

# 1 Introduction

J. Doramas Jorge Calderón

## 1.1 C-Bridge in short

C-Bridge is the name given to a research project aimed at reconciling methodologically Cost-Benefit Analysis (CBA) and Computable General Equilibrium (CGE) for the purposes of conducting the economic appraisal of investment projects. The objective at the outset was to formulate CGE models that resemble as much as possible the vantage point of CBA in order to explore differences in results when modelling the same project with the two methodologies in parallel.

It was managed by the universities of Las Palmas de Gran Canaria, in Spain, and of SLU-Umeå, Sweden and included participants from a number of other universities in Europe and the US. The full list of participants is included in section 1.3 of this introduction. It was funded by the European Investment Bank (EIB) Institute under its EIBURS program. C-Bridge was conducted between January 2019 and February 2023. This document compiles the full set of papers, ordered in the form of chapters, that were produced as part of the research project.

The next section in this introduction is a preamble, discussing the rationale for C-Bridge. Section 1.3 introduces the research team and discusses some peculiarities of the project and issues of interest that sprang during its production. Finally, section 1.4 introduces the structure of this document.

## 1.2 Preamble

CBA is the EIB's preferred method of economic appraisal for projects that are candidate for receiving EIB finance. A common question to project appraisers from stakeholders and decision makers is "how much impact are you leaving out?". This turns out to be a loaded question, in at least three ways. One is what is meant by "impact". Second — and here let's purposely change the order in which the word appears in the question—, what is meant by "out"? Thirdly, what is meant by "leaving"?

### 1.2.1 Impact

The meaning of the word “impact” in the context of economic appraisal is ambiguous, where the context includes both producers and consumers of the appraisal results, and where such consumers frequently include non-economists. Among non-economists, the term “economic impact” happens to be more popular than the term “welfare”. Traditionally, non-economists associated “impact” to gains in incomes and jobs — perhaps tax receipts to the government also. Let us call this conception of economic impact “**traditional popular impact**”. It closely relates to the meaning that economists have usually given to the idea of economic impact. In the context of research into the economics of investment projects, economic impact studies, relying on input-output models (I/O), measure the extent to which an exogenous injection of capital expenditure in an economy leads to knock on expenditures across the economy, generating income to the various factors of production. The approach validates the connotations of exogeneity in the word “impact” —the entry into sudden, normally forceful, contact of two separate bodies. The two bodies would consist of the investment expenditure and the economy. Let’s call this the “**economic impact**” vantage point.

Subsequently, CGE modelling improved upon I/O, adding flexibility to economic impact studies by allowing for price adjustments. CGE models could also turn the exogenous shock into endogenous. But the models retained the focus on income, and normally neither addressed welfare nor non-marketed goods or services, with some exceptions only more recently. Moreover, just as I/O models, CGE were originally intended to assess the effects of policies, which normally apply to markets across the economy. In the last few years CGE models have also been applied to investment projects, particularly the so-called “mega-project”, or what economists would understand as “large projects” in that they can alter prices across an economy. Such large investment projects can include hosting an Olympic game, or building a major infrastructure facility, if not network.

All in all, we can make the rough generalisation that economic impact studies, whether conducted through I/O or through CGE, broadly corresponds to what the public has traditionally understood as economic impact, so that:

$$\text{Traditional popular impact} \approx \text{economic impact} \quad (1)$$

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Instead, welfare economics, with its normative connotations, ultimately geared towards influencing decision makers as to what they should do, takes a broader view than incomes or jobs. Traditionally, its tool of choice is CBA, which accounts for income flows, whether explicitly or implicitly (depending on the aggregation method) as well as, explicitly, non-financial (but valued in money terms) flows arising from non-marketed goods and services, including externalities, whether environmental or otherwise. In keeping with the welfare economics framework of determining whether a change (whether a policy or an investment project) would yield a societal improvement, CBA seeks to account for differences in utility (as measured by willingness to pay, or accept), thereby always comparing the state of the world with the change against the state of the world without the change.

Initial, rudimentary CBA's, dating back to Dupuit in the 19<sup>th</sup> century, dealt with the provision of public infrastructure. Pigou's welfare economics work in the first third of the early 20<sup>th</sup> century addressed change in general, whether through investment or policies. From its inception, CBA was conceived for projects and policies, and to include flows of nonmarketed goods and services, as well as of marketed produce. We label this vantage point "**economic welfare**". Therefore:

$$\text{Economic impact} \neq \text{economic welfare} \quad (2)$$

Recently, coinciding with the spread of what has been labelled the environmental, social and governance (ESG) movement in the operation of the private sector, the term "impact" has gained a broader meaning, to comprise benefits and costs to society, if not to the planet itself. People want to work on jobs with "impact", and ESG funds seek to buy securities in companies or sectors with impact, meaning considering effects on society and not just on financial profit. The concept of impact in the public's mind has therefore shifted to become closer to the scope of CBA. Call this "**new popular impact**", so that:

$$\text{New popular impact} \approx \text{economic welfare} \quad (3)$$

Decision makers that may use CBA also see the need to convey to the public the rationale for the decisions taken. Since the audience expects to hear "impact", there may be a tendency to describe the output of CBA in terms of impacts, which does not match the realm of the term, at least as traditionally understood by economists, who

would relate it to I/O. Recently, some CBA practitioners have arguably added to ambiguity in terminology by referring to benefits and costs in CBA studies as impacts, rather than welfare or societal gains or losses. By all means, the word impact is not unusual in the CBA literature, normally used as a synonym to “impinge”, “effect” or “affect”. By referring to benefits as impacts, CBA terminology comes closer to the new popular understanding of impact. While there is nothing fundamentally wrong with that, care has to be applied in two respects. First to acknowledge that there can be also negative impacts (i.e. costs). Second, that traditional impact studies —of the I/O or the initial CGE types—, are not mistakenly taken to stand for either a CBA, or for a CGE that takes a welfare vantage point.

Interestingly, the outset of ESG and “new popular impact”, has opened the door for CGE to strengthen its welfare credentials. CGE rests therefore somewhere between the two realms: the traditional “economic impact” and “economic welfare”, or “new popular impact”. It is important for CGE studies to make clear what their scope of analysis is.

Some governments already conduct CBA’s and CGE’s in parallel. The question arises then: is this unnecessary duplication? To answer this question, we would need to understand what CBA does that CGE does not, and vice versa.

### **1.2.2 Out**

For “out”, in the “how much are you leaving out?” question, the inquirer means what benefits and costs are not included in the appraisal. As with “impact”, the answer to this question also has popular and professional dimensions. The popular dimension has been discussed already: the public wants to make sure that the analysis is not just about income, the “traditional popular impact”, but that it has a broader societal scope, the “new popular impact”. The public wants to see a conversation in the realm of expression (3), rather than (1).

CBA would normally address the question satisfactorily: we are not leaving anything out; or rather, in a more qualified fashion, we are not leaving anything “significant” out. We will address shortly what we mean by significant. With CGE, we could also yield the same reply: we are not leaving anything significant out, so long as the models are of the latest type, adopting a “welfare” scope.

As for the professional dimension to addressing the “out” word in the question, we face two misconceptions, one held by CBA professionals and the other held by CGE professionals. In addressing these misconceptions, we will also answer what we mean by “significant” in our answer in the preceding paragraph.

Beginning with the misconception held by CBA practitioners, they tend to be unaware of the newer, “welfare” versions of CGE, and continue to view them as belonging exclusively to the realm of impact studies in the I/O sense. CBA professionals question whether CGE models can incorporate non-marketed benefits and costs, and whether they can express values in terms of willingness to pay or accept, in the sense described by compensated demand curves in welfare economics. This leaves it to the CGE analyst to make clear when presenting appraisal results what it is that the CGE model includes. C-Bridge explores how CGE models are modified to include these newer considerations.

As for CGE practitioners, they tend to view CBA as a partial equilibrium exercise which, by focusing on the primary market (the market where the project takes place) only, leaves out all effects in secondary markets. The misconception lies in failing to see that CBA’s foundations rest is general equilibrium – as is well documented in publications like Dinwiddy and Teal (1996), Just et al (2004), and Johansson and Kriström (2016). Let’s take for granted that both CBA and CGE would both correctly model the primary market – whether distorted and undistorted. Then, as will emanate from the discussions in chapters 4, 5 and 7, in the absence of distortions beyond the primary market —or, in other words, in the absence of distortions in secondary markets—, both CBA and CGE should produce the same result. Both techniques are grounded in the Arrow-Debreu general equilibrium model of the economy. Indeed, even with distortions in secondary markets, notionally, with exhaustive modelling incorporating all such distortions, CBA and CGE must produce the same result because, in effect, the two exercises will converge into a single exercise.

That CBA can choose to focus the analysis on the primary market alone does not mean that effects on secondary markets are excluded: they are reflected in the magnitudes of the primary market, so long as the appraisal uses the right parameters (i.e. long run elasticities). The primary market would fail to register all value effects from secondary markets when these are distorted. In such circumstances, CBA practice uses two

parallel strategies. First, it focuses on substantial distortions in secondary markets and explicitly models them in the CBA exercise. There is no reason why a CBA appraisal must be constrained to modelling only the primary market. Indeed, in practice, most often it does not. It includes as many (distorted) secondary markets as the CBA analyst believes are consequential to determine the societal case for the project. Second, the CBA appraisal adopts the assumption that small distortions roughly cancel out. Say, a non-consequential benefit due to a small increase in output on a taxed secondary market, broadly cancels out with a non-consequential cost caused by an increase in output on some other subsidised secondary market or, alternatively, by a reduction in output in some other taxed secondary market. Modalities of cancelling out are plentiful.

Combining this twofold strategy in the presence of distortions, CBA should catch most of the flows that are consequential to determine the case for a project and do so by focusing only on a few markets — the primary market plus, say, one, two, or three secondary markets. Bengt Kriström, one of the contributors to this project, calls this approach “partial general equilibrium”. It was a central objective of C-Bridge at the outset to do exploratory work on how much partial general equilibrium leaves “out”.

Clearly, appraisal design —choosing both what markets to focus on and what parameters to adopt to model market behaviour— is of primary importance for a well conducted CBA. The same applies to CGE. Which takes us to the third contentious word in our question.

### **1.2.3 Leave**

The third and final loaded word in “how much impact are you leaving out?” is “leaving”. It denotes a conscious decision on the side of the project analyst to include or exclude flows, markets, and various other elements in the appraisal. Analyst discretion is inevitable. Put two engineers to separately design a bridge in the same location over a river and they are unlikely to come up with exactly the same design, even if working under the same budget. The bridges designed by each engineer, however, should “do the job”. The same applies to CBA and to CGE. Two economists doing a CBA of the same project are unlikely to take exactly the same set of decisions and therefore come up with exactly the same result. Differences may start with the primary market itself, such as in the reaction functions assumed for the various participants. The two analysts would hopefully coincide in spotting a major distortion

on a secondary market, but may differ on how many other secondary markets include distortions that are consequential to the case for the project. The views as to the behaviour of each of those markets may also differ.

The same applies to CGE. The aim in CGE is to model an entire regional economy. The degree of aggregation or granularity in market modelling may vary from analyst to analyst, as would the parameters assumed for each of the markets. The assumed model closure—what set of variables are assumed exogenous—may vary as well.

Both CBA and CGE are models of the economy, and models are approximations. “Leaving” is part of analyst judgement, just as in any other profession. Differences among CBA exercises and among CGE exercises may perhaps go on to be compounded when comparing a CBA exercise with a CGE exercise. Note also that CBA and CGE modelling normally differ substantially in model size. In our bridge engineers analogy, both were working under the same budget. This element of the analogy does not apply to comparing CBA versus CGE appraisals. But C-Bridge does not go into evaluating whether the greater computational load of CGE is justified in terms of any increased accuracy and whether that eventual accuracy is consequential. The focus is rather on how the two methods can be brought to “do the same job” and then compare results.

### **1.3 The team and the project**

C-Bridge was managed jointly by the universities of Las Palmas de Gran Canaria (ULPGC), in Spain, and SLU-Umeå, in Sweden, the former taking also the lead administrative function. ULPGC conducts CBA research, mostly in the field of transport, and CGE in the area of tourism. SLU-Umeå has research tradition in both CBA and CGE, mainly in the field of forestry, natural resources and energy. Researchers in ULPGC and Umeå counted with input and support from academics and consultants mostly in Europe but also in the US. The full list of authors and collaborators in C-Bridge is the following:

Authors:

Cazorla-Artiles, José Manuel (ULPGC)

de Rus, Ginés (ULPGC, Carlos III University, Madrid, and FEDEA)

Eugenio-Martin, Juan Luis (ULPGC)

Inchausti-Sintes, Federico (ULPGC)

Johansson, Per-Olov (Emeritus, Stockholm School of Economics)

Kriström, Bengt (SLU-Umeå)

Njoya, Eric Tchouamou (Huddersfield Business School)

Pérez-Granja, Ubay (ULPGC)

Quinet, Emile (Paris School of Economics)

Valido Quintana, Jorge (ULPGC)

Collaborators:

Betancor Cruz, Ofelia, (ULPGC, currently EIB)

Böhringer, Christoph (Oldenburg University)

Campos Méndez, Javier (ULPGC)

Furtenback, Örjan (SLU-Umeå)

Grisolía Santos, José María (ULPGC)

Lecca, Patrizio (European Commission, JRC, Seville)

Pérez Sánchez, José María (ULPGC)

Socorro Quevedo, María del Pilar (ULPGC)

Sue Wing, Ian (Boston University)

Claudia Benitez, Desirée García and Érika Blanco conducted the survey work on the tourism case study and subsequent readying of data for modelling.

Despite writing the introduction, I am not part of the research team. My role in C-Bridge was twofold. First, project manager on behalf of the EIB Institute. The task here was to see that the project was delivered according to the terms of reference and that any deviation from them was justified. Second, as proponent of the research topic to the EIB Institute. The idea to propose comparative research on CBA and CGE came when noticing that in Australia, and more precisely in the studies carried out to appraise the expansion of Sydney airport, the authorities commissioned both a CBA and a CGE. Some comparative literature existed already (Forsyth, 2014). The comments of Prof.

Peter Forsyth from Monash University at the early stages of gestation of what became C-Bridge are appreciated.

Economists, whether academic or practitioners, tend to specialise on either CBA or CGE. There are very few who are well versed in both techniques. As expected, during the initial phases of the research project, considerable effort was spent by each side educating the other on their respective method. This task, however, was not straightforward. Perhaps the difficulties can be explained by the differing mind frame from which professionals of each discipline approach appraisals: CGE economists focus on expenditure and income flows; while CBA economists focus on differences between marginal value (measured by willingness to pay or to accept) and opportunity cost. Four issues in particular were prone to cause confusion. I only mention them, without entering into a technical discussion:

1. The extent to which the primary market reflects welfare, or value, effects on substitute and complement markets.
2. The extent to which (i) multiplier effects and (ii) what CGE calls induced activity, account for a societal net welfare gain.
3. The assumptions that lie behind the social discount rate, particularly regarding the project counterfactual.
4. The role of leisure in the labour market as an opportunity cost.

As, quite likely, is to be expected in a project like this, there is no complete unanimity of opinions among the authors. The research team has agreed on a set of general conclusions, drawn in the concluding chapter of the document. But the reader will notice across the various chapters that some differences in opinion remain. Part of it are the relative merits of CBA and CGE, and in particular the role that CGE — a tool aimed at modelling entire economies — may have in appraising projects which, while visibly large, may be small relative to the size of the economy.

It is not the intention of C-Bridge to judge whether one method is preferred to the other, or under what conditions. This would require judging three flows. First, the value (to the decision maker or to society) of the increased accuracy arising from the greater detail with which CBA models the project. Second, the value of the increased accuracy with which CGE models secondary markets and the economy at large. And third, the

difference in the cost of performing appraisals with each of the two techniques. It is perhaps inevitable that in the papers included in this document, passing references are made to these issues, particularly given that this is a research project whose ultimate motivation gears towards practical application. But C-Bridge has not sought to address them.

Rather, C-Bridge is to be understood as an attempt to encourage research work on reconciling CBA and CGE, as well as comparing the techniques. It by no means intends to come up the last word on the topic. In particular, a number of simplifications have been used. CGE models can consist of large modelling exercises, even without entering into dynamic general equilibrium models. The CGE models included here are either relatively simple — in order to keep comparisons between CBA and CGE manageable — or consist of existing models for the relevant economy, adapted with limited tailoring to the project at hand — in order to meet the budget and time constraints of the research project.

Eventual future research should prove most interesting. Indeed, while C-Bridge authors were applied economists, at times the project had the feel of multi-disciplinary research, if only because of the time spent discussing the meaning of terms and concepts. Moreover, further research is highly desirable, even necessary. Appraising investment projects is a multi-disciplinary endeavour. Vantage points involved include engineering (with all its various sub-fields), environmental, legal, sociological, financial and economic, and that without entering into political considerations. If economists wish to retain a say, while allowing for differences in opinion among us, we should at least speak the same language.

#### **1.4 This document**

The document consists of eleven chapters or papers, each with authors identified. The document should be treated like an edited tome, where the sequence of papers follows the thrust of the project's argumentation, but where authors can diverge from each other's views. The project's argumentation proceeds in four steps. Individual chapters are assigned to each of these steps.

The first step is to define and present CBA and CGE methods. It includes chapters 2, where Ginés de Rus presents CBA, and chapter 3, where Federico Inchausti-Sintes and Eric Njoya present CGE.

The second step is to compare and reconcile the two techniques. It starts with chapter 4, by Per-Olov Johansson, setting the scene by addressing the type of project that would be most relevant for comparing CBA and CGE: a large project that affects prices in various markets of the economy. Johansson explores the applicability of CBA for such a project and extends it to CGE in the chapter's appendix. In chapter 5, Bengt Kriström makes a direct theoretical, high-level, modelling comparison between the two techniques for a single, reference application. Emile Quinet makes in chapter 6 a similar comparison, but from the vantage point of the transport sector. The reader will notice some difference in the conclusions of these authors, but no strong disagreement. Finally, in chapter 7 Federico Inchausti-Sintes, Juan L. Eugenio-Martin and José M. Cazorla-Artiles make a reconciliation of the two techniques, from the vantage point of CGE.

The third step is to apply the two techniques in parallel to the same project and compare results, for various sectors of the economy. This includes three chapters, each addressing a sector of the economy. Chapter 8 applies the techniques to a project in the transport sector. Authorship is the same as chapter 7, with the addition of Jorge Valido and Ubay Pérez-Granja. Chapter 9 by Bengt Kriström, makes the comparison for a forestry project. The third and final chapter in the group, chapter 10, does it for the tourism sector, with the same authorship as chapter 8, except for Jorge Valido.

The fourth and final step is to draw conclusions from the material and findings in the previous chapters. Chapter 11 is authored by the research team. While there emerges a well-defined line of argumentation, the reader should consider that areas for future research are plenty. This introduction has hinted at some. The reader will surely find others.

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