2 CBA for the social appraisal of projects

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2.1 Introduction

Only projects with net social benefits should be approved. This simple idea is the reason why the economic appraisal of projects can contribute to social welfare and the rationale for the existence of Cost-Benefit Analysis (CBA) as a tool for guiding choice. Subjective decisions, based on goodwill and intuition, are not a sensible guide for public decision-making given the inherent difficulties of understanding the complex effects of a project on the economy.

A project is defined here as any public policy or investment that has the potential of increasing individual well-being. A public intervention with a positive impact on the economy in terms of Gross Domestic Product (GDP), and employment, does not guarantee a net positive effect on social welfare; these concepts are not synonymous. The focus of CBA is on the net welfare effect of public intervention, and its social value is to provide the government, and society, with information on the project's expected consequences on individuals' welfare. The analyst in charge of this task should be neutral (i.e., unbiased about the project) concerning technologies and alternatives to address the problem at hand. Finally, experience shows that the best methodology and good intentions are irrelevant in the absence of the right institutional design.[1]

A project consisting in investing scarce resources in the present, for a flow of consumption in the future, will affect the economy through multiple channels: directly, in primary markets and, indirectly, in upstream and downstream markets. The first round of direct effects on primary markets is followed by other effects in secondary markets, linked by relationships of complementarity and substitutability; and subsequently, induced effects (the multiplier effect) on the rest of the economy. A complex course of adjustments, in many markets, follows the initial perturbation. In this process, economic agents change their behaviour (consumption, input supply and production), which can complicate the process as these effects frequently extend

[1] This paper does not address the role of institutional design on the effectiveness of CBA on decision-making. The weakness of CBA to affect policy decisions is explained more by governance than methodology (see Mackie et al., 2014; Flyvbjerg and Bester, 2021: de Rus and Socorro, 2010).

beyond a short intervention period. They occur during the project's lifespan[2], which can be quite long in the case of infrastructure investment, and affect many heterogeneous individuals, in terms of wealth, health status, the moment in time and so on, and create winners and losers following the initial impact. Although quantifying all these effects and understanding whether the project is, ex-ante, of social value might be considered an impossible task, economists try to make an educated guess about what the net effect of the intervention is, to be able to deliver useful information to the decision-maker.

An alternative way to estimate the welfare effect of a project is through a Computable General Equilibrium model (CGE), in which the production technology, resource constraints and preferences are explicitly modelled and the equivalent variation of project effects on GDP and employment is calculated. This cannot be done with the "one model fits all", as the particularity of different public interventions requires specific modelling of some key elements not contemplated in the standard CGE model, which is more suitable for the analysis of public policies, like changes in trade policy or taxation. The difficulties and cost of this global approach are substantial and possibly unjustifiable for small or medium-sized projects, such as building a new airport or improving urban infrastructure, which would necessarily require a finer disaggregation and specific modelling.

The good news is that CBA can provide a reasonable estimation of the net welfare effect of many projects, bearing in mind the multimarket impact of such public interventions. Here, we do not seek to cover all issues involved in a standard CBA[3] but try to show the potential of this tool as a reasonable shortcut (Atkinson and Stiglitz, 2015) for the appraisal of many representative projects undertaken by governments and international agencies. CBA is incremental, meaning that the practitioner identifies effects that are like those of the counterfactual and can be safely ignored. In the case, for example, of multiplier effects, this means that if the project and the next best alternative share similar induced effects—these effects would be limited to the net value

[2] If the project affects emissions of greenhouse gases, for example, the time horizon extends beyond the life of the project. Similarly, toxic substances remain after the closure of a mine.
[3] See, for example, Boardman et al. (2018) and Campbell and Brown (2015). For a more advance treatment see Johansson (1993), Johansson and Kriström (2016). This paper draws on de Rus *et al*. (2022), de Rus (2021), Johansson and de Rus (2018) and de Rus and Johansson (2019).

of the existing distortions—, they should not be included in the net social benefit of the project.

CBA is not a partial equilibrium approach in the sense of the ceteris paribus assumption (everything remains constant in the rest of the economy). The approach has been frequently criticized as a narrow appraisal methodology, which is unjustified. There is a well-developed theoretical justification for the use of market demand functions for general equilibrium welfare effects assessment. The welfare consequences of projects can be estimated using a set of reduced-form elasticities, which incorporate general equilibrium effects in all the affected markets (Just et al, 2004; Chetty, 2009; Kleven 2018). Using the market that the project directly affects does not mean that the practitioner ignores what happens in other markets in the rest of the market related vertically or horizontally linked to the primary market. The observed general equilibrium demand is frequently sufficient to respond to the question of what the expected welfare effect of public intervention in the economy is.

Kriström (2022) argues that “a very useful aspect of CGE-modelling is that the complex market interactions are handled upfront; these are integral to the set-up of an equation system that is ultimately solved. But this does in no way mean that secondary market effects are disregarded in CBA, even though the approach is usually considered (in the textbook examples) a partial equilibrium approach. The fact of the matter is that CBA deals with the secondary market effects by definition; it is a general equilibrium approach. Indeed, depending on the project, general equilibrium welfare theory offers extremely useful simplifications. After all, the objective is to compute welfare change, the difference between utility in the status quo and the counterfactual. A correct measure is only obtained if the theory correctly represents the project”.

CBA mimics the economist’s way of thinking. Its philosophy is consequentialist. It identifies, predicts, and quantifies the economic effects of public action to estimate its net effect on social welfare. It seeks to measure the change in the utility (well-being) of individuals affected by public actions so that regulation and public investment are oriented to the benefit of society. In Sunstein’s words: "Policies should make people’s lives better. Officials should not rely on intuitions, interest groups, polls or dogmas. In a nutshell: *quantitative cost-benefit analysis is the best available method for assessing the effects of regulation on social welfare*" (Sunstein, 2018 p.22).

With CBA, the economist compares the intervention's pros and cons, relying on a set of modelling techniques and statistics that have increasingly been able to establish causal relationships and, using highly disaggregated data, obtain essential values for ex-ante evaluation. This process must be completed before the project's adoption. However, project evaluation (ex-post or in media res) is also crucial to check whether it is producing the desired results, to introduce corrections, if possible, and to create a set of statistical values and elasticities for future appraisals.

Both ex-ante and ex-post CBA are socially useful and complement each other. Project appraisal - comparing estimated costs and benefits - should be a key step in any democratic society. It provides the decision-maker, and society, with a summary of the foreseeable consequences of a policy or an investment yet to be approved.

Ex-post evaluation can be achieved by replicating the CBA model with actual data or by using statistical inference techniques to estimate the effects on certain observable variables, such as output or employment. Revealing a causal link between a policy and the employment rate, the improvement in individuals' health status, or any other outcome, is insufficient to judge a policy's impact on social welfare. The comparison of costs and benefits is unavoidable.

The following two sections highlight the use of CBA as a common evaluation method applicable to any public policy or investment project. Section 2.4 shows the equivalence of two alternative approaches to the application of CBA, as well as the use of shadow pricing. Section 2.5 discusses the treatment of indirect effects, induced effects and the wider economic impacts in CBA. The conclusions are presented in Section 2.6.

2.2 The social appraisal of projects

Although it would be uncontroversial to approve projects that only had social benefits at no cost, following a strict criterion of a social decision like this would keep us in inaction. Had we only implemented Paretian improvements (someone is better off without making anyone worse off)[4] we would still be living in the Stone Age. In practice, countries with a tradition of evaluation, follow the criterion of 'potential compensation'[5] (winners win more than losers lose). 'Imperfect compensation'

[4] This is the strong Pareto criterion. The weak version requires that everyone is better off with the project.
[5] For an intuitive discussion of the potential compensation criterion and the difficulties when relative prices change, see Johansson (1991).

however might be a better description, as the losers are somehow compensated, and equity effects and/or political acceptability are taken into account (for example, territorial imbalances).

An economic appraisal[6] specifically consists in checking if a public action, a new regulation, or an investment in educational or health infrastructures, for example, increases individuals' well-being. The social appraisal of projects lies precisely in this, and obviously, its content predates the decision to approve/reject the intervention. Although the most useful assessment is necessarily ex-ante, the ex-post evaluation aims to learn from mistakes and improve the ex-ante evaluation. Both are interconnected. Another possibility - when the decision is not irreversible - is to assess the positive and negative effects of the policy and introduce corrections.

There are other decision-support tools, such as multi-criteria analysis, which do not measure changes in social welfare. Additionally, cost-effectiveness analysis and cost-utility avoid the monetary valuation of benefits. Finally, CGE models are more appropriate for large shocks, such as the impact of trade agreements or changes in taxation. When CGE is used for the social appraisal of projects, like the construction of a new road, the use of an existing CGE model designed for large economic impacts will rarely add any value to the evaluation unless further modelling is done, which incorporates the project's specificities. However, the costs may sometimes be too high compared with the benefits. A standard CGE model built to capture the effects of changes in international trade, or similar, will barely recognize differences between the net welfare effects of an investment in urban commuting or high-speed rail. Both projects will trigger the induced effect from the transport sector on the rest of the economy, but their direct effects and wider economic benefits are substantially different (see Laird and Venables, 2017).

It is possible to use 'reduced-form strategies' instead of CGE models for the social appraisal of projects like building a dam, cleaning a natural area or opening a new railway line. The idea is to compare the intervention with the contrafactual w using sufficient statistics instead of the primitives. "The sufficient-statistic approach obviates the need to fully calibrate the structural model. This is especially beneficial in models with heterogeneity and discrete choice, in which the set of primitives is very large but

[6] The terms 'social', 'economic', and 'socio-economic' are often used as synonyms.

the set of marginal treatment effects needed for welfare evaluation remains small. By estimating the relevant marginal treatment effects as a function of the policy instrument, one can integrate the formula for the marginal welfare gain between any two observed values to evaluate policy changes" (Chetty, 2009).

CBA follows this approach. It is the most commonly used method by supranational agencies.[7] CBA is fundamentally incremental, incorporates social opportunity costs and avoids double-counting; unlike some impact studies, which include effects on output and employment, common to the counterfactual, and which often lead to the project's net benefits being overestimated.[8]

The social appraisal of projects is an economic instrument to improve public expenditure efficiency**.** CBA is available at a reasonable cost to evaluate the effects of public policies on social welfare: it requires the establishment of an analytical framework (see Section 2.3) in which the problem is identified, feasible alternatives outlined, and all those significantly affected are included. In this process, individuals' preferences are respected, evaluations include non-marketed goods, and effects are expressed in monetary terms to calculate the net social benefit. When this is not possible, we can use ranges of values and probability distributions to establish lower and upper bounds of social profitability and the probability distribution of a project's net social benefit. A summary of CBA content is:

(i) The project is a tool to achieve a defined objective.
The objective of the public action must be clearly defined, as well as identification of the set of alternatives available to achieve it. It must be justified why the course of action chosen contributes most to social welfare. It is not enough that the intervention under appraisal presents positive net social benefits; these benefits have to be greater than those corresponding to the next best alternative.

A project is usually part of a broader program. It does not make much sense to discuss a project without considering its role in the planning process. It is necessary to plan first and then evaluate the projects that respond to this broader strategy. Projects have multidisciplinary aspects, and careful discussion with experts can

[7] See, for example, EIB (2023), ADB (2017), EPA (2020), H.M. Treasury (2022), Infrastructure Australia (2021).
[8] See Crompton (2006).

prevent the economic assessment from being biased by ignoring information of interest about relevant interactions, less obvious effects, complementarities, other feasible alternatives or the inclusion of unnecessary actions.

(ii) Net benefits concerning what?

In the CBA of a project, two situations must be compared: one resulting from the approved action and the other without intervention. The latter might involve, for example, undertaking the intervention using another technology or comparing two different locations. The situation without the project is dynamic and includes minor interventions that might occur anyway without the public intervention under appraisal. The world moves on anyway in the absence of the project that is evaluated. It is essential to compare the expected effects of the proposal with the counterfactual: what would have happened had the project not been implemented? Overestimation or underestimation of the project's social benefit can be significant if the base case without intervention is not properly defined, Alternatives should include the possibility of postponing the project.

(iii) Identification and measurement of costs and benefits

The identification of costs and benefits should be straightforward if there are no significant effects on other markets if they can be ignored when secondary markets are not significantly distorted or if they are like the alternative course of action. The same applies to the income multiplier.

The benefits of projects are measured through individuals' willingness to pay, in many cases through the preferences revealed in the market. This approach applies to direct effects, indirect effects, and goods for which there is no market, but another market is found in which some useful information about willingness to pay is revealed. Where direct market data cannot be obtained, stated preferences must be used.

In general, the proposals under assessment involve the diversion (and sometimes savings) of resources from other uses. The two central concepts here are the social opportunity cost if the appraisal follows the changes in willingness to pay and in the use of resources, and the private opportunity cost if the surplus approach is chosen.

(iv) Net Present Value (NPV) as a numerical expression of the potential compensation.

The purpose of the CBA is to calculate the project's social NPV, for which it is necessary to fix the duration of its effects and the social discount rate. Where it is not possible to quantify the NPV precisely, probability distributions can be used for key variables and risk analysis can provide the NPV's probability distribution. There are cases where it may be appropriate to make a qualitative description of some effects, and then add this information to the net social benefit.

In principle, if the proposal's NPV is positive, this intervention will be among the candidates for approval, unless undesirable redistributive effects are found, or any other constraint is binding. Finally, even in the case of a positive NPV, when the intervention is irreversible and there is demand or cost uncertainty, the possibility of postponing the project should be considered.

(v) Economic profitability and financial viability

The project's CBA provides an estimate of its social profitability. Financial analysis is a part of CBA, and in competitive, undistorted markets, with optimal income distribution, the financial and economic results coincide. Although the financial analysis uses revenues instead of social benefits, and private costs instead of social costs, it is important to include the financial result alongside the social profitability. There will be many cases in which the proposal generates benefits greater than its social costs and simultaneously, presents a negative financial result.

In some proposals, it may be useful to calculate several outcomes as a function of the pricing policy. The existence of different possible combinations of social benefit and financial viability is common for revenue-generating projects. This information can be very useful, depending on the severity of the budget constraint.

Additionally, the financial analysis should provide a lot of detailed information, for example, the relevant production functions, and so on. Therefore, the CBA can be based on much more detailed production data than a typical CGE.

In short, project approval should be subject to the social benefits exceeding its social costs; and also seek that, as a whole, within the existing budget constraints, the set of proposals that maximize social welfare is selected. This requires that not only projects with net positive social benefits be approved, but that they do not block others that contribute more to social welfare.

Ignoring the appraisal of projects and leaving a politician to decide according to their intuition, or interpretation of what is good for the country, or any other motivation without technical support, is unnecessarily risky. Indeed, the monetary valuation of changes in the utility of individuals who differ in their income levels creates serious measurement problems, and this is without raising the point that an individual is always the best judge of their own interest. However, what other criterion is better than that of efficiency, which is the aim of CBA?

2.3 General equilibrium CBA rules

Supranational agencies have their own CBA guidelines for project appraisals. This is also the case for countries with an evaluation tradition. When there is no such culture in the ministries and public agencies of a particular country, there is a risk of 'copying recipes' from various sources that, when applied together, lead to inconsistencies and double-counting that bias the results. Therefore, a considered appraisal requires a rigorous analytical framework, with explicit assumptions, from which practical rules are formally derived (Johansson, 1993; Johansson and Kriström, 2016). For the results to be comprehensible and useful, it is necessary to know the original analytical framework.

Ideally, the practitioner would seek to measure the winners' increase in well-being to compare it with the reduction in that of the losers, but the problem lies in the impossibility of such measurement. Suppose that an individual whose hobby is river fishing suffers a reduction in his utility if a project is approved. Let's say the project consists of the construction of a hydroelectric complex upstream that will reduce both the price of electricity and the downstream flow of water. We know that the individual opposes the project, but we do not know how much his utility is reduced. Without a way to measure it, we cannot compare the 'harm' to that individual, nor of the many others who enjoyed the river through a variety of leisure and business activities that will be compromised by the project, with the welfare gains of those who will benefit from cheaper energy, less pollution and other leisure activities provided by the dam.

A referendum involving all those affected might solve the problem. However, one vote per person ignores the intensity of preferences. For example, suppose my net profit from the construction of the dam is marginally positive (I gain from the reduction in the price of electricity, but my environmental concerns almost offset that gain). My vote will be positive and will weigh the same as that of my neighbour whose well-being is significantly linked to maintaining the river's flow without the project (for example, in her leisure activities in the area). If my neighbour could compensate me for giving up the project, we would both be happier without the project. In sum, the referendum ignores the intensity of preferences, while the CBA incorporates them through the willingness to pay and accept.[9]

We have referred to the need for a model from which appraisal rules can be derived. Why do economists use 'willingness to pay' to measure the benefits of public policies and projects? This approach to measuring the change in individual well-being derives from the assumption that governments seek to maximize social welfare, which can take various forms but usually responds to the following four properties (Mas-Colell *et al.*, 1995, p.825): (i) Non-paternalism. In the expression of social preferences only individual utilities matter. (ii) Paretian property. Welfare increases with the utility of each individual. If one individual is made better off without making anyone else worse off, there is an increase in social welfare. (iii) Symmetry. In the evaluation of social welfare, all individuals are on the same footing. (iv) Concavity. This is based on inequality aversion. The extent of compensation is determined by the degree of inequality in society.

The function of social welfare depends on individuals' utility, and we assume that they maximize their utility, according to their preferences, and within the limits imposed by initial endowments and technology constraints. The utility of individuals is a function of the goods and services they consume, whose prices and quantities are affected by public interventions that change the economic equilibrium that affects them as consumers, owners of the factors of production, taxpayers and third parties affected by externalities. CBA seeks to assess the effects of government intervention on social welfare.[10]

The effect on firms and taxpayers has a simple metric: the monetary variation in profits and government net revenue. Measuring the change in consumers' utility, or

[9] The monetary measure of changes in utility and the aggregation of surplus across individuals is not without difficulties. See Boadway and Bruce (1984). For an intuitive explanation, see Johansson (1991), pp-40-56.
[10] For an analysis of 'who counts' in CBA, see Zerbe (2018), and Johansson and de Rus (2019).

third parties affected, for example by air pollution or noise, requires moving from what we would like to measure (utility) to what we can measure (willingness to pay).

Since utility is not observable, economists use units of income instead of welfare If my willingness to pay for a project is 300 euros per year, while my neighbour's is 1,000 to prevent it from being carried out, I would be willing to accept 500 to give up the project, as it increases the level of welfare of both with respect to the counterfactual. This is a Paretian improvement (as it would be if I were paid 300). When we jump from a few individuals to a sufficiently large and heterogeneous number, actual compensation is not feasible and economists use the principle of potential compensation, which means that in the case of the previous example, the project would be rejected as the winners could not compensate the losers and still be better off.

When calculating a project's net social benefit, and unless equity weights are used, the monetary valuations of winners and losers are added regardless of their income level. Therefore, such monetary valuations (assuming they are properly calculated) reflect both individuals' preferences and their income levels. Since the marginal utility of income is positive but decreasing, we have a problem with the comparability of those valuations.

If the distribution of income were optimal, or we were in a restricted optimum, given the disincentive effect of additional redistributive measures, transferring income from one individual to another does not increase social welfare. In other words, the marginal social utility of income is equal for all individuals; That is, a euro is a euro regardless of who wins or loses it. In these circumstances, in the previous example, if one wins 300 and the other loses 1,000, the project reduces welfare.

Does this conclusion hold when the distribution of income is not optimal? (recall that there is no compensation). We do not know because the effect on welfare depends on the marginal social utility and the marginal utility of income. Even with an identical social marginal utility for all individuals (all are equal in the eyes of the government), the marginal utility of income for the poor is greater than for the rich, and the poor's utility may increase more with the additional 300 euros than the reduction of the rich's utility by losing 1,000 euros.[11]

[11] Though one might think of a less inefficient way for income redistribution.

When the practitioner calculates the net social benefit of a project and obtains a positive result, most of the time they are applying the criterion of potential compensation, which implies that, if the redistributive consequences of the project were sufficiently undesirable, it could happen that the NPV of the project may not reflect the actual impact on welfare. What way out do we have when faced with this problem?

In practice, the potential compensation criterion is often applied under the assumption that fiscal policy has mechanisms for effective income redistribution. Its application is also justified by the argument that in the long-term everybody will be better off since the government carries out many projects, and different projects have different winners and losers. Moreover, it should not be forgotten that the potential compensation criterion is accompanied by actual (imperfect) compensations that mitigate the damage to the losers. It could also be argued that the difficulties of identifying the ultimate beneficiaries can make the task impossible; or that the costs of identifying winners and losers and establishing compensation mechanisms outweigh the benefits.

A frequent error in projects' social appraisal occurs when the practitioner mixes CBA's two main aggregation methods. A project's NPV can alternatively be calculated by adding surpluses or through changes in willingness to pay and real resources. Once one of these options has been chosen, the practitioner should follow the logic of the approach until the end. The best antidote for this common error is to employ a model with consistent rules of thumb for the practical appraisal of projects. Again, the importance of having a model from which the evaluation rules are derived is evident. If we add surpluses, we must adjust to individuals' private valuations and add them up. When information is limited, the NPV calculus follows the maximum willingness to pay for the project and the social opportunity cost of the resources. Care must be taken not to mix both procedures. In this latter approximation, income transfers do not count. In the former approximation, they are included, and they 'net out' in the sum preceding the calculation of the net social surplus.

Johansson (1993) derives general equilibrium cost-benefit rules for marginal and large projects that affect the environment. The core approach is general and can be applied to any other government intervention, such as the provision of public infrastructure. The key idea is that the economy is integrated by households and firms, ultimately owned by the former. The indirect utility function of a representative consumer is a function of prices, wages, exogenous income, firms' profits, taxes and public goods. Under the assumption of well-behaved functions and prices adjusting to equate supply and demand, the monetary valuation of the utility change produced by a large project can be approximated through the conventional rules of adding consumer, producer, and taxpayer surpluses, if the consumer´s willingness to pay does not include any change in exogenous income, profits or taxes.

CBA can be thought of as a set of shortcuts to circumvent the impossible task of precisely measuring the total effects of an infrastructure project on the economy during its lifetime. This involves the effects on many households and markets during a project's lifespan. The good news is that under some conditions, particularly the fact that prices adjust continuously to equate supply and demand, it is possible to approximate the net welfare effects by focusing on the primary market (or group of markets). "Often, we are interested not in a single market but in a group of commodities that are strongly interrelated either in consumers' tastes [...] or in firms' technologies. In this case, studying one market at a time while keeping other prices fixed is no longer a useful approach because what matters is the *simultaneous* determination of *all* prices in the group. However, if the prices of goods outside the group may be regarded as unaffected by changes within the markets for this group of commodities, and if there are no wealth effects for commodities in the group, then we can extend much of the analysis…" (Mas-Colell *et al*., 1995, p.342).

We now move to a more formal discussion of the CBA analysis framework to make explicit the assumptions behind the practical rules followed to try to answer the demanding question of whether society should invest public money in an infrastructure project. The general equilibrium cost-benefit rules derived in Johansson (1993) will be our basic framework.

Let's assume the existence of an economy with identical households, where firms are ultimately owned by households. The representative household consumes private goods and a public good, interpreted here as the level of public infrastructure, and supplies a vector of different types of labour. The indirect utility function of the economy´s representative household, $V(.)$, is written as:

$$V = V[p, w, Y + \Pi(p, w, z) - \tau, z]$$

$$= max_{x^d, L^s}\{U(x^d, L^s, z) \quad s.t. \quad Y + \Pi + wL^s - \tau - CV - px^d = 0\}, \tag{1}$$

p: price vector

w: factor prices vector

Y: exogenous income

Π: profit income

τ: lump-sum tax collected by the government

z: public good

x^d: private goods vector

L^s: labour vector

CV: compensating variation

$U(.)$: utility function of the economy's representative household.

Firms, owned by households, maximize profits (Π):

$$\Pi = pF(L, z, K) - wL - 1 \cdot K, \tag{2}$$

where $F(L, z, K)$ is the production function, and the price of capital (K) is equal to 1.

The government controls the variable z. Suppose z is the stock of public infrastructure and a project that increases z (for example, a free access new road) which requires the use of real resources as production factors and other produced goods.

Totally differentiating the indirect utility function (1) and profit function (2), the cost-benefit rule (3) is obtained. The effects of the project, time savings, accidents avoided, and so on, can be interpreted as a small change in z and evaluated according to (3).

$$dV/V_y = (x^s - x^d)dp + (L^s - L^d)dw + [(V_z/V_y)dz + pF_z dz - dC - dCV] = 0, \tag{3}$$

where V_y is the marginal utility of income; superscripts s and d denote supply and demand respectively; V_z is the marginal utility of z and F_z is the marginal productivity of z.

Even if the change in the stock of infrastructure affects other markets, if prices adjust to reach a new equilibrium, the first two terms on the right-hand side of expression (3) net out, and so we can concentrate the effort in the primary market. With a project cost, calculated at initial prices, equal to dC, the term dCV measures the representative household's willingness to pay (net of project costs).

We can then calculate the NPV of a small project from the terms within brackets in (3): the households' direct willingness to pay (V_z/V_y) plus the direct impact on profits $(pF_z dz)$ minus the project costs (dC). Changes in profits or costs due to changes in prices are not accounted for in the evaluation if demand equals supply in the new equilibrium. The first three terms in brackets in (3) account for the change in resources and willingness to pay due to the infrastructure investment. In (3) access to the infrastructure is free.

The economic effects of large projects

In the case of large projects, the general equilibrium rule is a generalization of (3) if the project does not induce significant price changes. Once we abandon the assumption of perfect divisibility, we enter the world of incremental changes. Then, different sizes may be available and capacity design must be considered. There are also different technologies available to solve a common problem. The evaluation of large projects is difficult when significant price changes are expected, and the economic consequences of a particular project may have considerable long-term effects.

In the case of a large project, we can still follow the insight of expression (3) as long as the first two terms in parenthesis vanish once the project is implemented. In expression (3) the evaluation is conducted following the changes in willingness to pay and changes in resources. An alternative and equivalent approach is to add surpluses as changes in prices which do not add value (transfers) net out in the process of aggregation.

Following Johansson (1993), the social willingness to pay can be expressed as:

$$V(p^1, w^1, Y^1 + \Pi^1 - \tau^1 - CV, z^1) = V(p^1, w^1, Y^0 + \Pi^0 - \tau^0 - CV^p, z^1) = V^0. \quad (4)$$

Where V^0 refers to the level of utility attained without the project and CV^p denotes the partial willingness to pay for the project as a user of the infrastructure, excluding any effects on lump-sum income, profits, and taxes. Superscripts 1 and 0 denote with and without the project. The difference between CV and CV^p is the following:

$$CV = CV^p + \Delta Y + \Delta \Pi - \Delta \tau, \quad (5)$$

where ΔY, $\Delta \Pi$ and $\Delta \tau$ are the change in exogenous income, profits, and taxes, with the project. The change in taxes is interpreted here as the project costs.

This leads to the standard approach of defining the effect of the project as the sum of the consumer compensating variation, producer surplus and taxpayer surplus.[12]

In the actual appraisal of projects, the monetary valuations in expression (5) are commonly approximated with two alternative approaches, expressed as:

$$NPV = \sum_{t=0}^{T} \delta^t (B_t - C_t), \quad (6)$$

where B and C are the social benefits and social costs of the project in real terms, δ^t is the real discount factor, T denotes the project life, and no disaggregation by final beneficiaries is applied:

Alternatively, decomposing B and C by groups of individuals produces the aggregation of surpluses;

$$NPV = \sum_{t=0}^{T} \delta^t (\Delta CS_t + \Delta OS_t + \Delta LS_t + \Delta RS_t + \Delta GS_t + \Delta ES_t), \quad (7)$$

where ΔCS_t is the change in consumers' surplus, i.e., the difference between what consumers are willing to pay for the goods and what they pay;[13] ΔOS_t is the change in the surplus of the owners of capital, i.e., firm revenues less variable costs; ΔLS_t is the change in the surpluses of workers and ΔRS_t the change in the landowners' surplus, which is equal to the wages and land income, respectively, less the minimum payment they are willing to accept for the use of the factor; i.e., its private opportunity cost; ΔGS_t

[12] The problem with large projects with significant impacts on the prices of secondary markets is the near impossibility for individuals to give a sound answer to the questions involved in expression (5).

[13] The change of CV^p in expression (5) to CS in expression (7) is not harmless, unless certain conditions hold (see Willig, 1976).

is the change in taxpayers' surplus, which equals tax revenues less public expenditure; finally, the change in the 'rest of society' surplus (ΔES_t) includes the value for the individuals of non-marketed goods, such as the project effects on the landscape, clean air, climate, or even safety levels, that may change when a project is carried out, net of compensation payments. For example, the negative externality of a power plant that contributes to global warming, or the positive externality of an investment in alternative energy sources that reduces it, net of any compensation.

2.4 Applying the CBA rules

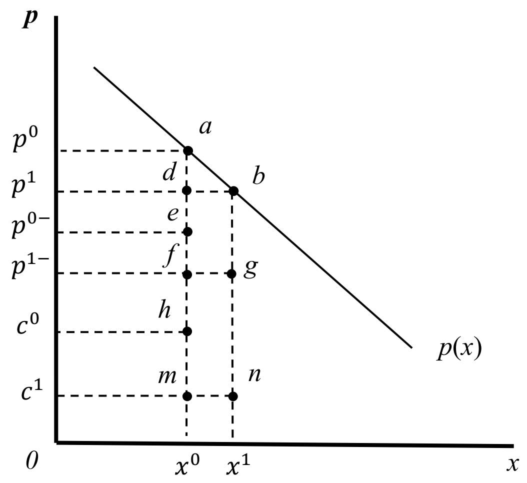
Once the costs and benefits of the project are identified, the practitioner must choose one of the available alternative aggregation methods for their measurement. A clear understanding of the chosen method will prevent common errors that may lead to the overestimation or underestimation of the net benefit.[14] The first aggregation method consists in adding the change in surpluses, as in expression (7). Although it is more informative, its application is difficult in practice given the data usually available and the problems in identifying beneficiaries.[15] The alternative aggregation method is to follow the changes in willingness to pay and resources (ignoring transfers). At first glance, it seems easier, but there are disadvantages associated with its use. The willingness to pay is constant for existing demand, assuming quality in a broad sense to be constant, but there is an increase in willingness to pay of generated demand. In this case, any distortion (e.g., profits or taxes) in secondary markets affected by the change in the primary market must be added, without accounting for any change in the use of resources in secondary markets.

The equivalence of the two aggregation methods is shown with the help of Figure 1, corresponding to an infrastructure project affecting a primary market with the demand function $x = f(p)$ where x is the number of users per year and p is the price. Figure 1 shows the inverse demand function $p(x)$. Marginal costs are constant and equal to c^0 without the project. The initial equilibrium is (p^0, x^0). The market price includes a specific tax (τ), so the price charged by producers (p^-) does not coincide with the price paid by consumers (p), where $p = p^- + \tau$. With the project, the marginal cost goes down to c^1, and the quantity goes up to x^1, so there is a generated demand equal to $(x^1 - x^0)$. Recall superscripts 1 and 0 denote with and without the project.

[14] There are all sorts of measurement/prediction errors, which apply to both methods (Mackie and Preston,1998).
[15] The existence of a fixed factor may completely modify the predicted distribution of the social surplus.

Notice that, although the price goes down, the reduction is lower than the reduction in the marginal cost. Investment costs are ignored for simplicity.

Figure 1.



Assuming no income effects, optimal income distribution and price equal to social marginal costs in the rest of the economy, the change in welfare with the project is the sum of the changes in surpluses of all the agents affected in the primary market, which can be calculated using the standard assumption of a linear approximation between the initial and the final price.

The change in consumer surplus for existing demand (x^0) is equal to the area ($p^0\ adp^1$), and for the new consumer equal to *abd*. The total change in consumer surplus is represented by the area ($p^0\ abp^1$) and measured with the so-called 'rule of a half'):

$$\Delta CS = \frac{1}{2}\left(p^0 - p^1\right)\left(x^0 + x^1\right). \tag{8}$$

The change in the surplus of the owners of capital (the firm) is represented in Figure 1 by the following change in revenues and costs: a reduction in the revenues of the existing demand equal to the area ($p^{0-}efp^{1-}$), an increase in revenue from the generated demand represented by the area ($fgx^1\ x^0$), the reduction in variable costs of the existing demand ($c^0\ hmc^1$), and the additional costs of serving the generated demand equal to the area ($mnx^1\ x^0$). The total change of the owners' surplus is:

$$\Delta OS = (p^{1-}x^1 - c^1 x^1) - (p^{0-}x^0 - c^0 x^0). \tag{9}$$

The change in taxpayers' surplus is represented by the area $(dbgf)$, and calculated as:

$$\Delta GS = \tau (x^1 - x^0). \tag{10}$$

This increase in tax revenues is not a transfer under the assumption of price equal to marginal cost in the rest of the economy if the specific tax τ also affects the other markets, the value of expression (10) is offset by the loss of taxes in another market unless the project is associated with an increase in productivity or when different economic activities have different tax rates.

Finally, as the other surpluses do not experience any change, the change in social surplus is obtained by adding expressions (8), (9) and (10):

$$\Delta CS + \Delta OS + \Delta GS =$$

$$= (c^0 - c^1)x^0 + \frac{1}{2}(p^0 - p^1)(x^1 - x^0) + (p^{1-} - c^1)(x^1 - x^0) + \tau (x^1 - x^0). \tag{11}$$

Rearranging and simplifying in (11), the change in willingness to pay and resources is obtained:

$$\frac{1}{2}(p^0 + p^1)(x^1 - x^0) - c^1 x^1 + c^0 x^0 . \tag{12}$$

Expressions (11) and (12) are equivalent and are represented in Figure 1 by the areas $abnm$ and $c^0 hmx^0 c^1$.

The social opportunity cost of resources

Shadow pricing consists of applying conversion factors to market prices to approximate the social opportunity cost. This adjustment only applies to the change in willingness to pay and resources approach. When a project is implemented, society forgoes other goods, as resources divert from other uses. This is the social opportunity cost of the project (C_j): [16]

$$C_j = \sum_{k=1}^{s} p_k dx_k, \tag{13}$$

[16] See Johansson (1993) and de Rus (2021). This section deals with inputs that can be purchased in markets. Non-market resources are not discussed here.

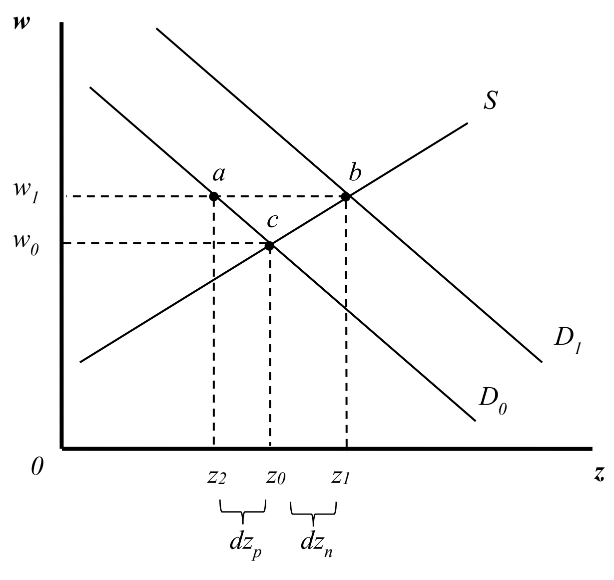
with $s \leq n$ goods or services, assuming only two inputs (z_1 and z_2) that are fully utilized to produce and consume goods, $x_k = f_k(z_1, z_2)$, and assuming also that market prices are equal to the marginal value of the goods diverted to the project. Recalling that any profit-maximizing firm uses additional units of inputs until its market price (w) equals the value of its marginal product ($w = p_k \frac{\partial x}{\partial z}$), through the total differentiation of the production function ($dx_k = \frac{\partial x_k}{\partial z_1} dz_1 + \frac{\partial x_k}{\partial z_2} dz_2$) expression (13) can be expressed as:

$$C_j = \sum_{k=1}^{s} (w_1 dz_1 + w_2 dz_2), \qquad (14)$$

which is a more practical way to work out the project's cost as it is easier to calculate the quantities and prices of the inputs required.

The validity and usefulness of expression (14) for identifying and assessing the costs of a project are subject to two underlying assumptions: all the changes in input markets are marginal and input markets are perfectly competitive, without distortions such as indirect or income taxes. This is the case represented in Figure 2 in the initial equilibrium (w_0, z_0)

Figure 2.



When the effect of the project in the factor market is not marginal and the demand for the input shifts from D_0 to D_1, the input price goes up to w_1 and two effects are affecting the opportunity cost of the input allocated to the project: (i) the private demand for the input goes down until w_1 is equal to the value of the marginal productivity and (ii) the increase in the input price increases the quantity supplied. Now, we can calculate the opportunity cost of the input. The project needs *dz* units of the input. This quantity required by the project has two components: new supply (dz_n) that is offered at the new equilibrium input price, and a quantity diverted from the private sector (dz_p), which shifts to the project at the higher price w_1, as represented in Figure 2 at the new market clearing price w_1. The opportunity cost of the new supply (dz_n) is represented by the area cbz_1z_0 and the quantity of the input diverted from private firms (dz_p) is represented by the area acz_0z_2. The shadow price of the input can be calculated as:

$$\frac{1}{2}(w_0 + w_1)dz\ . \qquad (15)$$

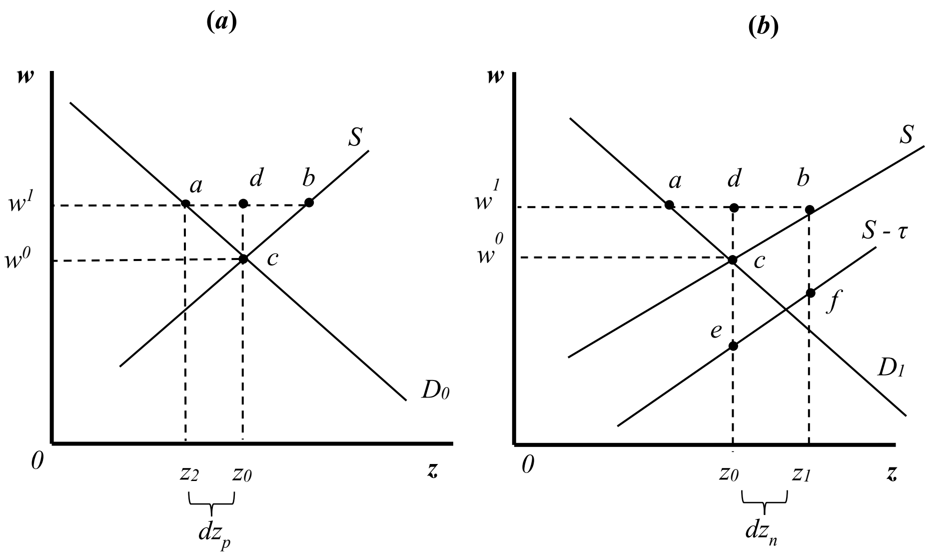
In a more realistic context of project appraisal (e.g. existence of subsidies or taxes, or high unemployment), the previous expression is modified to account for the distortions.

Let's consider a specific tax (τ) in Figure 3. Initially, without the project, the input market is in equilibrium, with the supply (*S*) and demand (D_0) determining the input price w_0 and quantity z_0. The existence of τ introduces a distinction between the market supply function (*S*) and the opportunity cost of the input supplier, $S - \tau$. The function $S - \tau$ shows the social marginal value of producing the input and the demand function is the value of the marginal productivity of the input for the firm. At the equilibrium input price (w_0), the value of the marginal productivity of the input for the firm is equal to the opportunity cost of the input supplier for the marginal unit of input plus the tax.

With the project, the demand for the input shifts from D_0 to D_1, the input price goes up to w_1 and the private demand for the input goes down until w_1 is equal to the value of the marginal productivity of the input. The increase in the input price also has the effect of increasing the quantity of the input offered at this price, and the equilibrium quantity goes up. Now, we can calculate the opportunity cost. The project needs *dz* units of the input. This quantity required by the project has two components: additional production (dz_n) at the new equilibrium price, and quantity diverted from the private sector (dz_p), which shifts to the project at the higher price w_1. The opportunity cost of dz_n is the social marginal cost of producing the input (the value of leisure in the case of labour). The input suppliers receive $w_1 dz_n$, represented by the area dbz_1z_0 in Figure 3(b), but the social opportunity cost is lower (area efz_1z_0) and can be calculated as:

$$\left[\frac{1}{2}(w_0 + w_1) - \tau\right] dz_n. \tag{16}$$

Figure 3.



The opportunity cost of the input quantity already used in the private sector (dz_p), shifts to the project at the higher price w_1, is acz_0z_2. However, the social opportunity cost of these units is higher than the expression (16) and equal to the lost value of their marginal productivity in the private sector (including the tax) when the quantity dz_p shifts to the project. The input supplier receives w_1dz_p, but the social opportunity cost is lower (area acz_0z_2) and can be calculated as:

$$\frac{1}{2}(w_0 + w_1)dz_p\ . \tag{17}$$

In the case of the existence of specific taxes levied on the product market, the shadow price of the deviated input includes the additional specific tax (θ), as the profit-maximizing firm must equalize the wage and net value of the marginal productivity of the input. The shadow price is, in this latter case:

$$\left[\frac{1}{2}(w_0 + w_1) + \theta\right] dz_p. \tag{18}$$

The practitioner should be aware that, depending on the method used, the opportunity cost is different. In the case of adding the change in surpluses, the private opportunity cost is what matters, and the shadow price should be ignored, whereas the social opportunity cost must be used when the approach followed is the change in willingness to pay and resources.

The shadow price of public funds

Governments usually finance the payment of projects cost with tax revenues. This is the case for example, of some public goods, some private goods like a free sports facility or, even when the users pay, some projects require additional financial support, as is the case of a natural area with an entry fee insufficient to cover the total cost. Unfortunately, tax collection has efficiency costs, i.e., is not a mere transfer of income between consumers, producers, and the government.

The excess tax burden or deadweight loss of the tax is the net value of the production lost with the introduction of the tax, and hence constitutes an opportunity cost of the project. The social cost of public funds is $SCF = R + EB$, where R is the tax revenue and EB is the tax excess burden.

For example, consider a project whose investment cost (I) occurs only in year 0 (when the government charges an indirect tax in a market unrelated to the project) and produces a constant annual benefit (without charging anything for the good) during the T years of project life. Assuming a real discount rate equal to zero, NPV is equal to:

$$NPV = -\lambda_g I + T\,\Delta CS, \tag{19}$$

where λ_g is the shadow price of public funds.

Then, if the deadweight loss is equal to 20 per cent of the tax revenue, the marginal cost, the shadow price (or shadow multiplier) of public funds is equal to 1.2, and the cost of the project is equal to $1.2I$. Note that, for NPV greater than zero, $\frac{T\Delta CS}{I} > \lambda_g$, i.e., for a project funded by taxes to be socially profitable, the social benefit obtained per unit of money invested must be greater than the opportunity cost of the public funds.

A more general expression for a revenue-generating project (partially financed by taxes) is the following:

$$NPV = -\lambda_g I + \sum_{t=1}^{T} \frac{\Delta CS_t + \lambda_g \Delta PS_t}{(1+i)^t}, \tag{20}$$

where i is the social discount rate and PS is the producer surplus.

Expression (20) shows that the shadow price of public funds should be applied to both costs and revenues because the annual net revenue reduces the need for public funding and therefore the need for taxes ($\lambda_g(1 + i)^{-t}$ is the present value of 1 euro collected by the project).

Finally, the social marginal cost of public funds (*SMCF*) is obtained by taking the first derivative of *SCF* with respect to *R*:

$$SMCF = 1 + \frac{dEB}{dR}. \tag{21}$$

The deadweight loss (*dEB/dR*) is positive and increases with the size of the tax, i.e., the *SMCF* increases when additional tax revenues are required for the financial support of new projects. Finally, we must also highlight that this implies a high benchmark for the number and size of public projects passing the test of a positive NPV, as the marginal benefit of additional projects requiring financing is expected to diminish, while the *SMCF* is expected to increase.

2.5 Beyond direct effects

The purpose of CBA is to estimate the net welfare effect of public policies and projects. As noted, the practitioner can focus on the analysis of the primary market or in a group of strongly interrelated markets, under the assumption that what happens in other markets does not affect welfare when the rest of the economy is sufficiently competitive or, even when significant effects are present, they can be presumed approximately similar to those associated to the counterfactual.

Indirect effects and wider economic impacts need some market distortion to play a role in the economic appraisal of projects. The treatment of the indirect effects is similar for any secondary market affected by the project (Harberger, 1965; Mohring, 1971). Moreover, indirect effects can be positive or negative depending on the sign of the distortion and the cross elasticities. Nevertheless, even with distortions, when optimal pricing is applied in secondary markets, there are no additional benefits (or costs).

The existence of a wedge between price and marginal cost in other related markets may change the value of the project in any direction, though the usual criticism is that the traditional approach of measurement (changes in surpluses in the primary and closely-related markets) seriously underestimates the social benefits of many projects. For example, many promoters of public infrastructure investment argue that there exist other benefits, beyond direct user benefits, such as changes in productivity and industry reorganization, so it is critical to avoid the potential underestimation of transport improvements, including some of these alleged additional benefits.

Moreover, gains in productivity derived from industry reorganization are not, in principle, additional benefits. This is a well-known result in economics. Although transport cost reductions, for example, may allow firms to reorganize plants, inventories and warehouses that lead to productivity gains, these effects have already been measured with the transport demand (Mohring and Williamson, 1969). What we need for the existence of additional benefits, and not merely double-counting or transfers, is the presence of market distortions, a wedge between price and marginal costs, such as agglomeration economies following changes in proximity (Venables, 2007) or the benefits of urban redevelopment in the presence of a market failure (Laird and Venables, 2017).

The defence of infrastructure investment for economic development based on the results of the econometric aggregate approach and impact studies is rather discredited today (Gramlich, 1994), though promoters still use the argument of infrastructure investment as a sufficient condition for economic development by ignoring endogeneity, or the difficulty of disentangling relocation and growth in the estimates ("much of the estimated effect of transportation costs and infrastructure on the spatial organization of economic activity is probably due to reorganization rather than growth" Redding and Turner, 2014). In this sense, Laird *et al*. (2014) warn of the use of expenditure and costs instead of genuine benefits. They mention the recent shift by planners in the United Kingdom, using changes in gross value added, including wages, as a benefit.

Two different sources of wider economic benefits are associated with land use and the labour market following the impact of a transport improvement. First, a reduction in transport costs may boost private investment and be a cause of the redevelopment of a zone in a city. In the case of a change in land use, the benefits can come from the greater attractiveness of the new area (increase in consumer surplus), or when the existence of the developer's market power, or a coordination failure by firms, is removed, thanks to the transport improvement (Laird and Venables, 2017). Second, the impact on the labour market might be another source of wider economic benefits, though the risk of double-counting is high: the increase in productivity due to an increase in labour density is already measured as agglomeration economies, as well as the creation of new jobs through shadow pricing when measuring the opportunity cost of inputs.

Criticisms of CBA as a method for the social appraisal of projects come from two different perspectives. One is technical and identifies weaknesses in the methodology that aims to estimate the impact of public projects on social welfare. The other is essentially political. The CBA emphasizes the net welfare consequences of the project that the government proposes and ignores the rhetoric of the promoters arguing about the impacts of the project on job creation, regional development, or multiplier effects. Effects that in some cases are inexistent, relocation or double-counting; or do exist but are not incremental, i.e., they are common to the project and its alternative. This is the reason why robust appraisal of projects requires a previous analytical framework to assess the project with consistent rules.

The practical rules of measuring the direct effects of a project on the primary market, ignoring the effects on other markets, are general equilibrium rules when there are no distortions in the rest of the economy (Harberger, 1965; Johansson, 1993). As said, CBA is incremental and adding indirect effects and multipliers to the rest of the economy is incorrect if there are no distortions, and unnecessary if other alternative projects are also similarly affected by such effects. Even with price changes in secondary markets, market demand in the primary market (without distortions) already incorporates all the effects in the rest of the economy (Sudgen and Williams 1978, Mohring 1993, Boardman *et al*., 2018).[17] As an illustration, Figure 4 shows the case of a project reducing the cost of good *x* (primary market), which affects the market of good *y* (secondary market). In this case, the indirect effect in the secondary market is due to the substitutability in demand between both goods.

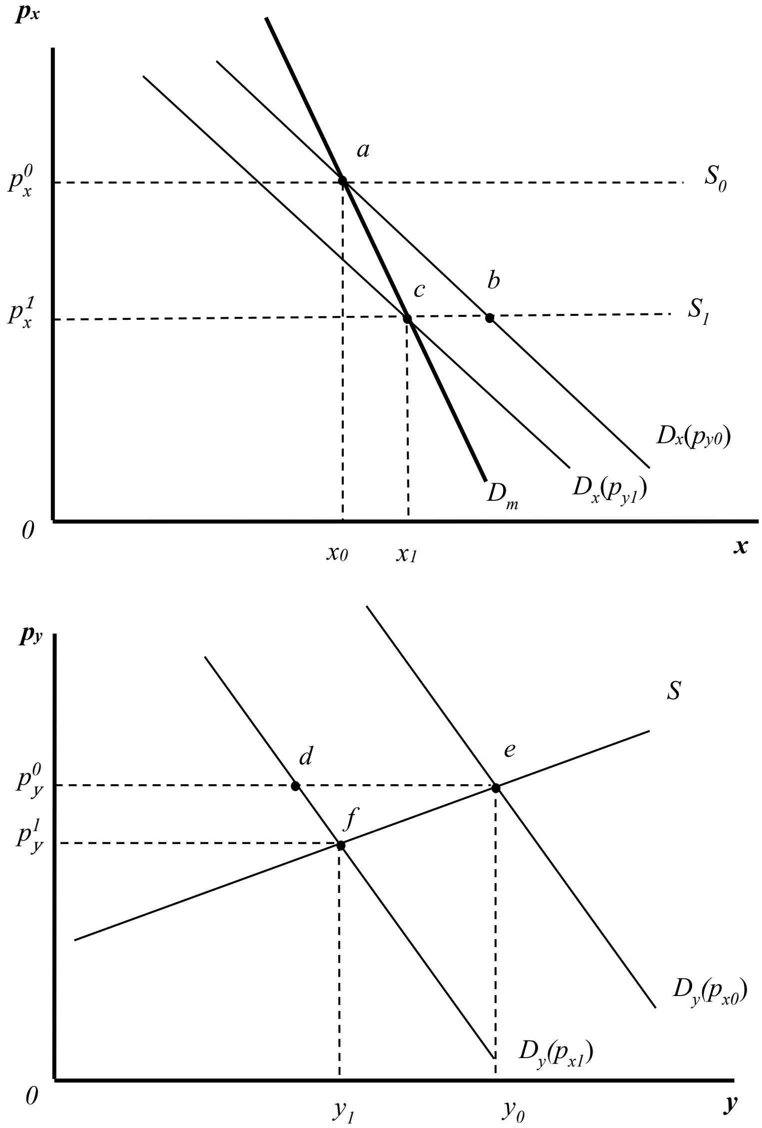
The project reduces the cost of producing good *x* and its price goes down from p_x^0 to p_x^1. The social surplus is equal to the area $p_x^0 ab p_x^1$. The strongly interrelated market of

[17] Kotchen and Levison (2022) analyse the benefits and costs of regulation in the case of undistorted secondary markets. They develop a tool that the practitioner can use to evaluate the magnitude of secondary-market effects in particular applications, showing how they are likely to be relatively small in most circumstances, and providing evidence supporting this conclusion.

good y is affected by this price reduction, shifting the demand from $D_y(p_{x0})$ to $D_y(p_{x1})$. It is important to note that the positions of the demand in both markets reflect the existence of both goods and the changes in their prices. When the price of x goes down, some consumers of y then prefer to buy the substitute - and the demand of y shifts to the left. This fact causes a gain for consumers that continue consuming y equal to the area $p_y^0 dfp_y^1$, but the producers lose the area $p_y^0 efp_y^1$ and hence welfare loss represented by the area *def* should be subtracted from the area $p_x^0 abp_x^1$ in the primary market.

The good news is that the partial equilibrium demand schedules ($D_x(p_{y0})$ and $D_y(p_{x0})$) are not observable and the estimated quantity changes in the market of good x include additional shifts in demand, as represented by $D_x(p_{y1})$. The observed quantities x_0 and x_1 are general equilibrium quantities measured with the equilibrium demand scheduled D_m. The practitioner measures the increase in welfare with elasticities corresponding to this observed demand and therefore the area is $p_x^0 acp_x^1$ (approximately equal to the gain in consumer surplus represented by the area $p_x^0 abp_x^1$ minus the area *def*).

Figure 4.



A public policy consisting of the construction of a hydroelectric complex that lowers the price of energy will have different indirect effects on other markets and an income multiplier effect on the rest of the economy, but only the net difference to other competing projects matters for project appraisal. The point is to be clear about what we are looking for. If what we want to know is the impact that this investment has on gross added value or employment, a CGE model might be appropriate. If we are trying to decide which project contributes most to social welfare, we could, in principle, use the same CGE model, but designed for the appraisal of welfare changes (and for the type of project under evaluation), and subtract the induced effects common to the counterfactual. CBA does this directly and, as may be expected, at a significantly lower cost.

Another reason why CBA has been criticized as an incomplete methodology is the evidence of agglomeration economies associated with large infrastructure projects that increase accessibility to large cities. Public policies such as investment in subways and high-speed lines that reduce the cost of travel, usually attract workers and companies from the periphery to the city centres. The increase in the density of workers increases productivity, a benefit that conventional CBA does not capture by not accounting for these productivity increases derived from concentration, which also includes additional tax collection as a benefit (Venables, 2007).[18]

This omission is not just present in the CGE model, but a problem of both. A general equilibrium model cannot foresee such effects unless this nonlinear relationship between the concentration of workers and average productivity is explicitly incorporated into the model.

The misplaced temptation to incorporate these additional effects into any project that increases proximity must be replaced by an effort to obtain a more precise understanding of what the project is expected to solve (and how it will do so). The significance of these additional benefits is context specific. Moreover, following the same reasoning, reducing the density of workers in areas where firms and workers were initially located can reduce productivity and therefore generates negative dynamics in those areas losing employment and economic activity, which represent an additional cost to be included in the appraisal. It may also be the case that the reduction in transport costs will increase dispersion. This is more likely for interurban projects if certain local factors are present, including land prices and significant wage differentials between areas (see Duranton and Puga, 2004; Graham, 2007; Venables, 2007).

The narrative of the promoters (public agencies or interest groups) of a public policy must be very precise, describing the objective of the public action, the problem to be solved and why a particular line of action is superior to others. Furthermore, the project's rationale should be explained in the context of a specific program of

[18] The three sources of wider economic benefits (imperfect competition, tax revenues arising from labor market impacts and agglomeration economies) have not received the same attention in the economic evaluation of projects. The focus has been directed at agglomeration economies because they are considered to be the main source of wider economic benefits and because their econometric estimation is easier (see Graham and Gibbons, 2019).

government planning. For example, it is not uncommon to see the justification of projects based on agglomeration economies, that favour the concentration of economic activity, while overlooking its consequences on territorial imbalances.

2.6 Conclusions

The economic appraisal of projects can contribute to increasing social welfare. The rationale of CBA is to choose the best projects from a social perspective. The CBA of any project is context specific. The project's objective should be clear, as well as explain how the public intervention is expected to affect the economy. Practical CBA applications need to be based on the identification of quantity changes in the primary markets, and the fact that only the existence of distortions in the rest of the economy can generate additional welfare changes.

Indirect and induced effects in the rest of the economy have zero social value in the absence of market failures. Indirect effects (beyond the main group of strongly interrelated markets) may be ignored when the project is not going to produce large price changes in the rest of the economy and there are no significant distortions; or even when they are large in absolute terms, are not expected to be significantly different compared with the counterfactual.

A project must be judged by its potential to improve the health status of the population, increase human capital, or have other positive real economic effects. Including multiplier effects in the net present value confuse the social appraisal of projects with impact studies and may also conceal poor value for money. Multiplier effects can be ignored if the magnitude of any distortion associated with these effects is similar for both the project and the alternative. The absolute value of the project's multiplier effect is not incremental and therefore irrelevant to the estimation of the project's net welfare value.

A project with negative social NPV reduces social welfare. Adding the multiplier effect is not going to change its net social value. Nevertheless, when choosing between mutually exclusive projects, both with positive net present value, and when there is evidence of a significantly different multiplier effect between them, the net difference of these effects should be included. Even in this case, only the price-marginal cost gap is relevant. The distinction between redistribution and growth (i.e. gross and net effects) is crucial. CBA aims to calculate the net welfare effect of a project. The inclusion of transfers and gross benefits artificially inflates the value of a project. CBA is strictly constructed on an incremental basis, and double-counting must be avoided.

In contexts of high unemployment, it is easy to forget that any welfare effect of unemployment reduction must be net of its social opportunity cost. The way CBA deals with job creation is through shadow pricing. The value of these accounting prices varies substantially with the specificities of the labour market. In the case of high unemployment, the successive round of effects (employment multiplier) might imply additional benefits related to the creation of additional jobs, but the distinction of net effects (both net of opportunity cost and net compared to the alternative) is crucial to avoid grossly overestimating a project's welfare effect.

Finally, regarding equity, a useful way to deal with distributional issues is to show how different groups are affected by the project. Another is to use a specific social welfare function. Clearly illustrating how different groups are affected should be a part of project appraisal. The difficulties in identifying the final beneficiaries and spatial distribution of efficiency gains, when multiple equilibria are possible, require further work.

Acknowledgment: the author is grateful to José Doramas Jorge, Per-Olov Johansson, Bengt Kriström and Jorge Valido for long and fruitful discussions. Their comments and suggestions have contributed to this final version. Any remaining errors and omissions are entirely the responsibility of the author.

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