992).

Because of the heavy reliance of many high-income countries—and particularly the United States— on income taxes, traditional public finance models focus on this tax and labor supply response is often assumed to be the only way that households can respond to the incentives created by the income tax. The apparent discrepancy between the broader coverage of the income tax and the exclusive focus on the labor market might be explained by the key insight of the Solow model—that national income is determined only by the supply of labor and technology. Feldstein (1999) pointed out that there are many other margins of adjustment to changes in income tax rates, as payers seek to reconfigure their affairs to reduce their income tax liabilities. Given Feldstein's insight, it seems desirable to think of household labor supply for income generation in (5) as covering more factors than simply labor.

The c(p,w,G) function represents the direct cost to government of providing its chosen vector of public outputs, G. It is increasing in both p and w. The first derivative, cp, indicates the quantities of goods used by government to produce its outputs, while c_w indicates the labor demanded by the government. The second derivatives, c_{pG} and c_{wG} indicate the marginal changes in government purchases of goods and labor required as the vector of government output changes. The expression (w_h – w) is the negative of the wage tax rate and when multiplied by the negative quantity of labor supplied generates positive government revenue that offsets the cost of government activities. As in equation (5), z_p refers to export supply and $-(p-p_w)z_p(p,w,w_h,G,u)$ refers to government tariff revenue. β and α are transfers to the government and the private sector from the rest of the world. In the behavioral model represented by equations (5) and (6), these transfers are exogenous and the level of utility is endogenous.

Importantly, this model breaks the link between the cost to government of providing services and the value of these services that is implicit in the National Accounts treatment of goods and services provided by government (Lequiller and Blades 2014) and in many model-based analyses of government activities. These goods are no longer valued at the cost of their inputs. If a government-provided activity has a benefit greater than its cost—something which is hopefully the most common case and appears to be the case frequently for activities such as agricultural R&D—then this can be captured by a model that represents the demand for, and virtual prices of, goods provided by the government. Expansion of a publicly provided good for which the marginal benefit exceeds the marginal cost will increase economic welfare, while expansion of a good valued less than its social cost will reduce welfare.

10.1 Benefit-Cost Analysis with Compensation Measures

To obtain a compensated measure of the welfare impact of changes in government provision of goods financed by domestic taxation, we hold u and w constant and differentiate equations (12) and (13) in B, G and w_h to solve for the reduction in foreign compensation to the private sector needed to maintain a fixed level of utility, and the household wage rate, w_h, associated with a specified change in public provision, dG. The resulting equations are:

(12a) $dB = z_G dG - e_w dw_h$, and

(13a) $c_G.dG + (p-p_w).z_{pG}.dG - (w_h - w)e_{wG}.dG = [e_w + (w_h - w)e_{ww} - (p-p_w)z_{pw}].dw_h$

The only term in equation (13a) that lacks a clear interpretation is $(p-p_w).z_{pw}$. This refers to changes in compensated import demands associated with changes in the wage rate received by households. For example, if wage rates to households fall there will be some incentive to substitute leisure for work, with possible increases in the import demand for hammocks. A widely invoked assumption of net separability between labor supply and consumption decisions allows us to drop these effects from the derivation for simplicity, while recognizing that they may be relevant and could be incorporated in some model-based evaluations.

With this assumption, we can use equation (13a) to solve for the change in household wage rates, and hence the tax rate on labor income, associated with provision of a set of publicly provided goods

$$(14) \qquad dw_h = \frac{1}{(e_w+(w_h-w)e_{ww})}.\{c_G + (p-p_w).z_{pG} - (w_h - w)e_{wG}\}dG$$

Substituting (14) into (12a) gives us the expression for the compensated welfare impact of a change in G:

$$(15) \qquad dB = [z_G - \frac{e_w}{(e_w+(w_h-w)e_{ww})}\{c_G + (p-p_w).z_{pG} - (w_h - w)e_{wG}\}].dG$$

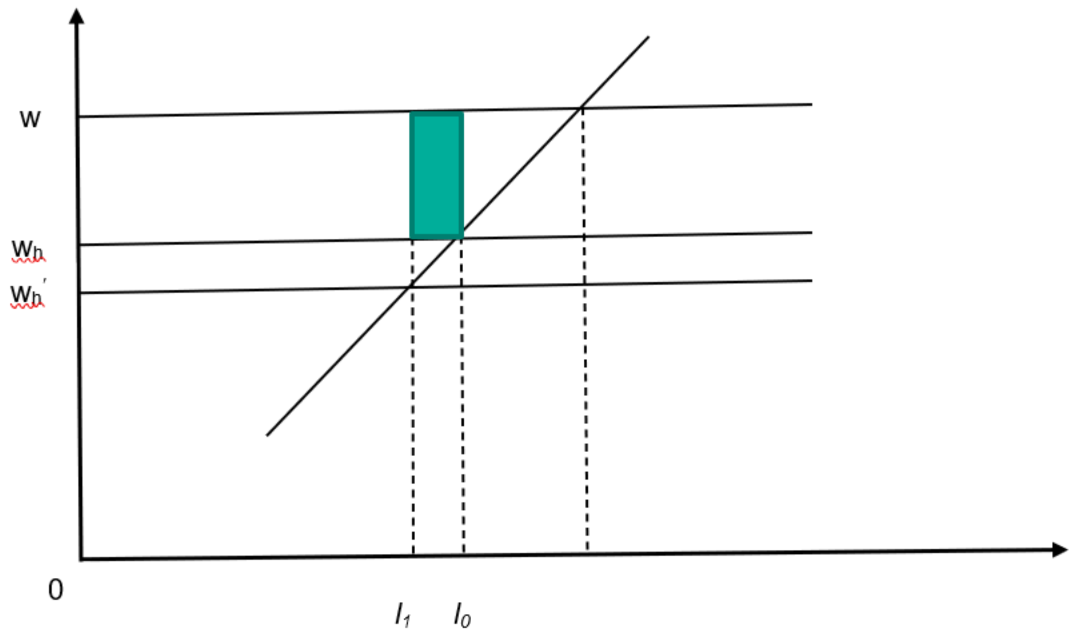
Replacing the term for the marginal benefit of G, z_G, with θ, this yields:

$$dB = [\theta - \text{MCF}.\{c_G + (p-p_w).z_{pG} - (w_h - w)e_{wG}\}].dG$$

Equation (15) has a simple, powerful interpretation. The first element of the welfare effect of a change in government provision of goods is the direct welfare benefit of the goods provided, z_G, which is positive when the intervention improves welfare. These direct net benefits are compared with the costs of providing the goods, scaled up by the compensated marginal cost of funds (MCF) to allow for the costs of raising, through distorting taxation, the budget revenues needed for the project. The direct fiscal cost of providing the goods is given by c_G, while the indirect fiscal costs (or benefits) are given by $(p-p_w).z_{pG}$ and $(w_h - w)e_{wG}$. The criterion for acceptance or rejection on Pareto efficiency grounds is that the term in square brackets be positive.

The MCF term in (15) requires explanation because of its importance in evaluating the relative benefits and costs of government projects and because of its relative unfamiliarity in the Benefit-Cost literature, with exceptions like Spackman (2020). It is the cost involved in transforming a dollar in the hands of individuals into a dollar of public funds and results from the increase in distortions required to raise additional revenues. The numerator of the MCF, e_w, is the cost to taxpayers of an incremental increase in the tax rate. The denominator $(e_w + (w_h - w)e_{ww})$ is the amount that the fiscal authorities receive from this tax increase. The denominator is less than the numerator, and hence the MCF is greater than one, because of the deadweight costs resulting from the increase in the tax rate. The nature of this loss is shown in Figure 7 for a tax on labor that is increased from an initial level of $(w_h - w)$. For convenience, we show labor supply, e_w, as positive but this makes no difference to the result. The increase in the tax rate reduces the wage rate received by households from w_h to $w_h{'}$ and hence reduces labor supply from l_o to l_1. As shown in Martin (1997), the second-best welfare impact of a change in a tax in a distorted economy consists of both the conventional welfare triangle (which we ignore when considering an incremental change in the tax) and the rectangle shown shaded in Figure 7 that represents the loss of revenue to the government from the behavioral response to the rise in the tax rate.

Figure 7: Tax revenue and a change in the tax rate



The MCF is invariably one or greater, depending upon the elasticity of supply of labor/demand for leisure (and/or other taxed goods in the more general case considered in Anderson and Martin (2011)). The term e_w in the numerator of the MCF is negative, while the $(w_h\text{-}w).e_{ww}$ term is positive, so the MCF is greater than one. Inclusion of the MCF term in equation (15) means that it provides a definite criterion for acceptance or rejection of project proposals. Only projects with a return high enough to surmount the hurdle imposed by their direct and indirect costs, scaled up by the MCF, meet the Pareto Criterion of generating benefits that exceed their costs and so, potentially, allow compensation of any individual losers from the policy.

There is considerable uncertainty about the value of the MCF coefficient. To get a feel for its potential value, it is helpful to rearrange it into the form used by Mayshar (1991, p1329) for the compensated MCF of a tax on labor: $MCF = \frac{1}{1-\left(\frac{t}{(1-t)}\right)*\eta^c}$ where t is the proportional tax rate and η^c is the elasticity of supply for labor (or taxable income). There is agreement that the full elasticity of taxable income is likely to be higher than the elasticity of labor supply, because the elasticity of taxable income includes margins of adjustment not included in the labor supply literature, such as tax evasion.

Based on a survey of literature on the elasticity of taxable income, Saez, Slemrod and Giertz (2012) concluded that this supply elasticity ranged from 0.12 to 0.4 for the United States. They translated an elasticity of 0.25, roughly in the middle of this range, into an MCF of 1.2, implying a marginal efficiency loss of raising public funds equal to 20 percent of the amount of funds raised. Following the same procedure, the bottom of their elasticity range would translate into an MCF of 1.09, while a top-of-the-range elasticity of 0.4 would translate into an MCF of 1.4. Heckman et al (2010) conclude that the MCF is roughly 1.5. Feldstein (1999) estimated an elasticity of taxable income of unity, which would translate into an MCF of 3, although this estimate is now widely viewed as too high.

Ideally, the MCF would be calculated for each country to provide an indication of the broad cost of raising revenues needed for projects in that country. In countries with higher income tax rates, the MCF would generally be larger. It would also tend to be higher in countries with complex systems that facilitate avoidance and evasion than in those with simple, comprehensive tax regimes. Developing countries also face a challenge in that their informal sectors operate largely outside the tax system and higher tax rates increase the incentive for resources to move to the informal sector. Auriol and Warlters (2012) provide estimates of the Marginal Cost of Funds for a range of African countries but, unfortunately, they do not distinguish between compensated and uncompensated measures to be discussed below.

The $(w_h - w)e_{wG}$ and the $(p\text{-}p_w).z_{pG}$ terms in equation (15) both refer to the impacts of publicly provided goods on the supply of taxed factors and on net exports of goods subject to trade taxes. Public sector provision of complements to leisure such as roads to recreational areas may, for instance, encourage households to increase their demand for leisure, thus reducing taxed output. By contrast, public provision of infrastructure that is complementary with market work may increase the amount of labor subject to taxation.

The benefits and costs in equation (15) can also be expressed in ratio form to create a Benefit-Cost ratio. According to Hendren and Sprung-Keyser (2019, p12), this is done in Benefit-Cost analysis by including the induced impacts on government revenues $\{(p\text{-}p_w).z_{pG} - (w_h - w)e_{wG}\}dG$ in the numerator, while leaving the $MCF.c_G$ term in the denominator[4]. Given that the induced impacts on government revenues need, like the direct cost, to be adjusted by the MCF, it seems simpler to express the benefit-cost ratio based on (8) as:

$$(16) \qquad \text{BCR} = \frac{WTP}{\text{MCF}.\{c_G + (p - p_w).z_{pG} - (w_h - w)e_{wG}\}}$$

This benefit-cost approach has the advantage of providing a cutoff value of 1 for project acceptance or rejection just as (15) provides a net benefit criterion of zero. Clearly, satisfaction of the criterion does not depend on whether induced tax revenues are allocated to the benefit side of the ledger as a positive or to the cost side as negative. In equation (16), transferring a positive revenue change from a positive component of the benefit in the numerator to a reduction in costs in the denominator will result in the same absolute reduction in both. While this will change the value of the BCR for values away from the criterion it will not affect the value of the BCR at the criterion point of unity. However, if projects are to be ranked, it is very important that the same approach should be used for all projects.

The $(p\text{-}p_w).z_{pG}$ term in equation (15) has a particularly important interpretation in the Benefit-Cost literature. It converts the marginal values of outputs at market prices, z_G, or the marginal cost of inputs, c_G, into their social values considering the implications of their provision or use for government revenues. Where the good being provided by the government is a pure private good perfectly substitutable with a traded good, the direct benefit of the good provided is q. In this case, $z_{pG}=1$ since the additional unit of the publicly provided good directly replaces a unit of imports and reduces negative net imports by 1. Thus, in this case, $dB = p.dG$ and this approach yields the famous border price rule that an additional unit of a good provided by government should be valued at its border price, p_w, rather than at its domestic price (see Squire and van der Tak 1975 or Dinwiddy and Teal 1996).

The special circumstance in which much of the early work on benefit-cost analysis was undertaken—with a focus on industrial projects producing private goods funded by foreign aid in heavily distorted

[4] This seems a questionable interpretation. Consider a traditional benefit-cost evaluation of a manufacturing project. Adjusting from domestic to world prices would require a reduction in the price of protected outputs, an adjustment to the benefits in the numerator. Adjusting input costs to world prices involves adjustments to the denominator.

economies—may explain why this literature emphasized the border-price rule so strongly. It remains an important guide to policy but needs modification now that the focus of development work is so much more strongly on provision of public goods that are not directly substitutable for private goods and the cost of raising funds for development projects must be addressed much more directly if they are to be sustainable.

10.2 Benefit-Cost Evaluation Using Money Metric Measures

While the compensated measure of welfare change given by equation (8) is useful for many applications, it is useful to consider alternative, uncompensated, approaches. This is partly because it may not always be possible to obtain compensated measures, partly because it is important to understand the differences between different measures and partly to show that combining approaches will result in errors. It is particularly important to understand the differences between the measures because uncompensated or "money-metric" measures are often presented as being simpler than compensated measures, and as involving "actual" behavioral responses that should be preferred over the hypothetical measures involved with compensated measures (see, for example, Ballard and Fullerton 1992; Hendren and Sprung-Keyser 2019). However, there is no reason for this presumption. At the point where the benefit-cost ratio is unity, there is no change in utility with the uncompensated measures, just as there is (by definition) no change in utility using the compensated measures.

Because the derivation of the uncompensated measures is messy, it is presented in the Appendix with only the key results presented here. The first key result is:

(17) $e_u du = [\theta - \text{MMCF}.\{c_G - ((p\text{-}p_w)\chi_I + (w_h - w)\chi_l)\theta + (p\text{-}p_w)z_{pG} - (w_h\text{-}w)e_{wG}\}]dG$

where $\theta = z_G$ is a money measure of the benefit to recipients of the public good; and MMCF= $\frac{e_w}{(e_w + (w_h - w)e_{ww} - \{(w_h - w)\chi_l + (p - p_w)\chi_I\}e_w)}$ is the Marshallian (or uncompensated) Marginal Cost of Funds (MMCF) that includes the income effects of the tax increase needed to finance the reform times the tax rates applying on the affected factor and goods, $\{(w_h - w)\chi_l + (p - p_w)\chi_I\}e_w$, along with the substitution effects of the tax increase on the factor being taxed, $(w_h - w)e_{ww}$.
When projects are financed using income taxes, the MMCF is likely to be closer to unity than the compensated MCF= $\frac{e_w}{(e_w + (w_h - w)e_{ww})}$ used in equation (15) because the income effect of the tax increase reduces household income and hence increases labor supply and tax revenues. In developing countries, this may be less the case because it reduces consumption of goods subject to tariffs and commodity taxes, which are higher relative to income taxes than in developed countries. However, note that the numerator now contains two income effects not included in equations (15) and (16). The first is the income effect of public good provision times its effect on the supply of labor times the tax rate, $(w_h - w)\chi_l.\theta$. The income effect of providing the good reduces the supply of labor and hence the government revenues from labor taxes. By contrast, this income effect reduces the demand for taxed goods.
A useful reformulation of equation (17) is based on equation (9) and compares the money metric welfare impact with the compensated measure in equation (15):

(18) $e_u du = \frac{1}{\{1 - (p - p_w)\chi_I + (w_h - w)\chi_l\}}[\theta + \text{MCF}.\{c_G - (p\text{-}p_w).z_{pG} - (w_h - w)e_{wG}\}].dG$

$= \text{FXM}.[\theta - \text{MCF}.\{c_G + (p\text{-}p_w).z_{pG} - (w_h - w)e_{wG}\}].dG$

Where FXM is the foreign exchange multiplier for the model under consideration, as introduced in equation (9), given the structure of the taxes represented in the model used for the evaluation. Since FXM is positive, it does not change the sign of the welfare measure and nor does it change the criterion for project acceptance or rejection. If the model contains taxes on labor, taking away income causes an increase in the supply of taxed effort, and hence reduces the welfare impact of a reduction in income. By contrast, if the model contains large taxes on consumers, the income effect of a welfare reduction will reduce consumption of the taxed good and hence exacerbate the income loss resulting from a transfer. Since the FXM depends only on income effects, it need be evaluated only once for any given model and can then be used to transform money-metric measures into compensation measures for multiple different reforms.

The widespread use of MMCF measures and incomplete models has not only resulted in error but may also have created the impression that there is no need to make this adjustment to the cost of goods provided by governments. Where government revenues are raised primarily by taxes on labor, the income effect of a tax increase reduces the demand for leisure and increases the supply of labor. For this reason, the uncompensated supply of labor, at least by prime working-age males, is typically regarded as close to zero. In his comprehensive survey of labor supply elasticities and tax implications, Keane (2011, p1070) finds an average compensated labor supply elasticity of 0.31 for males, but an average uncompensated elasticity of only 0.06. For women, by contrast, he finds much higher elasticities, including many over 0.8 and some as high as 5.0, albeit with much greater dispersion of estimates. A more recent survey by Chetty (2012) points to an average compensated elasticity of around 0.5 in a range of industrial countries, made up of an intensive margin elasticity of 0.33 and an extensive margin (or participation) elasticity of 0.25. Attanasio et al (2018) focus on women's labor supply and find an average compensated elasticity of 0.54 and an uncompensated (Marshallian) elasticity of 0.18.

In an unpublished but widely cited paper, Kimball and Shapiro (2008) argue that the income and substitution effects of labor supply are similar in magnitude, but opposite in sign, implying an uncompensated elasticity of labor supply of roughly zero, which would imply an MMCF close to 1. This result is similar to those of Keane (2011) for males and Attanasio et al (2018) for women. This might raise questions about whether it is worth adjusting the costs of government projects when the MMCF is close to 1. However, equation (18) makes clear that this is unlikely to be a correct interpretation. If the measured cost of a publicly-provided good is reduced by a negative income effect that increases labor supply, then the assessed benefit of the publicly-provided good must be similarly reduced to account for the reduction in labor supply resulting from the real income increase generated by the publicly-provided good. By contrast, if the project is funded by a consumption tax increase, a rise in the tax rate will reduce spending on taxed goods and increase the measured MMCF and the benefit of the real income increase resulting from the project. Either way, equation (19) shows that the money metric measure will change relative to the compensated measure, except under the coincidence where the income effects on tax revenues of income and consumption taxes cancel out.

10.3 Money Metric or Compensated Measures for Benefit-Cost Analysis?

One question that arises with aid-funded projects is whether the marginal cost of funds approach is appropriate. One might argue that, since aid is a gift, no increase in taxes is needed to raise the funds needed for an aid-funded project. While this argument has some intuitive appeal, it is also clear that money is fungible, and that aid-funded projects are typically projects that the government would, itself, like to undertake but for constraints on its resources. It is also clear that the aid funds are typically quite limited and some recognition of the scarcity value of these funds is appropriate. Given this, it seems reasonable to use the marginal cost of funds that is relevant to the marginal projects under consideration by government. This marginal cost may involve adjustments to a single tax rate, or to a set of tax rates, of the type frequently seen in the process of formulating a national budget. Anderson and Martin (2011) deal with the case where a set of tax rates is adjusted to achieve fiscal balance.

A key question when using Benefit-Cost analysis is whether to use a compensated or an uncompensated approach. When a simple cost-benefit analysis of the type considered by Ray (1984) is envisaged, it seems clear that a compensated approach would be the best choice. It is simpler than a money metric approach and avoids the need to adjust the benefits as well as the costs inherent with the money-metric approach. While adjustment of government outlays for the marginal cost of funds has not been the practice in the past, it is a relatively straightforward adjustment once a value has been chosen—perhaps between the 1.2 suggested by Saez, Slemrod and Giertz (2012) and the 1.5 suggested by Heckman et al (2010).

Use of an MCF adjustment to government budget outlays has the advantage of reflecting the cost of raising fiscal resources, and of raising the hurdle for acceptance of Benefit-Cost projects in line with the costs associated with publicly funded investments. Moreover, it raises the hurdle in a way that is neutral between projects with different time profiles of benefits. Another way to create a high hurdle for projects that use scarce fiscal resources is to impose a high discount rate, such as the 10 percent used by the Millennium Challenge Corporation (Ospina and Block 2017). The challenge with this approach, relative to using a discount rate based on returns in the private sector, such as the 7 percent discount rate suggested by the US Office of Management and Budget (OMB 2015), is that the higher rate discriminates against projects with longer gestation periods and/or longer-lived investments. The discrimination against longer-lived projects is even greater relative to an approach using the Social Rate of Time Preference approach (see, for example, Boardman et al 2018).

Unfortunately, no single approach can cover all situations. Some projects are much more easily evaluated using model-based approaches that readily account for issues such as endogenous factor prices or nontraded goods. In this situation, traditional cost-benefit approaches require complex iterative calculations involving breaking nontraded goods down into their traded and nontraded components (Dinwiddy and Teal 1996 p100). Model-based approaches are also likely to be useful in situations where an intervention involves multiple shifts in profit or expenditure functions—changes which are exceedingly difficult to track using graphical approaches. It is possible to track the consequences of multiple interventions in sophisticated partial-equilibrium models such as IMPACT (Robinson et al 2015) although it is difficult to go beyond simple welfare measures such as consumer surplus that approximate changes in economic welfare. Computable general equilibrium models such as MIRAGRODEP (Laborde, Robichaud and Tokgoz 2013) routinely produce estimates of the welfare change in money-metric form. MIRAGRODEP also includes a government budget constraint like equation (13) that potentially allows incorporation of the costs of interventions and their funding.

While it might be possible to generate compensation measures of welfare change by adding auxiliary modules to general equilibrium models, this approach becomes challenging when there are changes in product and factor prices. An easier approach to obtaining comparable measures of welfare change is to calculate the foreign exchange multiplier for any model used to generate measures of changes in economic welfare.

12 ENDOGENOUS PRICES AND FACTOR RETURNS

Where the products produced by a single country or household are differentiated from those produced by others, or where a country, household or firm is large in relation to the market in which it trades, substantial investments will likely change the prices of outputs and/or inputs. Factor prices are likely to be endogenous in many situations because they are frequently assumed to be nontraded.

Traditional Cost-Benefit procedures have mechanisms for dealing with situations where the prices of traded goods, nontraded goods, and/or factors change. Some of these, such as iteratively assessing the traded-good content of nontraded goods, appear ad hoc and messy (see, for example Dinwiddy and Teal 1996, p100). An alternative is to use models that include both the behavioral equations and the relevant market clearing conditions needed to determine the relevant price changes (see Dinwiddy and Teal 1996, p108). These can, in turn, be used to calculate varying shadow prices of flex-price commodities for use in traditional cost-benefit analysis. Alternatively, the model, once constructed, might be used directly to estimate the welfare impacts of the intervention.

13 ALTERNATIVE EVALUATION MEASURES

Two alternative approaches to evaluation need to be considered. The first is the Marginal Value of Public Funds (MVPF) approach of Hendren and Sprung-Keyser (2019) and the second is the Cost-Effectiveness approach.

13.1 The MVPF Approach

The Marginal Value of Public Funds (MVPF) approach of Hendren and Sprung-Keyser (2019) seeks to streamline the approach to Cost-Benefit analysis. It does this partly by ignoring the Marginal Cost of Funds, which it associates with benefit-cost analysis. It also simplifies relative to BCA by using uncompensated demand functions to assess the impact of interventions on the demand for and supply of taxed goods—which it associates with "actual" impacts on demands for taxed goods. Finally, it moves the impacts of project outputs on tax revenues from positive entries in the numerator to negative entries in the denominator. It turns out that the MVPF for an investment project is a ratio version of equation (17), with the assumption that the MMCF=1.

$$(19) \qquad \text{MVPF} = \frac{\theta}{[c_G - \{(p - p_w)\chi_I + (w_h - w)\chi_l\}\theta + (p - p_w)z_{pG} - (w_h - w)e_{wG}]}$$

The numerator of (19) is the willingness to pay, as in Hendren and Sprung-Keyser (2019). The denominator consists of the direct cost of the project, c_G, plus the income effects of a change in G on the revenue from taxed labor and tradables $\{(p - p_w)\chi_I + (w_h - w)\chi_l\}\theta$, minus the compensated effect of the change in G on revenues from taxed labor$\{(w_h - w)e_{wG} + (P - p_w)z_{pG}\}$.

An unfortunate feature of this approach is that the direct marginal benefit of this public good, θ, appears in both the numerator and the denominator. If the estimated marginal benefit of the good changes, both the numerator and the denominator need to be recalculated. While the numerator does incorporate the actual impacts of the change in G on revenues, this turns out to be unhelpful. The substitution and income effects on demand for the taxed goods cannot be grouped together into a stable parameter that would remain constant while the willingness to pay, θ changes. By contrast, the denominator of equation (16), the full cost of the public good, remains constant when the willingness to pay (which equals θ) changes.

Hendren and Sprung-Keyser (2019) see a benefit in the MVPF approach of being able to consider spending choices and tax choices independently. This, however, has two disadvantages. The first is the arbitrariness in decision making associated with arbitrarily pairing projects and their revenue sources: a project evaluated using an efficient tax alternative (such as a lump sum tax) to raise the required public funds is more likely to be approved than one that is evaluated using a distorting tax (such as an increase in the income tax rate). The second is that the income effects associated with the project are not the income effects associated with the project and its funding. This means that the perceived advantage of using "actual" demands for taxed goods and "actual" revenues is more apparent than real. In fact, at the criterion point where the marginal benefits of a project equal its marginal costs, there is no change in real income, which is why the compensated and uncompensated criteria lead to the same decisions on project acceptance when they are implemented consistently.

Benefit-Cost Analysis appears to have at least three advantages over the MVPF approach. First, it allows projects to be compared on a consistent basis, with the same approach to raising the revenues needed to implement these projects. Second, it avoids the restriction of assuming a unitary marginal cost of funds imposed arbitrarily under the MVPF approach. Third, it avoids the problem of having the valuation of project output appear in both the numerator and the denominator of the criterion for project acceptance.

13.2 The Cost-Effectiveness Approach

The Cost-Effectiveness Analysis (CEA) is particularly useful when it is difficult to evaluate the benefits of an investment, but the costs are relatively easily assessed. If, for instance, the goal is to improve nutritional outcomes among children, or lower the incidence of diet-related diseases, then it may be difficult to place a well-grounded valuation on the outcome and seeking to do so may seem to generate more controversy than it is worth. CEA comes at a high cost relative to a Benefit-Cost analysis, however. Cost-Effectiveness allows analysts to compare alternative approaches to achieving a particular goal, like various approaches to saving statistical lives through reductions in accident rates, but it does not provide policy makers with the information they need to make comparisons across goals, even though policy makers must allocate resources across different goals, such as the poverty reduction and improvements in nutrition.

When using CEA, perhaps the best approach is to compare the cost per favorable outcome on alternative approaches to achieving this goal. Boardman et al (2018) note that projects must meet two criteria to be suitable for CEA. The first is that there can be only one major benefit that clients are unable or unwilling to monetize. The second is that the only cost is the financial cost of the project to the government agency that will fund it. They also point out that it can be used to compare alternative approaches to achieving a quantified—but not monetized—goal. Since different approaches are likely to yield different amounts of the goal, quantification of goal attainment is needed so that cost effectiveness can be expressed using a ratio such as the cost per life saved.

Assuming a proposed project meets the conditions for use of CEA, the evaluation of costs should follow the procedures outlined for Benefit-Cost analysis in earlier sections. It should consider not just the financial cost to government, but also the cost of changes in government revenues induced by the project, and the cost of raising the public funds spent on the project. Dhaliwal et al (2012) provide a valuable guide to procedures for rigorous calculation of cost in the context of impact evaluation.

Interpretation of CEA results is more challenging than for Benefit-Cost Analysis, since the lack of a value on the outcome makes it difficult to know whether a more costly per unit alternative that generates a larger increase in the goal might still be more worthwhile given the value of increases in the goal. Once estimates of the cost per unit of the goal achieved by alternative projects, the first step is to look for projects that are dominated by other approaches, such as projects that cost more to achieve a smaller increase in the goal. Once the field has been narrowed to non-dominated projects, the next step is to estimate the incremental cost and effectiveness of moving from the lowest-cost alternative to proposals that cost incrementally more. Finally, the decision maker needs to decide how far up the set of increasingly costly per unit of achievement curve to go.

14 BENEFICIARY ANALYSIS

Thus far, the analysis has considered evaluation of the overall benefits and costs of interventions. This focus is very valuable because it allows us to identify whether it is possible for everyone to be made better off by adopting the project and making transfers from the gainers to any losers (Varian 1992). However, it does not allow us to assess whether other potential goals of policy makers, such as reducing inequality in income and gender outcomes or improving nutritional outcomes. Identifying these outcomes requires analysis at the household or individual level, as well as at the national level.

There is a great deal of commonality between the framework outlined above and the framework needed to identify impacts at the household level. At the household level, we are concerned both to identify the direct impacts of interventions on household welfare identified in equation (1) and about the economic impacts through both direct changes in household profits or the costs of achieving a given level of utility, and about changes brought about through changes in product, input or consumer prices. A money measure of the welfare impact of changes in household welfare can be derived using a version of equation (2) specialized for each household:

(20) $$B_i = \pi_i(p,w,G) - e_i(p,w_h,G,u) + \gamma_i$$

Where the subscript i refers to household i; $\pi_i(p,w,G)$ is household profit from its own-business activities; $e_i(p,w_h,G,u)$ is the household's expenditure function; p is a vector of domestic prices; γ_i is transfers from outside the household, including any redistribution of tax revenues to the household; and all other terms are as previously defined.

Versions of equation (20) can be used to make partial assessments of impacts on gender equity. If, for instance, interest focusses on the impacts of a reform on households headed by women, then these impacts can be identified from model results stratified by gender of the household head. Some other impacts on gender outcomes require identification of the activities controlled by female members of the household, or of the incomes of individual household members. Clearly, achieving gender equity has many dimensions beyond the purely economic impacts that can be analyzed in this way, but evaluating economic impacts is a useful first step towards closing the knowledge gap about gender impacts of development projects (for more details see Quisumbing et al 2014).

Household models like equation (20) are an important first step towards measuring nutritional impacts on households. By capturing the income effects of policy changes, they capture one of the important influences on food consumption. However, they do not automatically capture impacts resulting from substitution effects. If a policy change increases the price of a staple food, income effects will increase consumption of the good by households who are net sellers of the good, while substitution effects will reduce their consumption. Fully capturing the impacts of interventions on nutritional outcomes requires household models incorporating both income and substitution effects.

15 TRADEOFFS BETWEEN EFFICIENCY AND OTHER GOALS

Different approaches to agricultural development are likely to have different implications for the multiple economic goals held by policy makers. The presence of these goals changes the nature of the problem relative to one where policy makers are concerned only about the aggregate net benefits. One important thing to bear in mind is the general principle of economic policy that there should be as many policy instruments as there are targets (Tinbergen 1963). Just as it is difficult—but not always impossible—for a marksperson to hit multiple targets with a single bullet, it is difficult for a single policy to achieve multiple goals. Another useful insight from the theory of quantitative economic policy is Mundell's (1960) Classification Principle that instruments should be assigned to the goals to which they have the strongest and most direct linkages. While these basic principles apply to the most basic form of policy in which there are n fixed targets and n policy instruments (Hughes-Hallett 1989) and may need to be modified when we move to more complex cases, they remain a useful starting point.

A key step in policy prioritization is to set out the objectives to be achieved in clear, quantitative terms. A second is to identify the available policy instruments and both their direct impacts and ways in which they might be combined. A third is to identify how the available policies and instruments, and their combinations, might be evaluated and prioritized. The answers to these questions will guide the choice of information that needs to be collected for policy evaluation and prioritization.

The UN Sustainable Development Goals (UN 2015) reflect a set of widely shared goals towards which investments in agriculture may contribute: These include: (i) Poverty reduction, (ii) Reducing hunger, (iii) Improving health and nutrition, (iv) Increasing access to education, (v) Moving to gender equality, (vi) Improving sustainability, and particularly contributing to mitigation of climate change, and (vii) Peace and Justice. While these goals do not explicitly specify a goal of increasing real incomes, higher incomes with any given distribution of income can be expected to reduce poverty and hunger, while policies that both raise incomes and reduce inequality across individuals and households can be expected to reduce poverty, hunger and gender inequality. Impacts on sustainability can be measured using extensions of the framework outlined in this paper (see Laborde et al 2020), while policies that reduce conflicts over natural resources by providing well-defined property rights distributed relatively equitably might contribute to peace and justice. Higher incomes can also provide the resources needed to achieve other goals without making anyone worse off relative to the initial situation by redistributing some of the gains from growth.

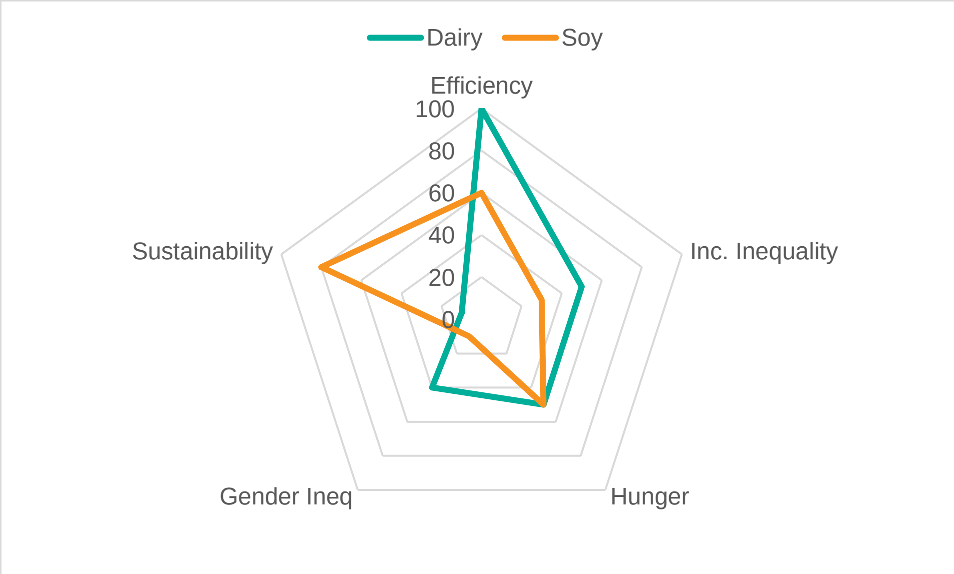
Many policy instruments might be used to influence these goals. Policies with Benefit-Cost ratios above one satisfy the Kaldor-Hicks criterion of allowing the gainers to compensate the losers and hence have a strong advantage over policies that fail to meet this criterion. To the extent that they generate gains in other goals, these gains come without cost and hence compare favorably with alternative projects that achieve distributional goals with negative net returns—whether these are interventions such as farm subsidies that are perceived to have favorable distributional gains or policies that attempt to redistribute either from the initially richer or from those who gain from a particular intervention. Harberger (1978) makes the important point that tax-transfer policies of redistribution should be included when policy makers are concerned about redistribution to ensure that policies designed that contribute to distributional goals are not adopted when they would be higher cost than a tax-transfer alternative.

There are many alternative agricultural policy interventions available in developing countries. Because households involved in agriculture are typically relatively poor, many of the policies that raise agricultural incomes will have favorable impacts on other goals such as reducing inequality, reducing hunger and improving nutrition. Policies that raise agricultural productivity through research and/or extension, and particularly raise the productivity of small, poor farmers, have frequently been shown to have very high rates of return (Alston et al 2000). They are also likely to improve sustainability by reducing emissions of greenhouse gases per unit of output. Particularly if they favor products primarily produced by women, they may also contribute to reducing gender inequality. Fan, Gulati and Thorat (2008) find benefit cost ratios for rural roads in the order of 8 to 20, for rural education 5 to 15 and for irrigation investment in the order of 4 to 8. These investments are also likely to contribute to other goals such as reductions in inequality and in hunger. By contrast, there is little strong evidence of improved land administration generating large economic gains (Gignoux, Macours and Wren-Lewis 2015), although it can contribute to improved gender equality and reductions in conflict.

One key step is to identify the impacts of all projects under consideration on the policy dimensions of concern. One way to present the resulting information is a radar diagram like Figure 5. This hypothetical example compares a dairy development project with one that introduces production of soybeans. In this purely hypothetical example, the dairy project has a higher economic rate of return and generates better gender and income inequality outcomes, perhaps because caring for dairy cows is a female-dominated activity. By contrast, the soy project has better outcomes on the sustainability dimension because of the high greenhouse gas emissions associated with dairy production (Mamun, Martin and Tokgoz 2019). The information in Figure 8 provides enough information for policy makers to decide between alternative investments using their own weights on the different objectives.

Presenting information on alternative projects in this way is helpful where none of the projects involve negative impacts. This information—or equivalent information presented in tabular form—may turn out to provide the information that policy makers need to make informed decisions. To decide between alternative sets of policies, with different outcomes on multiple objectives, requires some form of weighting on the different objectives and analysts likely face much greater challenges forging a consensus on these weights than on questions like shadow pricing health benefits.

Figure 8: Radar Diagram Comparing a Dairy and a Soybean Project



One possible way to move beyond simple presentation of the benefits of alternative packages of interventions might be to draw on the theory of quantitative economic policy (Fox, Sengupta and Thorbecke 1973; Preston and Pagan 1982: Hughes-Hallett 1989). This literature distinguishes between Fixed Target and Flexible Target problems. The Fixed Target formulation of the problem requires that there be the same number of instruments as targets and identifies the set of policy instrument settings needed to exactly achieve these targets. The Flexible Target approach specifies preferences about the targets and identifies policy choices that come as near as possible to achieving those goals. The Fixed Target approach seems too rigid for the prioritization problem at hand. A key question is whether the Flexible Target problem can be adapted to make it useful.

If preference weights were available, then this problem could be specified following Preston and Pagan (1982, p32) as the maximization of:

$$(21) \qquad (y-y^*)'Q(y-y^*) \text{ subject to } \quad y = A.x$$

Where y* is a vector of policy goals; y is vector of outcomes for the policy variables; Q is a matrix of weights; and A is a matrix of reduced-form coefficients relating outcomes, y, to policy instruments, x. The constraints would include the relationships between the policy instruments and the policy targets, and additional constraints such as the costs of each project and limitations on the government's development budget.

There are two important problems with this specification for our purposes. The first is the challenge of assigning agreed weights to the different target variables. The second is the assumption that the links between the policy variables and the policy targets are linear. It is highly likely that the relationship between government interventions and targets—especially GDP—are nonlinear. We would expect, for instance, that the first government employees working on research or extension or infrastructure would be allocated to the highest -priority tasks, so that the marginal return on additional investments in each activity would decline.

If the objective were re-specified as maximization of the overall economic return on investment, then a linear relationship between instrument levels and rates of return would be even less satisfactory. In this case, the solution would be to put all available resources in the project with the highest benefit-cost ratio. One potential solution is to seek information on the rate at which returns from each intervention would decline as additional resources were added. If this is available, then the problem becomes on one of allocating resources so that their marginal economic returns are equalized. The nature of this solution to the programming problem is of interest itself but, more importantly, it allows investigation of the solution as we add constraints that require increases in other goals, such as poverty reduction, improved nutrition or gender outcomes. Tightening these constraints will change the solution in the least-cost way and may result in changes in the activities used to achieve these constraints. The shadow value on these constraints will provide valuable information on the costs of improving these outcomes—information that policy makers can use to decide to what extent to pursue these goals.

Martin, Ivanic and Mamun (2021) adapt the Theil (1964) approach by moving from the fixed objectives with penalty approach to positing a positive welfare function to be maximized. Frequently, this welfare function is a simple, linear function of the multiple objectives, as when standard economic welfare measures such as EV are combined with an external cost of emissions based on a Social Cost of Carbon. Optimizing with respect to the choice of policy variables results in a set of endogenous policy choices that maximize the objective function. For some policy questions, such as a choice of tariff rates, the optimization problem may be unconstrained. For others, such as the allocation of investable resources, the optimization problem will be constrained. As applied by Martin, Ivanic and Mamun (2021), the social welfare function is normative. The same broad approach could also be used with a political social welfare function to identify how costly the inclusion of non-economic goals would be to the achievement of economic and social goals such as economic growth and poverty reduction.

16 CONCLUSIONS

A key first step in measuring the welfare effects of agricultural investments and policy reforms is to assess the direct impact of these interventions on proximate outcomes. If an intervention proves not to have a direct impact on an outcome of interest, then it will certainly not be effective in improving economic welfare. But having the type of direct impact that is commonly measured using impact evaluation procedures is only a necessary condition for the intervention to have a favorable economic impact. A sufficient condition for the intervention to be welfare improving is that the value of its benefits exceeds the associated economic costs.

A first step in evaluating investments in agriculture is to assess its impacts on outcomes such as producer incomes and the costs of achieving a given level of utility. Where an intervention has already been implemented—in whole or in part—these assessments might be undertaken using randomized control trials or any of the range of impact evaluation tools that have been developed to ensure that true causal impacts can be identified. These techniques may also be used—and in fact were originally developed—for use in evaluating innovations such as new varieties of crops or breeds of livestock.

With confidence that true—or at least as good as feasible--impacts have been established, then the process of economic evaluation can be undertaken. This should use methods grounded in economic theory, such as consumer expenditure and firm profit functions. These methodological approaches can be developed at different levels of complexity and rigor depending upon the nature of the problem under consideration and the resources available for the evaluation. A range of models will almost certainly be needed, ranging from very simple models using spreadsheet technology through increasingly complex partial and/or general equilibrium models. To measure overall changes in economic welfare and impacts on sustainability outcomes such as global warming, models at the national, regional or global level are likely to be required. To assess impacts on income distribution, nutrition and gender models at the household level with identification of individual characteristics such as the responsibility of different family members are likely to be needed.

Where an intervention requires the use of public funds, or quasi-public funds such as foreign aid, then it is important to consider not just the amount paid, but the costs of raising those funds through distortionary taxation. This can readily be done through a marginal cost of funds, MCF, coefficient applied to both direct project expenditures and indirect impacts on fiscal revenues such as changes in tax collections when a publicly provided good replaces an imported good subject to import duties. This results in a Benefit-cost ratio for project evaluation of BCR = $\frac{WTP}{MCF.Fiscal\ Cost}$. The inclusion of the MCF, which is typically greater than one, in the denominator, reflects the scarcity and cost of public funds and provides a market-consistent rationing device for projects that require public funds.

A key, and frequently ignored, distinction is that between compensated and money-metric measures of welfare change. While this distinction is unimportant in the absence of distortions, it becomes very important in the presence of high rates of taxation, such as the tax rates on labor income in the industrial countries and commodity taxes such as the VAT in many developing countries. While all well-founded measures of welfare change use compensated measures of welfare change, such as Compensating Variation, at the household level, some measures of welfare change in distorted economies allow policy-induced changes in real income to change tax revenues while others do not. When summarized as, for instance, a Marginal Cost of Funds (MCF) the two measures can be quite different. Money metric measures of the welfare cost of income taxes are likely close to 1.1 or 1.2 while compensated measures are likely closer to 1.5

In general, it is best to use compensated measures where there is a choice, because it is challenging to track the welfare impacts of income changes on tax revenues. When performing simple spreadsheet-based welfare evaluations familiar from traditional textbooks on Cost-Benefit Analysis, it may not even be obvious that an alternative measure is available. However, there are many cases where money metric measures of welfare change are much more easily obtained. This is particularly the case when welfare changes are measured using general equilibrium models, as in Laborde et al (2019). Both money-metric and compensated measures of welfare change are perfectly valid measures of the welfare impacts of interventions. But they must be used consistently. Substantial errors can be made by combining the two unless they are adjusted for compatibility.

The discount rate is a critical variable in evaluating the welfare of many interventions in agriculture and other sectors. It's desirable to use consistent discount rates to avoid inconsistent treatment between projects of similar duration and purpose. Most industrial countries appear to use discount rates between 3 and 7 percent for domestic projects. But foreign aid projects are widely measured against discount thresholds of 10 to 12 percent. It appears that, given the overall scarcity of foreign aid funds, this is frequently being done as a filtering or rationing device. While this approach does help to ration out the available funds, it does so in a very costly way, by discriminating against projects with longer payoff periods. A better approach would use the MCF to ration out the available funds while avoiding penalizing projects with long payoff periods.

The Hausmann-Rodrik-Velasco approach is clearly quite consistent with wide use of benefit-cost techniques. In this context, it provides a potentially quick and valuable way to identify high-return, low-cost interventions that relax binding constraints. Once such abnormally high-return points of entry have been exploited, the key to further success is identifying ways in which further progress can be made by increasing all necessary inputs and avoiding the inefficiency associated with allowing the creation of individual binding constraints.

The Marginal Value of Public Funds approach is a new, simplified and initially appealing approach to measuring the returns to public investment. Because some of the impacts that it includes in the denominator of the Benefit-Cost ratio (BCR) vary with the value placed on the public good provided, the cost of each increment of the public good provided is no longer a constant and evaluation of a change in the quantity of the public good provided requires recalculation of both the numerator and the denominator of the Benefit-Cost ratio—a problem avoided in more traditional applications of the BCR. Its elimination of the marginal cost of raising funds also reduces its generality in cases where this coefficient is not close to unity. For these reasons, we do not recommend using this approach to project evaluation.

If it is truly infeasible—or impossibly controversial—to estimate the benefits of a particular goal such as an improvement in nutrition or the saving of lives, then simplified approaches such as Cost-Effectiveness Analysis allow investigation of the costs of achieving particular goals, such as increasing Quality Adjusted Life Years (QALYs). This approach is useful for comparing approaches with impacts that can be measured on a common scale, such as QALYs, but does not permit comparison between these investments and others that affect human well-being on dimensions that are not relevant to this measure—such as reductions in poverty, improvements in nutritional outcomes or increases in sustainability.

Because policy makers have multiple goals, including raising incomes, reducing inequality, improving nutrition, and improving sustainability, a policy package must include a range of policy interventions. Analysts can provide a valuable service by providing information on the impacts of different policies on those different goals and allow comparison with alternative policies such as tax-transfer approaches to reducing inequality and hunger. Programming approaches based on the theory of quantitative economic policy may help provide further guidance for policy on the design of policy options.

ABOUT THE AUTHOR

Will Martin is a Senior Research Fellow in the Markets, Trade, and Institutions Division at IFPRI.

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APPENDIX 1: COMPARING MONEY METRIC AND COMPENSATED MEASURES OF WELFARE CHANGE

Standard measures of welfare change such as Equivalent Variation and Compensating Variation can be defined in two alternative ways—a compensation and a money-metric approach. In the standard textbook case of a change in consumer prices, there is no difference between the two approaches and the difference can be ignored. But, in the second-best case where there are continuing distortions, there are potentially large differences between the two and these are frequently important sources of confusion. Since the real world contains many substantial distortions, such as income taxes, sales taxes and trade taxes, it is important to understand the fundamental differences between the two measures.

In the pure consumer case, where we consider the welfare impacts of a change in one price, the consumer has fixed income, y, and an expenditure function $e(p,u)$, where p is a vector of prices and u is the utility level. The well-known Compensating Variation measure of welfare change may be written in compensation form as:

A1.1 $$CV^c = e(p_1,u_0) - e(p_0,u_0)$$

where CV^c is a *compensation* measure of the compensating variation, and the subscript 0 refers to initial income and prices while the subscript 1 refers to the same variables after the change. This is a *compensation* measure in that it indicates how much additional income needs to be given to the consumer to hold welfare at u_0 when the consumer price rises from p_0 to p_1.

A *money metric* version of this welfare change is given by:

A1.2 $$CV^m = e(p_1,u_0) - e(p_1,u_1)$$

This is a *money metric* measure in that it uses the expenditure function to convert a change in utility from utility units into a money measure.

In the case of a consumer facing undistorted prices, there is no difference between the compensation measure and the money metric measures and both definitions are used interchangeably. This equivalence is easily seen by recalling that nominal income, y, is unchanging so that $e(p_0,u_0) = e(p_1,u_1)$.

There is also a pair of Equivalent Variation (EV) measures:

Compensation EV: $EV^c = e(p_1,u_1) - e(p_0,u_1)$ and

Money Metric EV: $EV^m = e(p_0,u_0) - e(p_0,u_1)$

As soon as we move to a case with distortions, the equivalence between the compensation and the money metric measures breaks down. As an example, consider the case of a sales tax that creates a wedge between the wholesale price, p^w, of a good and its retail price, p. With the tax being redistributed to the consumer, the budget constraint of the consumer is given by:

A1.3 $$e(p,u) - (p-p^w).e_p(p,u) - y = 0$$

where e_p is the consumer's demand for the taxed good and all other terms are as previously defined. If we consider a change in the wholesale price of the taxed good from p_0^w to p_1^w that is fully transmitted to the consumer, then we can solve for the resulting utility levels, u_0 and u_1 using the budget constraint:

$e(p_0,u_o) – (p_0-p_0^w).e_p(p_0,u_0) – y = 0$, and

$e(p_1,u_1) – (p_1-p_1^w).e_p(p_1,u_1) – y = 0$

Money metric EV is, as usual, given by $EV^m = e(p_0,u_0) – e(p_0,u_1)$.

The compensation version of EV is obtained as the size of the transfer from outside the economy needed to maintain utility level u_1 following the change in prices:

A1.4 $\quad EV^c = e(p_1,u_1) - (p_1-p_1^w).e_p(p_1,u_1) - [e(p_0,u_1) + (p_0-p_0^w).e_p(p_0,u_1)]$

Recalling that $e(p_1,u_1) - (p_1-p_1^w).e_p(p_1,u_1) = e(p_0,u_o) – (p_0-p_0^w).e_p(p_0,u_0)$, eqn A1.4 becomes:

A1.5 $\quad EV^c = e(p_0,u_o) – (p_0-p_0^w).e_p(p_0,u_0) - e(p_0,u_1) + (p_0-p_0^w).e_p(p_0,u_1)$ or

$EV^c = EV^m – (p_0-p_0^w).e_p(p_0,u_0) + (p_0-p_0^w).e_p(p_0,u_1)$, or

A1.6 $\quad EV^c = EV^m - (p_0-p_0^w).[e_p(p_0,u_0) - e_p(p_0,u_1)]$

Equation A1.6 makes clear that the difference between the compensated EV measure and the money metric measure is the income effect of the change on the quantity of the taxed good demanded times the tax rate. When the tax rate is high and the income effect of the price change on the demand for taxed goods is large, then there will be substantial differences between the money metric EV and the compensated EV.

APPENDIX 2: MEASURES OF WELFARE CHANGE WITH THE UNCOMPENSATED MCF

To obtain an uncompensated version of equation (15), we change the closure of the model represented by equations (12) and (13) to make transfers from the rest of the world constant and differentiate with respect to G, w_h and u to obtain:

(A2.1) $z_G dG - e_w dw_h - e_u du = 0$ and

(A2.2) $c_G dG - (w_h - w)e_{ww} dw_h - e_w dw_h - [(w_h - w)e_{wu} - (p - p_w)e_{pu}]du + (p - p_w)z_{pG} dG$

$- (w_h - w)e_{wG} dG + (p - p_w)e_{pw} dw_h = 0$

Assuming net separability between labor supply and commodity demand decisions, as is common in this literature, allows us to drop the $(p-p_w)e_{pw}dw_h$ term. Substituting for $e_u du$ from equation (A2.1) into (A.2.2) yields:

$$c_G dG - (w_h - w)e_{ww} dw_h - e_w dw_h + [(w_h - w)\frac{e_{wu}}{e_u} - (p - p_w)\frac{e_{pu}}{e_u}](z_G dG - e_w dw_h)$$

$$+ (p - p_w)z_{pG} dG - (w_h - w)e_{wG} dG = 0$$

Which may be rearranged into terms in dw_h and dG alone as:

(A2.3) $(e_w + (w_h - w)e_{ww} + \{(w_h - w)\chi_l - (p - p_w)\chi_I\}e_w)dw_h = [c_G + \{(p - p_w)\chi_I + (w_h - w)\chi_l\}z_G + (p - p_w)z_{pG} - (w_h - w)e_{wG}]dG$

Where χ_l refers to the effect of a change in real income on the quantity of labor supplied, while χ_I is a vector of income effects on demand for taxed goods.

Equation (A2.3) allows us to solve for the dw_h that preserves the government's budget balance.

$$dw_h = \frac{1}{(e_w + (w_h - w)e_{ww} + \{(w_h - w)\chi_l - (p - p_w)\chi_I\}e_w)}.[c_G + \{(p - p_w)\chi_I - (w_h + w)\chi_l\}z_G - (p - p_w)z_{pG}$$

$$- (w_h - w)e_{wG}]dG$$

Substituting for dw_h in (A2.1) and rearranging yields:

(A2.4) $e_u du = \theta.dG - \frac{e_w}{(e_w + (w_h - w)e_{ww} + \{(w_h - w)\chi_l - (p - p_w)\chi_I\}e_w)}.[c_G - \{(p - p_w)\chi_I + (w_h - w)\chi_l\}z_G$

$- (p - p_w)z_{pG} - (w_h - w)e_{wG}]dG$

$= [\theta - \text{MMCF}.\{c_G - ((p - p_w)\chi_I + (w_h - w)\chi_l)\theta + (p - p_w)z_{pG} - (w_h - w)e_{wG}\}]dG$

where $\theta = z_G$ and MMCF= $\frac{e_w}{(e_w + (w_h - w)e_{ww} - \{(w_h - w)\chi_l - (p - p_w)\chi_I\}e_w)}$ is an uncompensated Marginal Cost of Funds (MMCF) that includes the income effects of the tax increase needed to finance the reform times the tax rates applying on the affected factor and goods, $\{(w_h - w)\chi_l - (p - p_w)\chi_I\}e_w$, along with the substitution effect of the tax increase on the factor being taxed, $(w_h - w)e_{ww}$. It contrasts with the compensated MCF= $\frac{e_w}{(e_w+(w_h-w)e_{ww})}$. Where, as in most of today's high-income countries (or at least in the literature on the MCF in the industrial countries), the dominant source of tax revenues is income taxes, the income effect through labor markets, $(\mathrm{w}_h - \mathrm{w})\chi_l$, is much larger than the income effects through tariffs, the literature tends to ignore the $(p - p_w)\chi_I$ term. In this case, the MMCF corresponds to Mayshar's (1991) uncompensated marginal cost of funds $\frac{1}{1-\left(\frac{t}{(1-t)}\right)*\eta}$ where t is the proportional income tax rate and η is the uncompensated elasticity of supply for labor.

Funding for this work was provided by the Millennium Challenge Corporation. This publication has been prepared as an output of the project "Advisory Services – Program Management for Development and Implementation within the Agricultural Sector" (DCO-PR-18-0293)

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