WHY DO WE NEED TO RETHINK THE METHODS FOR SOCIO-ECONOMIC ASSESSMENT OF INFRASTRUCTURE PROJECTS?

A SURVEY OF THE ACADEMIC LITERATURE AND BUSINESS IMPLICATIONS

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Summary of the study

- There is today a broad consensus both on the stimulating nature of infrastructure on economic activity and at the same time on the existence of a growing infrastructure deficit at the global level. This implies a double incentive for increased investment in this area. In view of the inherent characteristics of infrastructure projects (major investments, long-term profitability, direct and indirect impact on the collective surplus), a socio-economic assessment of infrastructure investment projects appears essential to guide public decision-making.

- The preferred tool of socio-economic assessment is the cost-benefit analysis (CBA). The CBA consists in weighing the socio-economic benefits of a project (i.e. the improvement in social well-being induced by the project) against its costs in order to inform decision-makers about the net benefit resulting from a project. However, although there is a broad consensus on the need for such an analysis, there is a considerable heterogeneity prevailing at the international level regarding the implementation of this method. Moreover, CBA is subject to much criticism, concerning its implementation (monetary evaluation of non-market consequences, choice of discount rate) and the significance of the impacts omitted from its analysis. During a recent symposium on the subject, Quinet (2015) stated that *"many mechanisms directly impact the level of activity and are not taken into account by traditional analysis"*.

- However, in a context of strong budgetary pressure from the States and public bodies in general, an improvement in the methods of socio-economic evaluation of infrastructure investment projects is needed

because it would make it possible to identify the most profitable projects and it could enable to increase the number of projects carried out, and thus permit a convergence of the stock of infrastructure needed.

- The objective of this study is to pave the way for a redesign of evaluation methods in infrastructure investment projects by reconciling operational needs with academic research. This involves, on the one hand, an analysis of the theoretical and empirical arguments that call for a review of traditional evaluation methods, and on the other hand, a critical analysis of the implementation of these methods by governments and international institutions.

- Part I Chapter 1 underlines the contributions of the theories of endogenous growth and of the new geographical economy, detailing the various mechanisms by which infrastructure can be a driver of economic activity. In summary, infrastructure provides intermediate goods and services that participate directly in the production process. In addition, they improve the use of other factors of production and thus reduce production costs. Finally, they influence the companies' choice for a location and thus contribute to the agglomeration of economic activities, generating positive externalities.

- The next chapter presents a review of the empirical literature on the link between infrastructure and growth. Research, estimation methods and the data used to establish such a link differs considerably. This makes it difficult to compare results and makes it necessary to set up reliable databases of infrastructure stocks and flows at the international level, which is a prerequisite for a precise study on this subject. A meta-analysis of the results of the aggregate sample studies shows an overall positive impact of infrastructure on growth. The analysis of microeconomic studies shows, however, that the scale of the results differs according to the type of infrastructure considered, the geographical area and the sectors of activity. A rigorous and precise assessment of the socio-economic benefits of a project can therefore only be carried out on a case-by-case basis, taking into account all the specificities inherent to each project.

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- Part II Chapter 1 presents the cost-benefit analysis (CBA) and the main difficulties associated with its implementation. First of all, the question arises as to the exhaustiveness of the costs and benefits identified, since CBA, as it is carried out most of the time, does not allow dynamic effects (which change the very structure of the economy) to be taken into account. There is also the question of the correct valuation (assignment of a monetary value) of the costs/benefits identified. Non-market goods and services do not strictly speaking have a "price", which makes their valuation in monetary terms more complex. What value should be given to the lives saved, to the preservation of cultural heritage or to a loss of biodiversity? Finally, the results of a CBA are very sensitive to the choice of the discount rate which allows future costs/benefits to be formulated in present value and whose calibration depends heavily on ethical considerations. How much importance should be given to future impacts?

- Part II Chapter 2 presents two lines of research to complement CBA and provide decision makers with results that better reflect the economic reality of a project. For example, the UK Department for Transport has developed an analytical framework to consider the wider economic costs/benefits of transport infrastructure. Moreover, while multi-criteria analysis is not a sufficient tool to reflect all the socio-economic issues of a project, it can in some cases provide an interesting additional analysis for the evaluation of non-monetary impacts and can take into account certain ethical considerations.

- This study highlights the need to set up databases at the international level, which are essential for a more in-depth analysis of the infrastructure deficit and the identification of sources of error in carrying out the socio-economic assessments of projects. These initial analyses would provide a solid empirical basis for developing a new assessment tool that should combine methodological soundness and flexibility, in order to be adopted at the international level and used systematically.

- The conclusions of this study lead to the following recommendations:

  - **Recommendation 1.** Establish an international database of infrastructure stocks and flows that is as disaggregated as possible in order to promote development of literature and research dedicated to the study of this issue on how to evaluate the real socio-economic impact of infrastructure projects. The results of these analyses would provide decision-makers with reliable estimates of this deficit and guide States not towards "more infrastructure" but towards an optimal stock of infrastructure.

- **Recommendation 2a**· Carry out an empirical analysis of past infrastructure projects in order to assess the extent and origin of errors in the evaluation of the costs/benefits generated by the projects. A prerequisite for this analysis is the provision of data on the *ex ante* and *ex post* evaluation of completed projects, in separate geographical areas.
- **Recommendation 2b**· Develop a tool that allows for a harmonized socio-economic assessment of projects. This model will have to take into account the specificities inherent to each project (type of infrastructure, geographical area concerned, method of financing, etc.) and reflect all the impacts (positive and negative) of a project on economic activity and social well-being.
- **Recommendation 3**· Carry out an exploratory analysis to determine whether accounting standards allow to consider the specificities of infrastructure investment projects.

General Introduction

ABSTRACT

- The academic literature offers several definitions of infrastructure. Here we will consider the definition given by Prud'homme (2004) according to which infrastructure is a durable good (not directly consumed) which, combined with other factors of production, provides services. Infrastructure includes transport, water (distribution and sanitation), energy (production, transport, storage), information and communication technologies, construction and services associated with education, health, security (excluding military expenditure), culture, ecological transition and climate change.
- Despite a broad consensus that infrastructure is essential for economic development, investment in infrastructure falls far short of what is needed, even in developed countries. This low level of investment leads to an infrastructure *gap,* the extent of which is difficult to determine, in particular due to a lack of data.
- Because of their specific characteristics (large initial investment and long-term profitability), infrastructure investment projects imply a systematic deterioration in the debt/GDP ratio, even though some projects generate future income flows, both direct and indirect, which, when discounted, are greater than the initial investment.
- One lever for reducing the infrastructure deficit therefore lies in redesigning the evaluation method for this type of project in order to provide decision-makers with an evaluation tool that integrates all the socio-economic costs and benefits generated by the projects and guarantees the comparability of the results. The objective of this study is to pave the way for this redesign of methods for evaluating infrastructure investment projects by reconciling operational needs with academic research.

Although there is a broad consensus on the essential role of infrastructure in the economic development of countries, the study of evaluating the benefits of infrastructure projects and the comparability of results is hampered by the heterogeneity of definitions.

Since Aschauer's (1989a) pioneering paper, which triggered extensive literature developments analyzing the impact of infrastructure on economic growth, studies have proliferated, but no consensus has emerged on the magnitude of the impact of infrastructure on growth. As Torrisi (2017) points out, the adoption of a clear and precise definition of infrastructure is a prerequisite for analyzing and comparing the results of the literature.

According to Hirschman's (1958) definition, infrastructure is an asset that combines the following two characteristics.

(i) They are durable, indivisible goods. As a result, infrastructure is provided with a long-term perspective, and infrastructure projects are characterized by high initial fixed costs as well as maintenance, replacement and/or upgrading costs.

(ii) They are goods that have, at least partially [2], the characteristics of public goods [3].

These are therefore goods that all individuals wish to consume but for which no one is willing to pay (Wickberg(2018)). This characteristic implies that infrastructure management is subject to market failures, which explains the predominant role of the State in their management.

Infrastructures can also be defined according to their function of enabling the emergence and development of economic activities. They put into action the potential of economic units for the benefit of society (Buhr(2003)). Jochimsen (1966) identifies three types of infrastructure: physical, institutional and personal. Physical infrastructure is those that are mainly studied in the literature. They aim to meet economic and social needs (e.g. access to drinking water) and are characterized by high fixed costs. Institutional infrastructure includes the rules and norms of a society as well as the means and procedures to guarantee them. Finally, personal infrastructure refers to human capital. Hansen (1965) proposes another classification by distinguishing between economic and social infrastructures. Economic infrastructure contributes directly to productive activities (e.g. roads) while social infrastructure increases the comfort of society (e.g. education or health infrastructure).

2. The partial abandonment of the hypothesis of non-rivalry is relevant in the case of infrastructure that can generate congestion, as is the case for motorways, for example.

3. Public goods are non-rival and non-excludable goods, i.e. the consumption of a good by one person does not reduce the quantity available to other persons and it is not possible to prevent a person from consuming that good.

The Prud'homme (2004) definition combines Hirschman's (1958) definition with the functional approach by defining infrastructure as durable goods that, combined with other factors of production, provide services. Table 1 provides a list of infrastructure and associated services.

TABLE 1 - Infrastructure and associated services

Infrastructure	Related services
Roads, bridges, tunnels, rails, ports, etc.	Transport
Dams, reservoirs, pipelines, etc.	Water supply
Sewage treatment	Wastewater treatment
Dams, canals, etc.	Irrigation
Landfills, incinerators, composting units etc.	Waste treatment
Equipment, network etc. District	Heating
Telephone lines, etc.	Telecommunications
Power plants, distribution network, etc.	Energy

Source: Prud'homme (2004)

AN INFRASTRUCTURE DEFICIT

Despite a broad consensus that infrastructure is essential for economic development, investment in infrastructure is far below what is needed, even in developed countries.
Figure 1 shows the global evolution of public capital stock and public capital investment since 1960. Both indicators declined over the period. More specifically, public capital stock has been declining sharply since the late 1990s and public investment has been declining since the early 1980s.[4] There has also been a recent increase in infrastructure stocks and flows since the mid-2000s, which can be explained by the dynamism of some developing countries, as shown in figure 2, which shows the evolution of the same variables by considering developed countries, emerging and developing countries, and developing countries separately. While public capital stock and public capital investment as a percentage of GDP were comparable irrespective of the level of development of countries at the end of the 1970s, the gap has widened since then, as there has been a much greater deterioration of these two indicators in developed countries. This is due, on the one hand, to low economic growth combined with high levels of debt in most developed countries. Short-term political considerations and government budget constraints can indeed negatively influence investment decisions. On the other hand, the specific characteristics of infrastructure investment projects make it difficult to

4. This time lag is due to the latency period between investments and project implementation.

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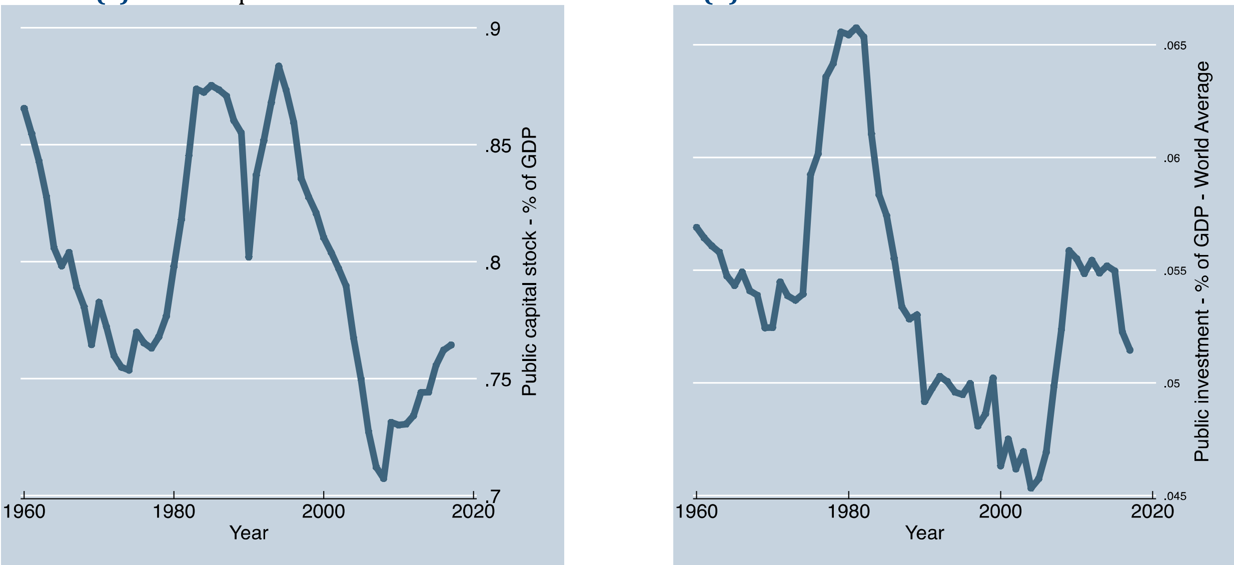
FIGURE 1- Evolution of the global public capital stock and global public capital investment between 1960 and 2017

Figure (a) shows the share of government capital stock in GDP in billions of constant 2011 dollars. Figure (b) shows the change in the share of government investment (gross fixed capital formation) in GDP in billions of constant 2011 dollars. Charts made from the International Monetary Fund's *"Investment and Capital Stock Dataset".*

(a) Public capital **(b)** Public investment



raise funds. They are characterized by high initial investments and long-term profitability, which is difficult to measure. Furthermore, the socio-economic impact of an infrastructure project for society can often be greater than the benefits generated for the private operator, thus making such projects unattractive to the private sector.

However, while Figure 1 shows a decline in the capital stock and investment in infrastructure, these data are not able to justify the existence and the magnitude of an infrastructure deficit. The evaluation of this deficit requires a prior estimate of the optimal stock of infrastructure, for which no unanimously accepted methodology has yet been developed. Figures on the infrastructure deficit differ widely from one source to another, due in particular to the variability of the scope of the infrastructure under consideration, lack of data and methodological differences. McKinsey Global Institute (2017), for example, estimates a global deficit of around $55 trillion between 2017 and 2035, with large regional variations. The Global Infrastructure Outlook (2017) points to a deficit of $820 billion by 2040.

Andrés et *al* (2014) propose an analytical framework to assess this deficit presented in

5. Canning & Pedroni (1999) show that there is a level of infrastructure that maximizes growth and beyond which infrastructure investment diverts resources from other, more productive uses.

FIGURE 2- Evolution of public capital stock and public capital investment between 1960 and 2017 by level of development of countries

Figure (a) shows the share of government capital stock in GDP in billions of constant 2011 dollars. Figure (b) shows the change in the share of government investment (gross fixed capital formation) in GDP in billions of constant 2011 dollars. Charts made from the International Monetary Fund's *"Investment and Capital Stock Dataset"*.

(a) Public capital **(b)** Public investment

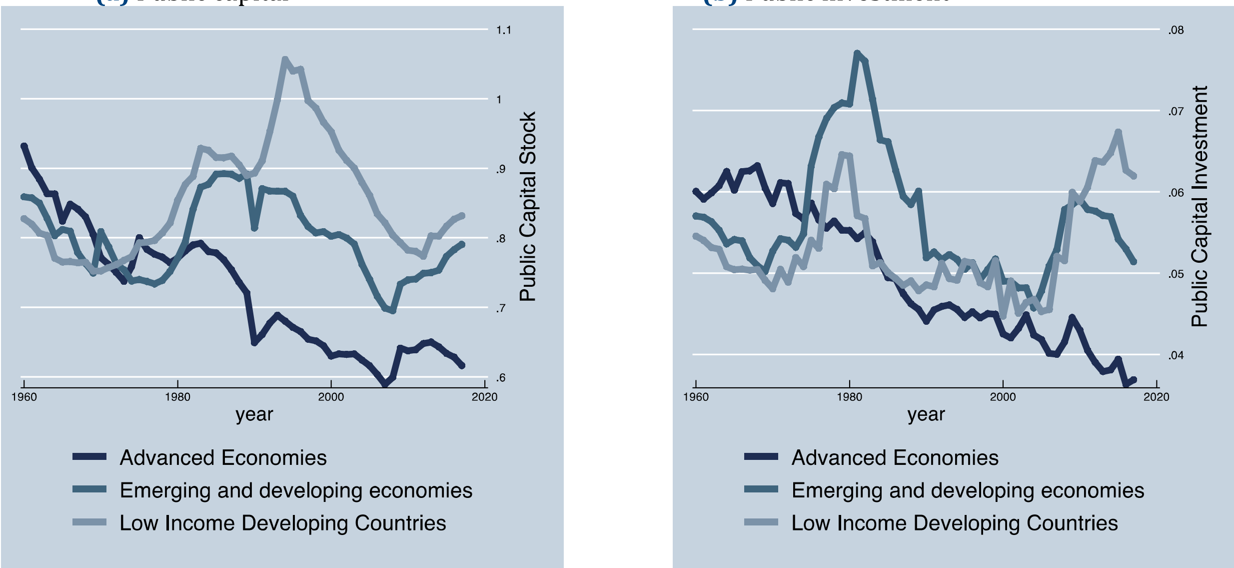


Figure 3. The first step, which is to assess the current situation in the country, presents a twofold challenge. The first difficulty lies in the definition of what should or should not be considered as an infrastructure. The second relates to data that are not always available and often heterogeneous from one country to another. The second step raises the question of the optimal infrastructure stock, which has been the subject of little academic study.[6] A national infrastructure stock may be either completely optimal or completely inadequate depending on the way it is distributed over the territory. While the third stage does not present any difficulties, the fourth stage is often complex, since a country's ability to finance infrastructure investment projects depends directly on the method of project evaluation, which is often poorly adapted to the economic reality. In an unfavorable economic context, States must make choices in terms of resource allocation and assess investment opportunities in the light of the issue of public debt sustainability. It is therefore essential to be able to identify projects that generate economic growth so that projects financed by debt do not lead to a deterioration in the debt-to-GDP ratio in the long term.

6. According to Straub (2011), only 5.2% of the analyses focus on this issue. One of the reasons for this gap in the literature is the lack of appropriate data.

FIGURE 3- Method for evaluating the infrastructure deficit

Figure based on Andrés et *al* (2014).

Step 1
Assessment of the current situation in the country

↓

Step 2
Assessment of the country's objective at time *t*

↓

Step 3
Projection of the country's situation at time *t on the* current investment path and assessment of the deviation from the target

↓

Step 4
Assessment of the country's ability to achieve its objective in the light of its financial and political situation

↓

Step 5
Evaluation of the remaining deficit

TOWARDS NEW METHODS OF PROJECT EVALUATION

Because of their intrinsic characteristics, the budgetary evaluation of infrastructure investment projects is problematic, as is the inclusion of their specificities into public accounts. Infrastructure projects imply a deterioration in the debt-to-GDP ratio, even though some projects generate future direct and indirect income flows that are superior to the initial investment. In order to stimulate investment in infrastructure, it is therefore essential to provide decision-makers with budget assessment tools that reflect the economic reality of projects.

The objective of this study is to pave the way for this redesign of infrastructure projects evaluation methods. To realize this, it is essential to reconcile academic research with operational needs. This involves, first of all, an analysis of the theoretical and empirical arguments that advocate for a revision of traditional evaluation methods. This

7. Infrastructure investment projects are characterized by unconventional financial flows (large short-term investment and long-term return). In addition, they generate important externalities, which are often difficult to evaluate in monetary terms.

8. Infrastructure generates important positive externalities, i.e. the private benefit of the infrastructure does not coincide with its social benefit, since the presence of an infrastructure generates economic benefits for the agents that did not participate in its financing.

analysis is developed in Part I. Overall, the studied literature points to a positive impact of infrastructure on growth, with a strong regional and sectoral heterogeneity. It is therefore on a case-by-case basis, through an adequate evaluation of the projects, that the estimation of the budgetary impact must be carried out. Part II presents cost-benefit analysis, the preferred analytical framework for the socio-economic assessment of projects, its strengths and the difficulties relating to its implementation. The first chapter shows that despite its attractions, the CBA, as it is generally applied, is not sufficient to reflect the socio-economic reality of the projects. The second chapter provides research paths to address these difficulties. The final section, CONCLUSION AND RECOMMENDATIONS, presents the main conclusions of this study and proposes a series of recommendations to contribute to the redesign of methods for the socio-economic assessment of infrastructure projects.

THE IMPACT OF INFRASTRUCTURE ON GROWTH

1 Theoretical approaches

"Many mechanisms directly impact the level of activity and are not taken into account by traditional analysis. This is the case for endogenous growth, agglomeration externalities, imperfect competition such as the new geographical economy, etc.".

Quinet (2015)

Abstract

- In order to properly understand the link between infrastructure and growth and to be able to draw the main lessons from the empirical literature on the subject, it is important to identify the mechanisms by which infrastructure can impact economic activity. This requires an analysis of the underlying theories.
- Endogenous growth theories identify two mechanisms by which infrastructure can influence the growth process. On the one hand, the services provided by infrastructure are directly relevant to the production function of enterprises. On the other hand, infrastructure has a positive influence on technical progress and thus on the productivity of companies.
- The new geographical economy complements this analysis by stressing that infrastructure influences the companies' location choices and therefore induces externalities (positive and negative) impacting on the companies' productivity, and therefore on economic growth.

INTRODUCTION

Infrastructure investments impact economic growth through different channels. First of all, they help to reduce the costs of production factors. For example, a water infrastructure improvement project reduces irrigation costs and thus reduces farmers' production costs. In addition, infrastructure contributes to improve the productivity of other production factors. The provision of efficient transport infrastructure linking residential and commercial areas can, for example, increase labor productivity (by reducing fatigue). To a lesser extent, and although this is only a positive transitional effect, the implementation period of such a project has a positive effect on the construction sector and thus on the economy [1]. In addition, infrastructure projects are usually associated with maintenance needs and therefore generate longer-term employment. Finally, infrastructure is a determining factor in the firm's choice for a location and can have an agglomeration effect which, under certain conditions, generates economic dynamism.

Several economic theories underpin these statements. In order to properly understand the link between infrastructure and growth and to be able to draw the main lessons from the empirical literature on the subject, it is important to identify the levers through which infrastructure can impact economic activity. This involves an analysis of the theoretical foundations, mainly derived from the theories of endogenous growth (Section 1.1) and the new geographical economy (Section 1.2).

1.1 INFRASTRUCTURES AS FACTORS OF PRODUCTION AND TECHNICAL PROGRESS - GROWTH MODELS

1.1.1 THEORY OF EXOGENOUS GROWTH

In the neo-classical growth theory initiated by Solow (1956), the long-term growth rate of an economy is exogenously determined by technical progress [2] and population growth, with the return on capital assumed to be decreasing [3]. From this perspective, the influence of investment on growth, if any, can only have a transitory effect, since the economy tends towards a long-term steady state.

1. The increase in GDP induced by public spending is called the fiscal multiplier. The magnitude of this effect depends strongly on the economic structure of the country and the international situation. The FOCA (2016) proposes a detailed discussion on this topic.

2. Technical progress is understood here in the broadest sense and includes improvements in production technologies, the emergence of new energy sources, the creation of new raw materials, new products, new ways of organizing work, new modes of transport, etc.

3. One of the fundamental assumptions of classical economics is the law of diminishing returns according to which, *ceteris paribus,* the marginal productivity of production factors (output generated by using an additional unit of a production factor) is decreasing. This hypothesis implies that in the long run, the economy tends towards a steady state.

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1.1.2 THEORIES OF ENDOGENOUS GROWTH

The work of Romer(1986) and Lucas(1988) raises the hypothesis of diminishing returns. From the mid-1980s, the idea that economic policies can influence on the growth path of an economy is considered. Growth then becomes a self-sustaining process through the accumulation of four factors: (i) human capital; (ii) physical capital; (iii) technical capital; and (iv) public capital.

Building on this research, Barro(1990) and Barro & Sala-i-Martin(1992) give public infrastructure a central role in the long-term growth process. In these models, infrastructure, because it provides intermediate goods and services, participates directly in the production process. Transport infrastructure is, for example, an integral part of the production process in the industrial sector (transport of raw materials to production centers).

The impact of infrastructure on production is not limited to this direct effect. Infrastructure also improves the use of other production factors and thus reduces production costs (indirect effect). In the field of energy, a quality power supply allows, for example, the use of more sophisticated machines and thus increases the productivity of other factors such as labor.

There are several ways to incorporate these effects into mathematical models. Direct effects are taken into account by considering infrastructure as inputs to the production function. Indirect effects are taken into account by considering that technical progress is a function of the stock of infrastructure. These methods are detailed in Box **1**.

BOX 1 - INFRASTRUCTURE IN ENDOGENOUS GROWTH THEORY MODELS

There are three ways to integrate infrastructure into endogenous growth models:

1 The infrastructure is a direct input from the production function

The production function is written:

$$Q = A.f\,(K, L, K1) \tag{1}$$

with Q *the* output of goods and services of the private sector, L *the* level of employment, A *a* measure of productivity and K *the stock of* private capital and $K1$ the stock of infrastructure.

Note that this modelling assumes that infrastructure is a pure public good.

2 The services produced by infrastructure are inputs to the production function

The production function is written:

$$Q = A.f\,(K, L, I(K1)) \tag{2}$$

with Q *the* output of goods and services of the private sector, L *the* level of employment, A a measure of productivity, K *the stock of* private capital, $K1$ the stock of infrastructure and $I(K1)$ the services provided by the infrastructure as a function of the stock of infrastructure.

A limitation remains in this second modelling, which assumes that infrastructure is paid for at its marginal cost[b].

3 Infrastructure is also a component of the productivity term A

The production function is written:

$$Q = A(\theta, K1).f\,(K, L, I(K1)) \tag{3}$$

where the services produced by infrastructure are inputs to the production function, as in equation (2), and productivity gains are a function of infrastructure and other sources of externalities θ.

This specification makes it possible to take into account the indirect effects of infrastructure that contribute to improving the use of other factors of production.

[a] This assumption is questionable, particularly in the case of transport infrastructure to which the non-rivalry criterion does not apply.

[a] As Straub (2011) points out, this assumption is unrealistic in the specific case of infrastructure.

1.2 THE CONTRIBUTIONS OF THE NEW ECONOMIC GEOGRAPHY

One of the weaknesses of these models mentioned above is that they ignore one of the important characteristics of infrastructure, namely that they generate spatial externalities. A geographical area can benefit from the infrastructure of its neighbors. A new road provides access to a larger market. New wastewater treatment infrastructure can have a positive impact on downstream areas, etc. In addition, infrastructure influences the location choices of economic agents, which in turn affects the price of goods and services. New infrastructure in a given geographical area can induce a dynamic of concentration of firms and thus increase: i) the demand for labor, which leads to a change in the equilibrium on the labor market; ii) competition between firms, which reduces the price of goods and services for households; iii) the price of production factors' fixed assets such as land; etc.

These specific externalities have been analyzed using the theoretical framework provided by the new geographical economy [4]. This recent branch of the economy studies the locational choices of economic agents. Broadly speaking, each location has a "first nature", i.e. all of its intrinsic attributes (nature of the soil, climatic conditions, proximity to a water point), and a "second nature" which can be explained by the spatial distribution of companies and workers. This second nature results from interactions between agglomeration and dispersion forces. As companies choose the location that provides them with the highest profit, agglomeration and dispersion forces are directly related to the profit function [5]. Profit is an increasing function of quantities sold and of the price. Market potential linked to locality is considered a force for agglomeration; while competitive pressure (which reduces the price and equilibrium quantity for each firm) is a force for dispersion. Profit is a decreasing function of production costs, which therefore constitute a dispersal force [6].

For some sectors, irrigation, energy or waste treatment infrastructure thus have an influence on the choice of location of firms because they have a negative impact on production costs. Moreover, transport infrastructure plays a central role in the choice of location for businesses, since it can be seen as an input into the production process for most of the goods (transit of raw materials to production sites, transit of finished products to consumers).

When the forces of agglomeration are greater than the forces of dispersion, a cumulative agglomeration process occurs: the high concentration of companies in the same geographical area also attracts subcontracting companies wishing to get closer to their market, and this generates migration flows to this employment area. This dynamism of the area generates positive externalities such as knowledge *spillovers* or labor market synergies that further emphasize these agglomeration forces.

Combes & Lafourcade (2012) identify four types of benefits in spatial concentration :

i) technological *spillovers* that correspond to innovations induced by the clustering of high-tech companies; ii) a better matching of labor supply and demand induced by the creation of a diversified employment pool and a decrease in unemployment [7] ;

(iii) a reduction in production costs for firms, induced by the concentration of subcontractors, which is a factor contributing to the increase in the supply of inputs; and (iv) an increase in the

4. See Fujita, Krugman & Venables (1999) for a summary of seminal work in this area.
5. The profit function is classically written $\Pi = P.\ Q - CT\ (Q)$ with P the price of the good, Q the quantity sold, $CT\ (Q)$ the total cost function of the business.
6. The main forces of dispersion are: (i) the rise in the price of immobile factors (such as land) induced by strong competition between firms; (ii) the size of distant markets, which are neglected and therefore constitute an opportunity cost; and (iii) congestion effects which increase the costs borne by companies.
7. A region with companies with different specializations attracts workers with multiple skills. This agglomeration effect helps to create a diversified employment pool from which companies can draw the skills they need to develop. The high number of companies also makes it easier for unemployed people to return to work.

companies' profit, operating in sectors with increasing returns to scale [8].

Combes & Lafourcade (2012) present the main results of the empirical literature analyzing the impact of spatial concentration on economic activity.

It should be noted that over-concentration of economic activities can also have perverse effects such as higher costs for less mobile production factors, saturation of local transport or increased pollution.

CONCLUSION

Theories of endogenous growth and the new economic geography lay the theoretical foundations for the analysis of the link between infrastructure and economic growth. Theoretically, three mechanisms can be identified by which infrastructure can stimulate growth. First, infrastructure provides intermediate goods and services that participate directly in the production process. In addition, they improve the use of other factors of production and thus reduce production costs. Finally, they influence the companies' location choices and thus constitute a strength for the agglomeration of economic activities, generating positive externalities. These theoretical elements have been the subject of numerous empirical developments which are analyzed in the following chapter.

8. In sectors with increasing returns to scale, the average cost of production decreases as the quantity produced increases.

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2

Empirical approaches

"Few in academic or policy circles would dispute the view that infrastructure development fosters growth, but there is little consensus on the actual size of the effect and the factors that shape it."

Calderòn & Servén (2014)

ABSTRACT

- This chapter presents an analysis of the empirical literature on the link between infrastructure and growth. The latter is characterized by a strong heterogeneity among the different research areas, estimation methods and data used. The following analysis will focus on the difficulty of comparability of the results and will underline the need to build up exhaustive databases of infrastructure stocks and flows at the international level in order to enable more precise studies on this subject.
- A meta-analysis of the results based on aggregate sample studies shows an overall positive impact of infrastructure on growth.
- The analysis of the microeconomic studies shows that the results differ according to the type of infrastructure considered, the geographical area and the sectors of activity.
- A rigorous and accurate assessment of the socio-economic benefits generated by infrastructure investments can therefore only be made on a case-by-case basis, taking into account all the specificities inherent to each project.

INTRODUCTION

The theoretical analyses of the previous chapter has shown that Aschauer's (1989a) paper has triggered the development of a vast literature aimed at estimating quantitatively the impact of infrastructure flows and stocks on economic activity. The analysis of this empirical literature detailed in Section 2.1 reveals a strong heterogeneity among the lines of research, methodologies and data used. This analysis is indeed essential for a proper understanding of the main findings, presented in Section 2.2.

2.1 DIFFICULTIES

Since Aschauer's paper (1989a), an extensive literature now deals with the empirical assessment regarding the link between infrastructure and growth. The most recent literature reviews are those of Straub (2008), in which 64 articles including 140 specifications are reviewed, and Pereira & Andraz (2013), in which 155 articles are reviewed. In the specific case of transport infrastructure, on which much of the literature has focused, meta-analyses have been carried out, such as those by Melo *et al* (2013) or Holmgren & Merkel (2017). Despite a common research theme, this literature is characterized by a high degree of heterogeneity concerning the research question and the models and data used. In order to extract the main results from this literature, it is therefore essential to analyze in more detail which issues and research question were tested and which of the estimated economic models and data were used.

2.1.1 NUMEROUS AREAS OF RESEARCH

Straub (2008) identifies seven different research questions addressed in the literature. These research questions and their relative importance in the sample of studies analyzed [1] are shown in Table **2**. This analysis highlights a dominant line of research in the literature which consists in estimating the elasticity of production with respect to infrastructure (93%). Another research issue that many studies have addressed is the distinction between permanent and transitory effects (35%). Other research questions are only analyzed in a small number of articles. This can be explained, first of all, by the lack of necessary data for studying these other issues. As Straub (2008) points out, the determination of the optimal infrastructure stock is highly constrained by the available data. Another obstacle impeding the analysis of certain research questions is methodological. For example, Straub (2011) argues that there is no universally accepted methodology to differentiate between the direct and indirect effects of infrastructure on economic activity.

1. Straub (2008) reviews 64 research articles written over the period 1989-2007. This sample represents only part of the literature on this subject.

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TABLE 2 - Research questions explored in the literature
This table presents the research questions studied in the literature and their relative weight based on 116 specifications in 64 research articles.

Question	Number of specifications (Total = 116)	Percentage
Comparison of the elasticity of infrastructure and private capital	108	93%
Direct and indirect effects of infrastructure	8	7%
Effect of infrastructure externalities in relation to other externalities	7	6%
Permanent and transitory effects	40	35%
Determining the optimal infrastructure stock	6	5%
Analysis of network effects	9	8%
Effects of maintenance expenditures compared to new investments	3	3%

Source: Straub (2008)

2.1.2 AN EVOLUTION IN ESTIMATION METHODOLOGIES

In addition to the above-mentioned heterogeneity among the research questions, there is a strong heterogeneity among the models used. There are three main approaches, which are detailed in Box 2 [2].

The first approach is dealing with the production function (see in particular Aschauer (1989a)), which consists in integrating the stock of infrastructure as an input to the production function, and eventually as a component of technological progress. Although it has been widely used, this approach is questionable in many respects. A first limit is the potential reverse causality between infrastructure stock and increased output. This method does not allow to assess whether it is infrastructure that generates growth or whether it is economic dynamism that is at the origin of the increase in the capital stock. As pointed out by Romp & De Haan (2007), some econometric methods have made it possible to solve this problem, such as the Granger causality test (see, for example,Canning & Pedroni (1999)), the use of panel data (see, for example, Canning & Bennathan (2000)), the use of simultaneous equation models (see, for example, Esfahani & Ramírez (2003)) or the use of instrumental variables (see, for example, Calderòn & Servén (2002)). Another limitation inherent in the production function approach is that it challenges the assumptions of classical marginal productivity theory. Indeed, integrating infrastructure as an input to the higher production function requires that the unit cost of infrastructure be determined on the market, that firms be aware of it and that they include it in their total cost. Finally, when the production function is based on the Cobb-Douglas type, the latter does not distinguish between direct and indirect effects.

2. For the sake of readability, this section provides only a general presentation of these methods. For more details, see Romp & De Haan (2007).

BOX 2 - THE DIFFERENT ECONOMETRIC APPROACHES

There are three ways to estimate the impact of infrastructure on economic activity:

1 Production function approach

A production function defined in Equation (1.1) where public capital is included as a factor of production.

$$Q_t = A_t L_t^{\alpha} K_t^{\beta} G_t^{\gamma} \tag{1.1}$$

Assume that returns to scale are constant $(\alpha + \beta + \gamma = 1)$. Equation (1.1) can be rewritten as follows:

$$ln\frac{Q_t}{L_t} = lnA_t + \beta ln\frac{K_t}{L_t} + \gamma ln\frac{G_t}{L_t} \tag{1.2}$$

The parameter γ stands for the elasticity of production with respect to infrastructure.

2 Approach via the cost function

This approach assumes that public capital - i.e. infrastructure - is an input provided by the government free of charge. These models specify a cost function (C) of the private sector and assume that the objective is either to minimize costs for a certain output level Q (with q_i and p_i the quantity and price of input i) or to maximize profit (Π) for a given output price (pQ).

$$C(p^i_t, q_i, A_t, G_t) = min \sum p^i_t q^i_t \quad subject \quad to\ Q_t = f(q_i, A_t, G_t) \tag{2.1}$$

$$\Pi(pQ, p^i_t, q_i, A_t, G_t) = max\ pQQ_t - \sum p^i_t q^i_t \quad subject \quad to\ Q_t = f(q_i, A_t, G_t) \tag{2.2}$$

This specification makes it possible to estimate, on the one hand, the elasticity of production with respect to infrastructure (as in the previous approach), and on the other hand, the elasticity of production costs with respect to infrastructure. One of the main advantages of this approach over the previous one is its greater flexibility in the structure of the production function.

3 Vector Autoregressive Models (VAR)

VAR models are data-driven and require as little economic theory as possible. These models use *lagged* variables, which implies that each variable is explained by its lags and by the lags of the other variables in the model. Formally one can write:

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \dots + A_p X_{t-p} + \Phi D_t + \varepsilon_t \tag{3.1}$$

X_t a set of variables, A_j the matrix of autoregressive coefficients for $j = 1, \dots, p$, Φ the matrix of coefficients of the deterministic term D_t and ε a white noise process.

All variables are therefore treated as if they were determined jointly. This approach, unlike the two previous ones, does not impose a link between the variables studied, since all the variables are estimated without any hypothesis of causality. This model also removes any assumptions about the structure of the production function.

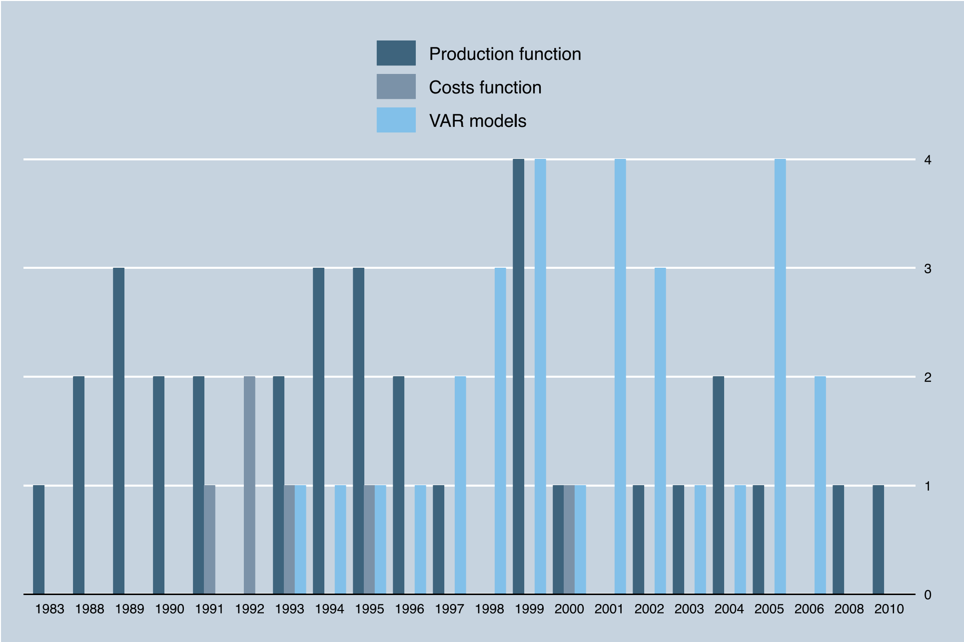
An alternative method is to consider the cost function of the firm and assume that public capital is an input provided by the government free of charge. This approach has the advantage of imposing fewer restrictions on the production structure than the previous approach (see for example Moreno *et al.* (2003) and Cohen & Paul (2004)). However, it also does not take into account potential reverse causality.

VAR models (*vector autoregressive models*) and their derivatives [3] allow to resolve

3. Such as VECM models which are error-correcting VAR models.

this reverse causality problem. In addition, they allow for indirect linkages between variables, i.e., the long-run effect of changes in public capital on output results from the interaction between the variables in the model. Finally, the VAR approach helps to solve problems related to the non-stationarity of data [4]. For these reasons, this approach has been increasingly used, particularly since the late 1990s [5] as shown in Figure **4**.

FIGURE 4- Evolution of econometric specifications
Number of specifications per year for Production Function Approach (PF), Cost Function Approach (CF) and VAR models Table constructed from the literature review of Pereira & Andraz (2013).



4. As Sturm *et al.* (1998) point out, from an econometric point of view, it is necessary to filter time series to make them stationary or to apply cointegration techniques to obtain reliable timings.
5. The literature review of Sturm *et al* (1998) lists 3 articles using this type of model, while those of Romp & De Haan (2007) and Pereira & Andraz (2013) list around 30.

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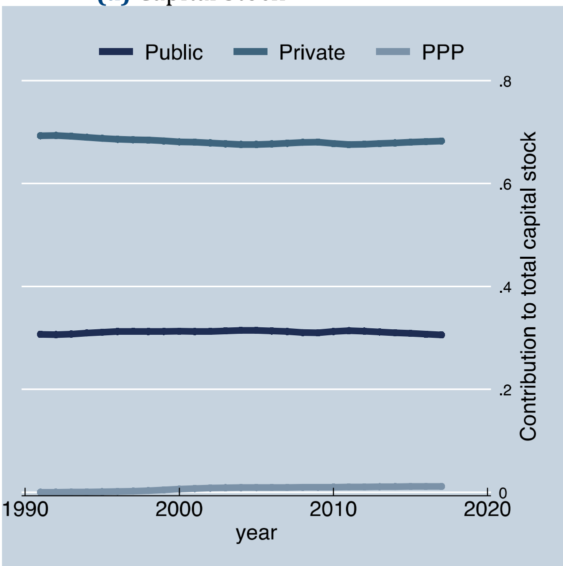
2.1.3 A LACK OF DATA

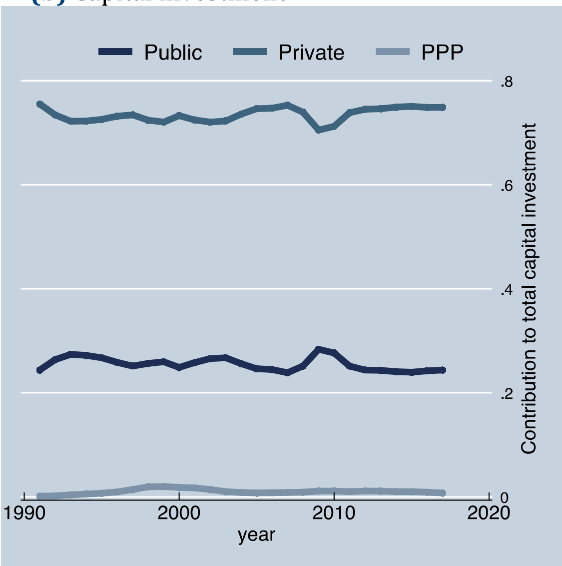
Furthermore, while many scientific papers have studied the link between infrastructure and growth, the results are not always comparable because of the many indicators used to assess a country's stock and flows of infrastructure. Researchers have used a wide variety of data.[6] Some analyses use the stock of physical infrastructure, which includes transportation, sewage treatment and other utilities such as water, electricity and gas distribution.[7] The data are based on the stock of physical infrastructure, which includes transportation, sewage treatment and other utilities such as water, electricity and gas distribution.
Other analyses use the public capital stock, generally calculated by the perpetual inventory method.[8] This proxy has a double disadvantage. Firstly, private sector spending is excluded while the private sector contribution to infrastructure financing is significant as shown in Figure **5**. Furthermore, to the extent that

FIGURE 5- Evolution of the contribution of the public sectors to investment and capital stock
Figure (a) shows the evolution of the contribution of general government (gross fixed capital formation), the private sector and public-private partnerships (PPPs) to the capital stock. Figure (b) shows the evolution of the contribution of general government (gross fixed capital formation), the private sector and public-private partnerships to capital investment. Data from the *Investment and Capital Stock Dataset of the* International Monetary Fund.

(a) Capital Stock



(b) Capital investment



the objective is to analyze the impact of infrastructure investments on growth, and not the impact of

6. In his analysis of 167 specifications, Straub (2008) identifies 65 analyses using public investment data and 75 using physical indicators. For a detailed list of data used in the studies, see Pereira & Andraz (2013).
7. See for example Albala-Bertrand & Mamatzakis (2004); Calderòn & Servén (2002); Stephan (2000).
8. This method consists of making the sum of past investments, adjusted for depreciation.

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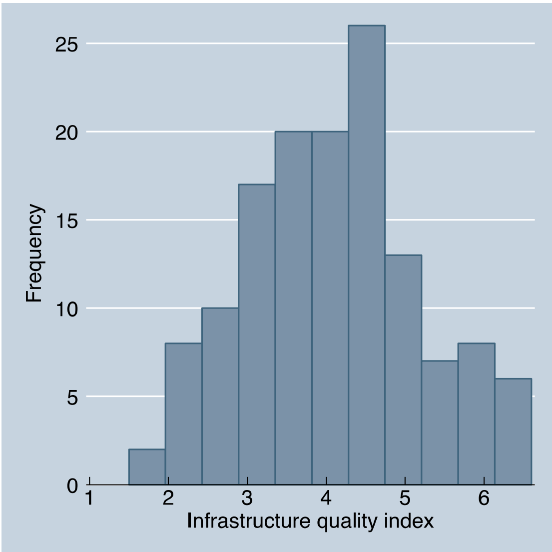
public spending on growth, this proxy is deemed to be unsatisfactory. Finally, public investment does not exclusively finance infrastructure. If the share of infrastructure financed by the private sector is not constant over time, this introduces a systematic measurement error (Straub (2011)).

Finally, some analyses use physical measurements such as the number of kilometers of roads. The disadvantage of this type of proxy is that it does not take into account the quality of infrastructure, which differs greatly from one country to another, as shown in Figure **6.** Figure 6 presents the distribution of the infrastructure quality index for 137 countries. The distribution of the index is very wide, with values between 1.5 and 6.6. This has been considered by many authors as a limitation such as by Canning (1999) and Calderòn &Servén(2002).

FIGURE 6- Infrastructure Quality Index

This graph shows the distribution of the infrastructure quality index (ranging from 0 to 7) for 137 countries in 2017. The higher the index, the higher the quality of the infrastructure. Data from the *World Economic Forum*'s *Global Competitiveness Index*.



In general, there is a consensus among researchers concerning the problem of data acquisition on this topic. The wide variety of proxies used in academic papers is largely due to lack of data. According to Gramlich (1994) [10], most studies focus on the public capital stock because it is difficult to measure

9. For example, Canning's (1998) database contains six physical measures: kilometers of roads, kilometers of paved roads, kilometers of railway lines, number of telephones, number of main telephone lines, and electrical generating capacity in kilowatts. Calderòn & Servén (2002) use the number of main telephone lines, electricity production capacity in kilowatts and the number of kilometers of paved road.

10. *“Most econometric studies of the infrastructure problem have used the narrow public sector ownership version of infrastructure capital as their independent variable. This is in large part because it is very hard to measure anything else.”* Gramlich (1994).

other indicators. Straub (2011) [11] argues that the databases do not provide any satisfactory measures. The establishment of reliable and accurate databases of infrastructure stocks and flows at the international level therefore appears to be a necessary prerequisite for a precise study of this subject.

2.2 Main results

2.2.1 A POSITIVE GLOBAL IMPACT

Despite a persistent debate on the impact of infrastructure on economic activity, most empirical analyses estimate positive elasticities as shown in Figure 7. Indeed, it can be observed that more than 76% of macroeconomic analyses estimating the elasticity of production to infrastructure find positive elasticities.

FIGURE 7- Results of literature estimates

This graph presents the distribution of the results regarding the estimates dealing with the link between infrastructure and economic activity according to whether this relationship is (i) positive; (ii) insignificant; (iii) indeterminate; or (iv) negative. Graph constructed by meta-analysis based on the results of the literature presented by Pereira & Andraz (2013).

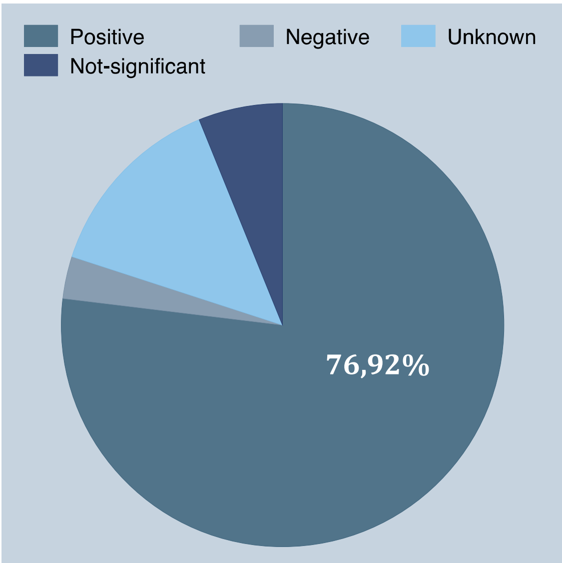
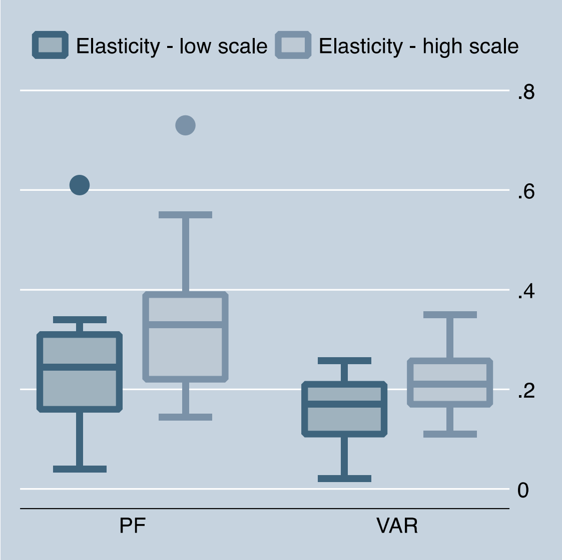


Figure 8 shows the dispersion of estimated elasticities when the effect is statistically significant, distinguishing between the production function approach and the VAR approach. A large dispersion of results is re-emphasized with elasticities ranging from 0.04 (Canning & Bennathan (2000) to 0.73 (Aschauer1989b)). In addition, lower elasticities are observed in the case of the VAR models, which produce average elasticities between 0.16 and 0.22 compared to 0.24 and 0.34 for the production function approach.

11. *"Again, the question arises of what other potential measures to use, and of suitable quality measures, which are notably absent form standard databases."* Straub (2011).

FIGURE 8- Dispersion of statistically significant elasticities on an aggregate sample Graph constructed by meta-analysis of the literature results presented by Pereira & Andraz (2013). This analysis includes 70 specifications performed on aggregated data.



An overall positive effect of infrastructure on economic growth can be identified, however, without being able to conclude on the scale and magnitude of this effect. Similar recent analyses such as those of Holmgren & Merkel (2017) and Melo et *al* (2013) focusing on the impact of transport infrastructure, come to the same conclusion. Some analyses have therefore focused on certain types of infrastructure, certain geographical areas (countries or regions) and certain sectors, in order to better take into account, the heterogeneity between projects and between the economic situation of the countries. The results are presented below.

2.2.2 DIFFERENTIATED EFFECTS ACCORDING TO THE TYPE OF INFRASTRUCTURE

A first explanation for the lack of consensus over the scale of positive impact of infrastructure on growth lies in the type of infrastructure considered. A highway does not produce the same goods and services as a wastewater treatment infrastructure. Not all infrastructure has the same impact on the economy and treating infrastructure as a product necessarily leads to different conclusions. Batina (1998) shows, in the case of the United States, that spending on road and highway infrastructure has a greater effect than spending on water and wastewater infrastructure. Canning (1999) shows, over the period 1960-90, that the productive impact of telephone networks is greater than the impact of energy and transport infrastructures. It further notes that the efficiency of transport infrastructure is higher than that of other types of infrastructure in developed countries. More generally, meta-analyses carried out on the literature, such as those of Holmgren & Merkel (2017) and Melo et *al* (2013), highlight a strong heterogeneity of results depending on the type of infrastructure[12].

2.2.3 A STRONG GEOGRAPHICAL HETEROGENEITY

Similarly, not all countries/regions have the same production structure or the same infrastructure needs. It is therefore difficult to draw broad conclusions on the basis of aggregate data. Some researchers have therefore focused their analyses on certain geographical areas [13]. Based on a sample of 48 countries, Arslanalp et *al.* (2010) compare the productive impact of infrastructure on OECD and non-OECD countries. It shows that the increase in public capital stock is positively correlated with growth. The effect is stronger for OECD countries in the short term, while it is stronger in the long term for non-OECD countries. Kamps (2005) analyses the effect of public capital by estimating the GDP's elasticity to public capital shocks for 22 OECD countries over a 25-year period. The results are reported in Appendix A. These estimates show that the impact of infrastructure is very different from one country to another. While there is a positive impact in most cases, the results show an overall negative effect for Ireland, Japan and Portugal and a negative short-term effect followed by a positive long-term effect for Canada, Norway, Spain and the United Kingdom. In the case of Japan, this negative impact can be explained by a capital stock that is already above the optimal stock. Thus, any increase in the stock of public capital would be counterproductive. For other countries, the explanation lies in the interaction between public and private capital, which is the result of two mechanisms working in opposite directions. On the one hand, an increase in public capital has a positive effect on the marginal productivity of private capital. On the other hand, an increase in public capital reduces the resources available to the private sector and thus reduces private investment. National and international macroeconomic factors do influence the scale of these two mechanisms and thus the impact of an increase in public capital on macroeconomic aggregates. Under certain conditions, it is possible that the first factor will dominate in the short term, while the second will dominate in the long term. Similarly, Yoshino & Nakahigashi (2018) examine the effect of infrastructure on productivity in Japan and Thailand. Their results once again show a strong geographical heterogeneity since infrastructure investments impact these two countries differently.

At an even more disaggregated level, Pereira & Andraz (2005) analyze the impact of transport infrastructure in Portugal. Their results show that while public investment in transport infrastructure has been a powerful instrument to promote long-term growth, this effect differs from region to region. A similar analysis was conducted

12. Holmgren & Merkel (2017) perform a meta-analysis of 776 estimates of the elasticity of production to infrastructure, and show that the effect is different for air, sea, road and rail transport infrastructure.
13. As the purpose of this section is purely illustrative, only the most recent studies are presented. For a more detailed list see Pereira & Andraz (2013).

by the same authors (Pereira & Andraz (2010)), this time considering motorway infrastructure in the United States. The results show that investment in highways has a positive impact on private sector variables, both on a global level as well as in most states, and that these impacts differ across the different regions.

These analyses show that it is essential to take into account country characteristics as well as regional specificities in order to assess the budgetary impact of projects.

2.2.4 STRONG SECTORAL HETEROGENEITY

In addition, some analyses take into account the heterogeneity among and within the different sectors. Pereira & Andraz (2007) analyze the case of Portugal and show that the overall positive effect nevertheless implies a strong sectoral heterogeneity. More specifically, seven sectors capture more than 70% of the benefits generated by public investment, leading to an increasing concentration of employment in these sectors. Li et *al* (2017) show that the impact of road infrastructure in China differs across sectors, with sectors that rely more on transport services experiencing higher productivity growth. Yoshino & Nakahigashi (2018) come to the same conclusion in the case of Thailand and Japan. In Thailand, the positive impact of infrastructure on productivity is verified in the manufacturing sector, but in other sectors the effect of infrastructure investment on productivity is negligible or non-existent. In the case of Japan, the results show that investment in infrastructure has an undeniable effect on productivity of the secondary and tertiary sectors.

CONCLUSION

The studied literature identifies an overall positive impact of infrastructure on economic growth. These results have relevant policy implications and show that investment in infrastructure can generate significant economic benefits by increasing business productivity. Taking these results into account in the budgetary evaluation, would better reflect the socio-economic reality of the projects. However, this positive impact is not homogeneous across infrastructure types, countries, regions and sectors. This positive effect must therefore be considered carefully in order to assess precisely, for each project, the expected budgetary impact.

Furthermore, this analysis highlights that there is a lack of large-scale data which is a major obstacle for identifying the main determinants able to assess a positive impact of infrastructure on productivity. The creation of a large database, with improved historical data as well as geographical and sectoral specificities inherent to each project, would offer the possibility to model this impact (by generalizing, for example, the methodology of Yoshino & Abidhadjaev (2017)) and to deduce results that can better be generalized.

More specifically, this type of analysis would make it possible to identify the factors that positively influence the impact of infrastructure projects on GDP, to determine the key factors for the success of these projects and thus make it possible to develop evaluation models that better reflect the socio-economic reality of the projects.

SOCIO-ECONOMIC ASSESSMENT OF PROJECTS

1

Cost-benefit analysis

"Reforms are required to project-appraisal procedures to ensure objectivity, improve both the analysis and the use of evidence at appraisal and ensure effective of cost-benefit analysis in decision making"

IEG World Bank (2010)

Abstract

- This chapter will present the cost-benefit analysis (CBA) which can be considered as the preferred tool for the socio-economic evaluation of infrastructure investment projects. CBA consists in comparing several situations using a synthetic indicator, such as net present value or cost-benefit ratio, which is supposed to reflect the changes in social welfare induced by a project. Technically, this method requires an assessment in monetary terms and a discounting of the socio-economic costs and benefits associated with each scenario considered.
- Due to CBA's success, States and international institutions have developed practical guides to facilitate and generalize the implementation of this type of analysis. However, there is currently no international standard for producing systematic estimates that are comparable.
- While there is a broad consensus on the benefits of such an assessment, some technical issues remain and make it difficult to apply the CBA. For example, there is a recent trend towards a lesser use of CBA within the World Bank, which can be explained by the inherent difficulties in using this tool.
- The complexity of implementing CBA lies mainly in: i) the exhaustiveness of the costs and benefits associated with a project, since this method does not allow to take into account dynamic effects which change the very structure of the economy (detailed in Part I); ii) the valuation in monetary terms of these costs and benefits, particularly in the case of non-market goods and services (how can the preservation of cultural heritage or damage to biodiversity be valued in monetary terms?); and (iii) the choice of an appropriate discount rate that strongly impacts the results of a CBA and which is highly dependent on ethical considerations (how much weight should be given to future impacts?).

INTRODUCTION

The socio-economic assessment of projects can be explained by the fact that the financial perspectives are not sufficient to assess the benefits of a project for society as a whole. A quantitative assessment of the socio-economic costs and benefits therefore becomes necessary. The preferred tool is the cost-benefit analysis (CBA), which has been widely used and implemented, particularly by international organizations such as the World Bank, in order to streamline the investment decision.
In France, it was the Boiteux report (1996) that raised a strong interest in CBA, particularly in the field of transport infrastructure, so that projects could be assessed on the basis of economically rational decisions.[1] The Public Finance Programming Act of 31 December 2012 assesses the French government's desire to systematize/structure the socio-economic assessment of public investment projects, which is now mandatory and subject to independent counter-assessment, at least for the most important projects. As an extension of this regulatory framework, a report on the socio-economic assessment of public investment, drafted by a committee of experts and chaired by R. Guesnerie, was published in 2017 [2].

This chapter introduces the CBA method of socio-economic assessment of projects and details some of the difficulties involved in its implementation.

1.1 COST-BENEFIT ANALYSIS, THEORETICAL FOUNDATIONS AND OPERATIONAL IMPLEMENTATION

The origin of the CBA goes back to Federal Navigation Act of 1936 issued in the United States, which required the *U.S. Corps of Engineers* to carry out projects to improve the waterway network provided that the total benefits of a project exceed the costs of the project. The evaluation method implemented at that time had no economic basis. By the 1950s economists finally decided to provide a rigorous theoretical framework in order to be able to develop consistent methods for the socio-economic evaluation of projects. More precisely, definitions based on economic reaearch break with older definitions.[3] Guillaume (1972) describes the theoretical foundations of CBA which he defines as a *"partial equilibrium analysis, classifying public projects according to the economic surplus they provide to society"*. CBA is therefore based on the theoretical foundations of welfare economics. CBA must take into account the following aspects: (i) the external effects of the project on both a firm's production functions and its utility to the consumer;

1. Previously, multi-criteria analysis was the most widely used. This trend has led to an increase in arbitrary decisions. See Quinet (2000) for more details on methods for evaluating infrastructure projects in France.
2. The committee wanted to publish a guide on the socio-economic evaluation of public investments, the drafting of which has been entrusted to the Treasury and France Strategy Directorate General (2017).
3. Such as that of Prest & Turvey (1965) for whom CBA is a technique that makes it possible to assess the profitability of projects by taking into account their short and long-term consequences and their secondary effects on different economic players.

(ii) non-market costs and benefits such as time saved for users or lives saved in transport infrastructure.

In a more operational way, CBA consists in comparing the costs and benefits generated by a reference scenario and one or more alternative scenarios. The alternative scenario describes the situation in which the project would not be carried out. In the specific case where the investment is aimed at improving an existing infrastructure, two alternative scenarios are possible: (i) *Business As Usual,* which consists in maintaining the infrastructure as it is at time *t*; and (ii) *do-minimum,* which consists in making small adjustments, planned independently of the project. The main steps of a CBA are described in Figure 9.

FIGURE 9- CBA Main Steps

Figure based on Gibson & Wallace (2016).

Step 1
Definition of the reference scenario and the alternative scenario(s)

↓

Step 2
List of costs and benefits associated with these different scenarios

↓

Step 3
Calculation of the Net Present Value (NPV)

↓

Step 4
Decision → The project that produces the highest NPV is the one to be realized

CBA therefore determines the feasibility of a project by quantifying all relevant costs and benefits in monetary terms. More precisely, the final objective of a CBA is to calculate a synthetic indicator, generally the Net Present Value (NPV), which can be completed by calculating the Economic Profitability Rate or the Cost-Benefit Ratio [4].

NPV is calculated as the discounted sum of all costs and benefits generated by a project (Volden(2019)):

$$V\,AN : \sum_{t=0}^{N} \frac{Bt - Ct}{(A+i)^{t}} \qquad (1.1)$$

where *B* is the social benefit, *C* is the social cost, *i the* discount rate, *t the* time and *N* the

4. The economic rate of return is an indicator of profitability. It is directly derived from NPV. The cost-benefit ratio is the ratio of the sum of discounted benefits to the sum of discounted costs.

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number of periods. The scenario offering the highest NPV is the one to be favored. CBA thus presents many analogies with the investment choices of private firms, with the difference that private profit is not maximized, but collective welfare.

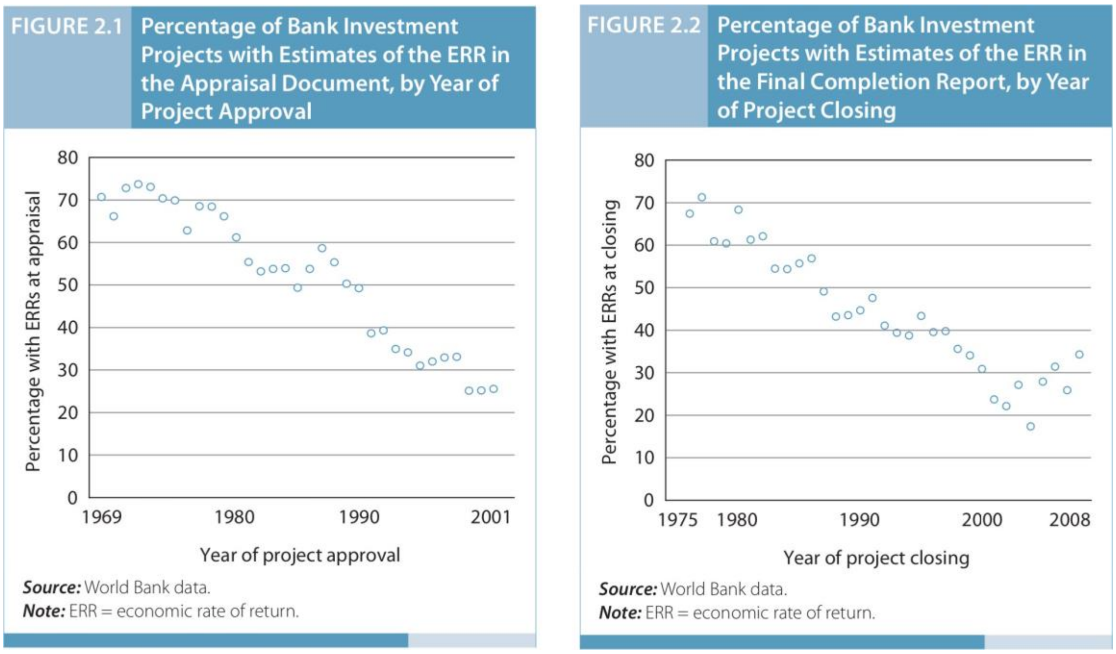
The complexity of implementing CBA lies in: (i) identifying the costs and benefits associated with the project; (ii) valuing these costs and benefits in monetary terms; (iii) choosing an appropriate discount rate; and (iv) defining the time horizon. However, as Gibson & Wallace (2016) point out, while CBA is widely used, there is no international standard for producing uniform analyses. Although some parameters are included in most CBAs, there is no unified analytical framework to implement such analysis. The European Commission's guide (2014), which aims to provide practical advice on the evaluation of major projects, identifies numerous sources of error at each stage of a CBA, such as the absence of a quantified analysis of an alternative scenario, the failure to take account of replacement costs in the calculation of residual values, or the use of nominal interest rates to calculate interest payments even though the analysis is carried out at constant prices. The CBA steps described in the European Commission's guide (2014) as well as the common errors identified are presented in Appendix B.

An example of a CBA is provided in Appendix C. which is dealing with the assessment carried out for a motorway infrastructure project in France. The costs and benefits taken into account in this analysis are : (i) the costs directly associated with the implementation of the project (investment amount and operating costs); (ii) the costs and benefits for users (time savings, tolls, fuel, comfort, vehicle maintenance costs) ; (ii) the costs and benefits for the community (increased safety, increased air pollution and greenhouse effect); (ii) the costs and benefits for the public authorities, mainly fiscal (change in revenues related to fuel and vehicle maintenance taxes); and (iv) the loss of revenue for the city's tunnel operating companies. This example highlights an important limitation of this assessment method, which does not consider certain other costs and benefits. One of the expected economic benefits of this motorway is, for example, increased economic dynamism and activity in this geographical area (establishment of new businesses, job creation). This example points to the encountered difficulties when carrying out a CBA and the limits of this tool.

1.2 A RECENT TREND TOWARDS A LESSER USE OF CBA

While this method has been widely used by the World Bank and has helped to demonstrate methodological thoroughness in project selection, the percentage of the World Bank's projects that are subject to *ex ante* and/or *ex post* CBA has been declining for several decades (IEG World Bank(2010)), as shown in Figure **10**. This trend

FIGURE 10- Evolution of World Bank projects having been submitted to a CBA



Source: IEG World Bank (2010)

is due to the inherent difficulties in using this tool. Guo *et al* (2008) indicate that in many cases the CBA is not part of the decision-making process because of the difficulties in accurately estimating the value of the costs and benefits associated with a project. A CBA carried out *ex-ante* necessarily involves many sources of error, such as omitted impacts, forecast errors and valuation errors (Volden (2019)). Furthermore, CBA only measures the direct effects of projects and therefore neglects dynamic effects, which account for a significant proportion of the gains associated with some projects. CBA is exposed to the risk of bias and manipulation [6].

5. Dynamic effects are those effects that change the behavior of agents and the structure of the economy. One example is the choice of location for businesses which, as we saw in Part I Section 1.2, is influenced by infrastructure.

6. Mouter (2017) interviewed policy-makers who claimed that it was easy to influence the results by "shifting of buttons in the model" (Mouter (2017), p. 1134). Mackie & Preston (1998) list 21 sources of error and bias in the evaluation of transport projects and conclude that optimism is one of the most important sources.

1.3 CHALLENGES AND LIMITATIONS OF CBA

This section describes three main issues related to the operational implementation of CBA [7], which mainly lie in: i) the exhaustiveness of the costs and benefits associated with a project; ii) the valuation in monetary terms of these costs and benefits; and iii) the choice of the discount rate.

1.3.1 THE ISSUE OF EXHAUSTIVENESS OF IDENTIFIED COSTS/BENEFITS

As detailed in Part I, infrastructure investment projects can have a non-negligible positive effect on economic growth. Infrastructures can in fact considerably modify the behavior of economic agents. The decision about the location of firms for example, may imply the introduction of new transport infrastructure. These transformations of the economy, which are likely to represent a significant part of the benefits of a project, are not considered in conventional CBA [8]. In a publication by the *Institute for Government (*United Kingdom), Atkins *et al* (2017) state that CBA does not allow the dynamic effects of infrastructure investment projects to be taken into account, as the techniques for estimating these effects are complex and costly to implement. Moreover, as Laursen & Svejvig (2016) point out, the definition of the benefits associated with a project is often vague and depends on the perspective taken. Finally, as explained by Coyle (2016), CBA does not consider the significant changes in behavior induced by new infrastructure, since it partly neglects social externalities, positive or negative, even when they are captured in private markets. A limitation of the CBA lies in the lack of exhaustiveness of the costs and benefits used for the calculation of the NPV.

1.3.2 THE ISSUE OF ASSESSING COSTS AND BENEFITS IN MONETARY TERMS

Furthermore, since the objective of CBA is to express the socio-economic costs and benefits associated with a project in a single unit, the first difficulty in implementing this evaluation technique lies in assigning a monetary value to each of these costs and benefits. This monetization is carried out differently depending on the marketable or non-marketable goods or services in question. Marketable goods and services have a market value, which can be directly used, whereas non-market goods and services have no "price" as such, and are therefore more difficult to monetize [9]. For the

7. Since the objective of this study is not to discuss the technical details of this tool, this section is not intended to detail an exhaustive list of the difficulties inherent in the implementation of CBA. For a detailed discussion of the technical difficulties of CBA, see the European Commission's guide (2014) which details for each stage of CBA the different technical tools useful for carrying out such an assessment, good practices and frequent errors.
8. In this analysis, these aspects of the economy remain are assumed constant.
9. This is the case, for example, with air quality, biodiversity, etc.

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marketable goods, the calculation is based on the variation of collective surplus [10] from the market price. For the non-marketable goods, the monetization of costs/benefits is more complex and relies on different techniques, mainly the evaluation of willingness to pay/receive as well as the hedonic price method.

- ❑ Assessing willingness to pay/receive

Economically, willingness to pay is the marginal rate of substitution between the non-market good and private consumption. There are two methods of assessing willingness to pay. The first method, known as revealed preferences, is based on the observation of the behavior of economic agents in order to deduce their preferences. The second method, known as stated preferences [11], consists in questioning economic agents and deducing their preferences from their responses. Beyond the methodological difficulties related to the assessment of willingness to pay, barriers remain regarding the use of this type of measure, which may reflect ability to pay and thus be biased towards the wealthiest households, as Nyborg (2014) points out. One way to avoid this bias is to weight willingness to pay according to income [12].

- ❑ The hedonic price method

This method is based on the idea that the value of a non-market good depends on its various attributes, which should therefore be isolated and monetized. In particular, this method is used to value certain non-market characteristics of real estate. Let's assume that one wishes to evaluate the price of the quality of the living environment: If one collects the price of a number of goods with identical characteristics, in addition to the quality of the living environment, the price of the quality of the living environment can be deduced from the price differences observed.

Furthermore, when market prices do not reflect the opportunity cost of inputs and outputs, they must be converted into shadow prices [13]. These prices measure the net impact on social welfare of a unit increase in the supply of a good by the public sector (Drèze & Stern (1987)), before being included in the CBA. Indeed, as the Asian Development Bank (2013) points out, when the government is heavily involved in financing infrastructure projects, the economic benefits provided by this infrastructure are not reflected in market prices. Guillaume (1972) gives the example of the shadow price of water in the case of a water infrastructure [14] :

10. In economics, the collective surplus is a measure of the aggregate welfare of all economic agents.
11. Two methods are used to deduce stated preferences: contingent valuation and conjoint analysis.
12. See the article by Johansson-Stenman (2005) for a discussion of this method.
13. The term used in Anglo-Saxon literature is *shadow prices*.
14. The article details two other techniques for calculating shadow prices.

> "Let's take the example of water investments. They improve farm irrigation, enable electricity generation and provide water to neighboring industries. Let's limit ourselves to the first effect. By conducting productivity studies for irrigated farms, it is possible to assess the value of the additional production that would result from improved irrigation. Assuming that farmers are willing to pay the monetary equivalent of this additional production, we can say that the marginal productivity of irrigation water will measure the "shadow price" of water or "imputed market price".

The European Commission's guide (2014) provides a list of costs and benefits associated with transport infrastructure and the most appropriate monetary valuation method [15]. These elements are presented in Table 3. The list shows that only the operating costs of the vehicles and the costs relating to the maintenance of the vehicles can be assessed based on their market value. Non-market costs/benefits, such as time savings or noise variation, should be assessed using the methods detailed above.

TABLE 3 - Typical economic costs and benefits of a transport infrastructure project
This table presents the main effects of transport infrastructure projects and the relevant assessment methods for their economic evaluation. This list does not include the costs borne by the project holders (construction, maintenance, etc.) nor the costs incurred using this type of infrastructure (e.g. tolls).

Effect	Method of monetization
Time savings	Revealed preferences (households and businesses) Announced preferences Cost reduction
Vehicle maintenance costs	Market price
Operation costs of transporters	Market price
Improved security	Revealed preferences (households and businesses) Announced preferences Human Capital Approach
Noise variation	Willingness to pay/accept compensation Hedonic price method
Variation in air pollution	Implicit price of air pollutants
Variation in greenhouse gas emissions	Implicit price of greenhouse gas emissions

Source: European Commission (2014)

1.3.3 THE DISCOUNT RATE ISSUE

The discount rate measures the relative importance of consequences occurring at different points in time. The choice of an appropriate discount rate is therefore

15. This list does not include the costs borne by the project holders (construction, maintenance, etc.).

an important issue, especially for long-term projects, as in such situations CBA results can be extremely sensitive to even small changes in this discount rate (Jones *et al.* (2014); Gollier & Weitzman (2009)). A high discount rate implies a preference for projects with a lower initial investment or with concentrated short-term benefits. Conversely, a lower rate favors projects with significant returns over the longer term. Indeed, as shown in Table **4,** the present value of 1000€ in 10 years, when the discount rate is 1%, is 2.3 times higher than when the discount rate is 10%. This ratio rises to 65 per 1000€ in 50 years, and to over 5,000 per 1000€ in 100 years.

TABLE 4 - Change in present value of a cost/benefit of 1000€ by discount rate and timing

		Present Values	
No. of years Discount rate (in %)	10	50	100
1%	910	608	370
3%	744	228	52
8%	463	21	0,45
10%	386	9	0,07

Source: Harrison (2010)

For example, a high discount rate makes the consequences of a long-term project negligible, which raises the issue of intergenerational equity. The estimated net benefits of projects whose benefits and costs are widely extended over time, such as climate change mitigation measures, are indeed very sensitive to this rate. However, there is no consensus on the correct discount rate to be used to evaluate public projects, nor is there a single discount rate [16] (Gollier & Hammit (2014)).

From a theoretical point of view, there are two approaches to determine the discount rate. According to the normative approach, the discount rate is a measure of the intertemporal rate of substitution, which means that it is directly influenced by ethical considerations. Like Harrison(2010) underlines, this approach comprises a wide range of discount rates, reflecting different value judgments. This approach therefore does not allow a discount rate to be determined on an objective basis. The positive approach is based on the opportunity cost of the capital used in the project: what would be the benefits to society if the funds were left to the private sector? According to Gollier & Hammit (2014), a key in economic research lies in the reconciliation of these two approaches[17].

16. The recommendations on the discount rate differ widely depending on the sources (academic, government, international institutions).
17. *"The literature has yet to resolve the discrepancies between the positive perspective and the normative perspective."*, Gollier & Hammit (2014).

In practice, discount rates recommended by governments or governmental organizations range from 1 to 15 percent, with the highest rates used in developing countries (Harrison(2010)). In the United States, the *Office of Management and Budget* recommends a rate of 3% or 7%, which is increased in order to consider the well-being of future generations and the uncertainty of future growth. In the United Kingdom, the recommended discount rate ranges from 1% to 3.5% depending on the time horizon used. In France, the Quinet Commission (2013) recommends a rate of between 1.5% and 2.5% depending on the time horizon taken. A project-specific risk premium is added to this discount rate. There is therefore a lack of consensus on both the methodology for estimating the discount rate and its calibration.

CONCLUSION

As many authors point out, CBA is a useful tool, but it is far from perfect for evaluating investment projects, especially when the impacts are spread over very long periods, as it is the case for infrastructure projects. The issues raised regarding the lack of exhaustiveness of the costs/benefits identified, the evaluation of the CBA and the discount rate to be applied, shows that the results of a CBA for a project can differ drastically depending on the way it is carried out. Ackerman & Heinzerling (2002) add that CBA ignores/disregards the issue of equity and morality [18], they argue that these analyses often are not carried out in a very transparent way (which makes it impossible to question the results) and that they may suffer from a lack of objectivity.

18. In particular, they give the example of a CBA carried out to assess the costs/benefits of smoking, the results of which lead to the conclusion that smoking induces a net benefit to the State.

2

Ways for improving the evaluation methods of infrastructure projects

"Case studies of policies for airport expansion and for waste management (...) illustrate the weakness of cost-benefit analysis and the need for alternatives."

Ackerman (2008)

ABSTRACT

- This Chapter will mainly focus on two methods that could complement CBA in order to provide decision-makers with results that better reflect the socio-economic reality of infrastructure projects.
- In order to allow CBA to take into account the dynamic effects induced by new infrastructure, some authors propose, under certain conditions, to add an assessment of "extended economic benefits" to traditional CBA. “Extended economic benefits” are defined as the economic benefits (or costs) that may result from an increase in the services provided by the infrastructure in addition to the benefits to users. One of the first projects evaluated using this method was *CrossRail*, a railway network that connects east and west London. Considering the dynamic effects increases the cost-benefit ratio of this project from 1.97 with conventional CBA to 3.2.
- Moreover, although multi-criteria analysis is not a sufficient tool to reflect all the socio-economic issues of a project, it can in some cases provide an interesting additional analysis for assessing non-monetary impacts and for taking into account some ethical considerations.

INTRODUCTION

The limitations of CBA, highlighted in the previous chapter, underline the need to improve this tool. It is indeed necessary to make it more flexible to the specificities inherent to each project and to derive results that reflect the reality of the projects. This chapter presents two ways for improvement: the English approach on the broader economic impact and the multi-criteria analysis.

2.1 TOWARDS GREATER COMPREHENSIVENESS OF COSTS AND BENEFITS

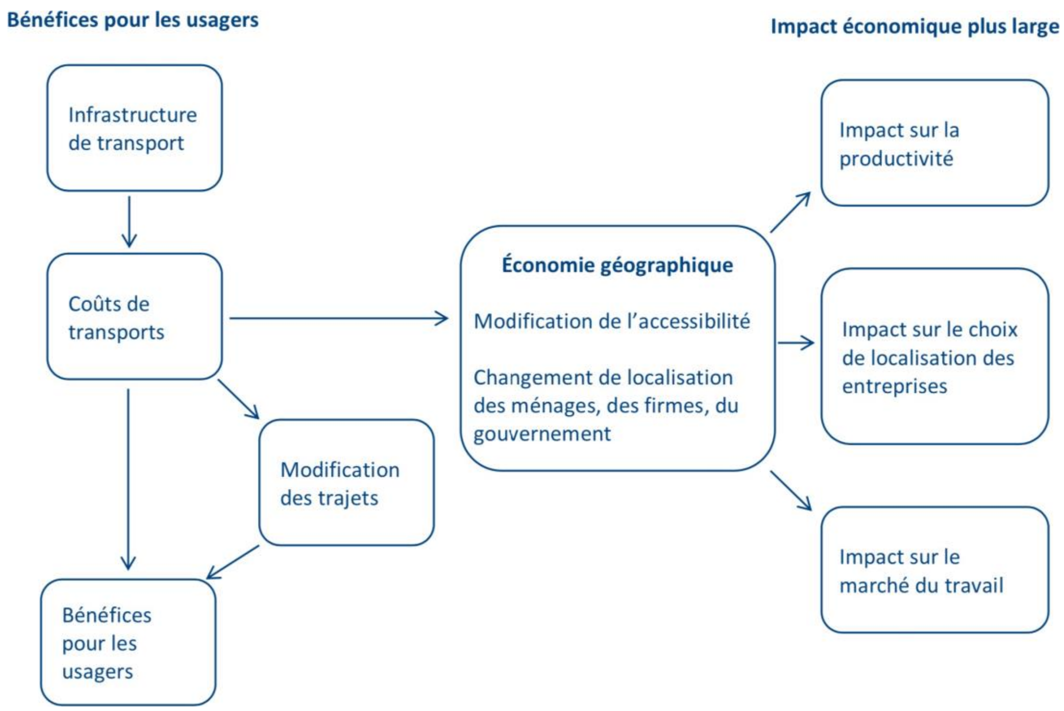
While the CBA appears to be an indispensable tool for the rational justification of the investment decision, it does not, as it is usually carried out, allow all the costs/benefits generated by a project to be taken into account. As Douglas & O'Keeffe (2016) point out, traditional CBA does not for example, consider the positive effects resulting from agglomeration phenomena (see Part I Section 1.2). In general, the spillover effects on economic growth detailed in Part I Chapter 1 are neglected in the classical CBA. This observation has led to new research developments which analyses how the full range of economic benefits can be integrated into the evaluation of infrastructure investment projects. Several conferences (2014-2016) on this subject has been organized in France by France Stratégie, the General Investment Commission and the General Council for the Environment and Sustainable Development. The final report of these colloquia (Auverlot *et al.* (2016)) stresses the need "to develop new methodologies for socio-economic evaluation, particularly in areas where it is poorly developed, as well as the need to improve existing practices and to undertake specific studies".

Some authors (see in particular Byett *et al.* (2015); Douglas & O'Keeffe (2016); Venables (2016; Veryard (2016)) propose an assessment of "extended economic benefits to be added to the traditional CBA" [1] , meaning assessing the economic benefits (or costs) that may result from an increase in the services provided by the infrastructure in addition to the benefits for users. These benefits are particularly important in the case of transport infrastructure which, as shown in Figure **11**, affects the productivity of firms, their choice of location and the labor market. The British Department for Transport (2016) indicates that, under certain conditions, these broader economic benefits should be added to the CBA of transport infrastructure projects in order to better reflect the socio-economic reality of the projects.

A good example that shows how wider economic benefits can be considered is the evaluation of the *CrossRail* project, a railway network aiming to connect east and west London. The conventional assessment of user benefits gave an estimate of £52.5 billion for a total cost of £26.6 billion.

1. The term used in Anglo-Saxon literature is *wider economic benefit.*

FIGURE 11- Benefit to users, geographical economy and wider economic benefit
Figure based on Veryard (2016)



The inclusion of agglomeration and labor market effects adds £42.5 billion to the benefits of the project and increases the cost-benefit ratio from 1.97 to 3.2. This example shows the impact of not considering these effects in the final decision when assessing an infrastructure investment project [2].

An analytical framework for assessing these wider economic benefits has recently been developed by the UK DepartmentforTransport (2016)) and describes the circumstances in which such analysis is appropriate. However, as the European Investment Bank (2013) states, this broader economic impact cannot be systematically included in all projects in order to avoid double counting of the benefits of project [3] and thus biasing the final decision.

2. Other examples are detailed by Douglas & O'Keeffe (2016).
3. Let's take the example of a project that would have an impact on both a primary and a secondary market. If the secondary market is fully competitive (marginal cost of production pricing), then the direct benefits measured in the primary market include all relevant benefits. In such a situation, taking into account profits on the secondary market would lead to double counting and therefore to incorrect estimates of net economic and social benefit. Conversely, in the case of imperfect markets (economies of scale, asymmetry of information, presence of taxes or subsidies), the impact of the project on the primary market may induce structural effects on the secondary market (such as a demand shock for example) which are not accounted for in the CBA.

2.2 MULTI-CRITERIA ANALYSIS

Another limitation of CBA lies in the difficulty of monetizing certain costs/benefits resulting from a project, as detailed in Part II Section 1.3.2. An alternative is the use of multi-criteria analysis (MCA) which includes an assessment (quantitative or qualitative) of non-market impacts in addition to considering the consequences on market goods and services. More specifically, the MCA assesses different scenarios according to a set of objectives defined by the decision-making body with associated monetary and non-monetary criteria weighted according to their relative contribution to the achievement of the objectives. The result of a MCA is a performance matrix constructed from the value obtained for each criterion and the weight assigned to each criterion.

While the MCA has the advantage of including non-monetary variables in the analysis, its implementation is nevertheless subject to a strong subjective bias since the choice of objectives, criteria and their weightings is undeniably arbitrary. Furthermore, MCA does not allow for the assessment of the change in well-being induced by a project and therefore does not (unlike CBA) allow for an optimal choice in the Pareto sense. Indeed, as Dodgson *et al* (2009) point out, the "best" option under a MCA may be incompatible with improved well-being.

CONCLUSION

This chapter presented two approaches that could be used to improve project evaluation methods. The UK approach paves the way for a reflection on the costs/benefits to be taken into account in the CBA, so that the results reflect the dynamic effects induced by new infrastructure. More specifically, this method consists in adding an assessment of "extended economic benefits" to the classical CBA. Moreover, for some projects, whose cost/benefit assessment is complicated by the presence of numerous non-market costs/benefits and the existence of ethical considerations, multi-criteria analysis can provide an interesting complement to the analysis although it is not a sufficient tool to reflect all the socio-economic issues of a project.

The first steps to be conducted for a future research project would be to develop these above-mentioned evaluation methods in order to improve CBA and making it applicable to all infrastructure investment projects.

4. As Dodgson *et al.* (2009) point out, there are many techniques for implementing a MCA, which underlines the disparity of situations to be assessed (type of project, time available for carrying out the analysis, available data, etc.).

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CONCLUSION AND RECOMMENDATIONS

The first observation that can be made based on this study, is the need to underpin the debate on the infrastructure deficit with figures that are both accurate and reliable. As detailed in the General Introduction of this report, estimates of this deficit differ from one source to another due to methodological discrepancies, and even more so due to a lack of data. However, States must have tangible elements in order to be able to set objectives for infrastructure facilities and thus conduct coherent investment policies. It is therefore essential to provide decision-makers with reliable and detailed estimates (by type of infrastructure, geographical area, etc.) of these needs so that consistent growth trajectory targets for the infrastructure stock can be defined. While estimation techniques are available to address this type of question, researchers lack data, which explains the lack of consensus on the scale of this deficit.

Recommendation 1. Establish an international database of infrastructure stocks and flows that is as disaggregated as possible in order to encourage the development of literature dedicated to the study of this issue. The results of these analyses would provide decision-makers with reliable estimates of this deficit and guide States not towards "more infrastructure" but towards an optimal stock of infrastructure.

Once the objectives have been clearly defined, the problem of project selection then arises. States, already heavily indebted, must make choices in terms of resource allocation. In addition, the *subprime* crisis has restricted financing opportunities by changing the terms and conditions on which loans are granted and the degree of long-term risk aversion for savers [6]. In this context, as pointed out by Quinet (2012), "the question of the ability of infrastructure investments to survive the bank credit crunch and budgetary rigor is particularly acute in Europe". In this context, it is therefore essential to focus on projects that increase the countries' potential growth. Furthermore, the issue of project financing, although not within the scope of this study, should not be neglected. In a context of growing State deficits, economic slowdown and strict budgetary constraints for the European countries [7], recourse to public debt financing (which remains the dominant method of financing infrastructure) can be problematic, since one of the consequences of this method of financing is an increase in the

5. It should be noted that infrastructure equipment is understood here in a broad sense and includes both the implementation of new projects and projects to improve existing infrastructure.
6. For a detailed analysis of this issue, see Quinet (2012).
7. Balanced budgets in the Eurozone are strongly constrained by the Stability and Growth Pact (SGP) and even more so by the Stability, Coordination and Governance Treaty (SCGT) of 2012, which stipulates that public budgets must be balanced. Specifically, the structural deficit of a Member State must not exceed 0.5% of GDP if its debt is above 60% of GDP, and 1% of GDP if its debt is below 60% of GDP.

debt/GDP ratio. However, this deterioration in the debt-to-GDP ratio may not be systematic because, as Stupak (2018) points out, the increase in GDP induced by new infrastructure may be greater than the increase in debt required to finance the project. As pointed out by the World Bank, the International Monetary Fund and the Asian Development Bank in a joint document (Central Asia Regional Economic Corporation Program(2019)), only certain infrastructure investments can improve potential economic growth and national debt repayment capacities. Thus, projects with a low or negative economic rate of return should be abandoned in order not to undermine the macroeconomic stability of States. The results of socio-economic assessments are therefore crucial in justifying debt financing of infrastructure investment projects.

There is a strong temptation to develop project classification methods, or taxonomies, in order to more easily identify projects that increase growth potential or achieve a specific objective. However, this study presents arguments against such methods. The previous chapters show that each project is unique and that the net benefit generated depends on a set of characteristics that cannot be generalized (type of infrastructure concerned, economic and social context, countries' infrastructure stock). These arguments therefore encourage the adoption of a case-by-case assessment. A rigorous and effective (but certainly more costly) approach would be to conduct a socio-economic assessment of projects using a method that ensures comparability of results. However, as detailed in Part II, such an assessment is not always carried out and there is a great deal of heterogeneity in the application of the CBA between States and international organizations. Moreover, this method, as it is generally applied, omits many impacts that nevertheless largely influence the results of the CBA (as shown by the example of the *CrossRail* evaluation in London).

A new tool should therefore be developed, whose methodology and flexibility would allow both international acceptance and systematic application. This tool should take into account, on the one hand, all the specificities inherent to a project and, on the other hand, all the costs/benefits (quantitative and qualitative, direct and indirect, static and dynamic). The results generated by this tool would make it possible to provide decision-makers with indicators of socio-economic profitability that correctly reflect reality and enable public investment decisions to be based on rational economic foundations. This is an ambitious undertaking, commensurate with the stakes involved, which requires, as a first step, the provision of data on the *ex ante* and *ex post* evaluation of completed projects, in distinct geographical areas, with appropriate hindsight. These data allow large-scale empirical analyses to be carried out in order to estimate the magnitude of *ex ante* evaluation errors and their determinants. These analyses would provide initial ideas for improving socio-economic assessment methods. The second step would be to set up a working group of researchers, operational staff and decision-makers, so that

the technical nature of the tool does not constitute a hindrance to its use, and that the indicators thus produced are adapted to the needs.
A first draft model, developed by V. Piron, confirms the importance of the underlying hypotheses and the variables to be included. Some results are presented in Appendix D. The following table shows the sensitivity of this type of analysis to the contractualisation methods used and to the budget discount rate. This model is an interesting tool for illustrating the sensitivity of socio-economic assessment to the variables included in the model and could provide a useful working basis for the construction of a more comprehensive tool.

Recommendation 2a Carry out an empirical analysis of past projects in order to assess the extent and origin of errors in the evaluation of the costs/benefits generated by the projects. A prerequisite for this analysis is the provision of data on the *ex ante* and *ex post* evaluation of completed projects, in separate geographical areas, with the requisite hindsight.

Recommendation 2b Develop a tool that allows for a harmonized socio-economic evaluation of projects. This model will have to take into account the specificities inherent to each project (type of infrastructure, geographical area concerned, method of financing, etc.) and reflect all the impacts (positive and negative) of a project on economic activity and social well-being.

Finally, if the purpose of this study is purely economic, the link to public accounting should also be considered. As Oustani *et al* (2009) point out, "several factors that have a direct effect on the value of an asset are ignored by the accounting technique". However, as stated by the *International Accounting Standards Board (IASB),* the two fundamental principles of accounting information are relevance and fair representation. In other words, financial information can be used to predict future results and/or confirm past results and must give a true and fair view of what it is intended to represent. Given the close link between national accounts and the State budget, it is conceivable that accounting standards may not be suitable for the analysis of atypical projects such as infrastructure investment projects. However, as Jones *et al* (2012) point out, this topic has been little explored in the academic literature [8].

Recommendation 3 Conduct an exploratory analysis to determine whether the accounting standards make it possible to take into account the specific features of infrastructure investment projects.

8. *'However, infrastructure reporting remains one of the most neglected topics in the accounting literature".*

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❑ SOCIO-ECONOMIC EVALUATION OF projects

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TABLES AND FIGURES

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ANNEXES

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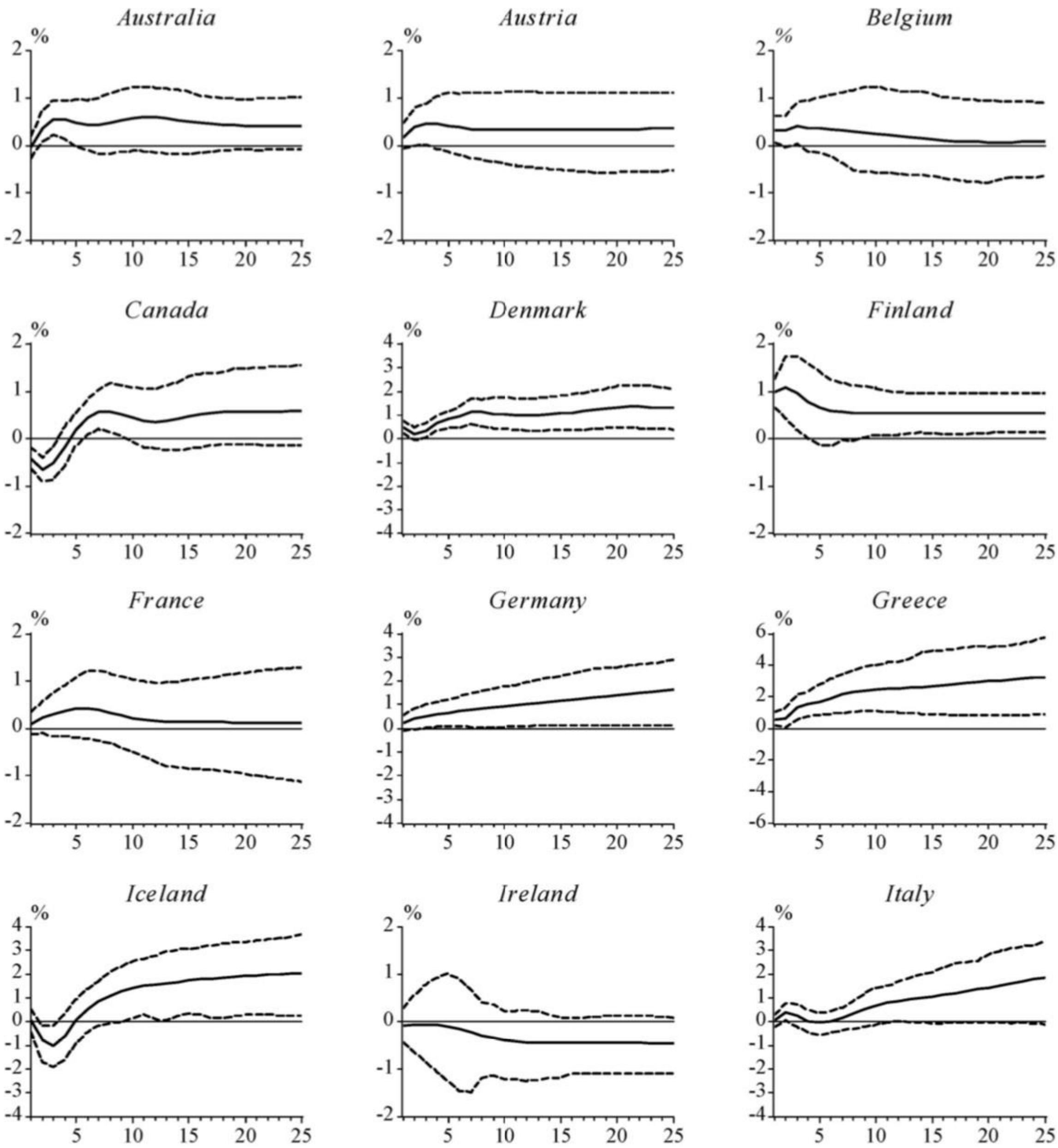
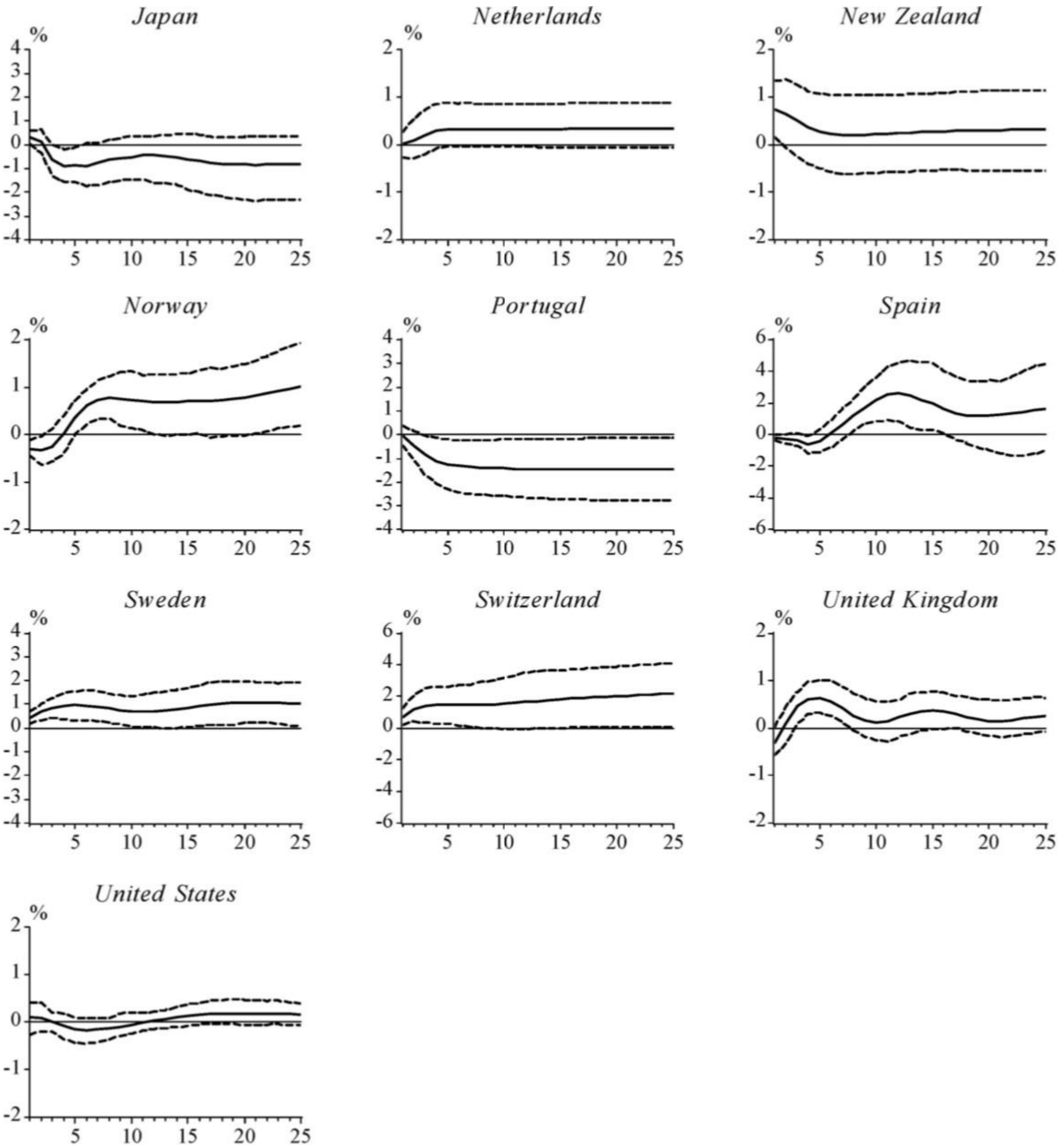
A. THE IMPULSE RESPONSE OF 22 OECD COUNTRIES TO INFRASTRUCTURE INVESTMENTS - KAMPS (2005)




Japan
Netherlands
New Zealand
Norway
Portugal
Spain
Sweden
Switzerland
United Kingdom
United States
%

B. FREQUENT ERRORS FOR EACH OF THE SEVEN STAGES OF A CBA EUROPEAN COMMISSION(2014)

1. Description of the economic, social, political and institutional context in which the project will be implemented.

(The socio-economic context and statistics are presented without explaining their relevance to the project.

(Socio-economic statistics and forecasts are not based on readily available official data and forecasts.

(Political and institutional aspects are considered irrelevant and are not sufficiently analysed.

2. Definition of objectives

(The economic effects taken into account in the CBA do not correspond perfectly to the specific objectives of the project.

(The objectives of the project are confused with its results.

(Where the objective of the investment is to achieve a certain level of compliance, the contribution of the project to achieving compliance is not indicated.

3. Project identification

(Artificial project splitting is adopted to reduce the project's investment cost to below the major project threshold.

(Artificial oversizing of projects

(Artificial undersizing of projects to support a request for financial assistance

(Biased evaluations due to unrealistic assumptions

(The institutional structure of project operations is not clearly presented.

(The benefits of a second phase of the project are sometimes included in the economic analysis of the first phase without the additional costs also being considered.

4. Technical feasibility & environmental sustainability

(a) Demand Analysis

(The methodology and parameters used to estimate current and future demand are not explicitly presented or justified or deviate from national standards and/or official forecasts for the region or country.

(Assumptions about user growth rates are too optimistic.

- Market analysis is often insufficient or incomplete, which can lead to an overestimation of revenues.
- The link between demand analysis and project design capacity (supply) is absent or unclear.

(b) Analysis of different scenarios

- The different options of the project are analyzed but not evaluated against an alternative scenario. The identification of possible alternatives is done "artificially"...
- Lack of "strategic thinking": project scenarios are not considered in terms of possible alternative means to achieve the objectives.
- The criteria used to screen project options are too numerous or irrelevant.

(c) Environmental and climate change considerations

- There is no consistency between the scenarios analyzed in the CBA and the scenarios analyzed in the EIA.
- Project cost does not include the cost of mitigation and/or adaptation to climate change and other environmental impacts.
- The benefits of mitigation measures are not adequately considered.

5. Financial Analysis

- Replacement costs are not included in the calculation of net book values.
- The total cost of the investment is not always in line with the values presented in the CBA.
- Costs related to the protection of archaeological remains at the project site, as well as costs related to environmental integration and climate change adaptation measures are not included in the project cost.
- VAT is included in the financial analysis even if it is recoverable.
- Amortization of assets, interest and loan repayments, VAT and income tax, and dividends paid to shareholders are included in operating and maintenance expenses.
- Grants received to cover (part of) operating costs are included in the calculation of the EU contribution as revenue.
- Fees received by governments in exchange for goods or services rendered are confused with transfer payments and excluded from revenues.

- In the calculation of the financial rate of return on public capital, cash flows related to replacement costs are accounted for twice: as operating expenses and as a capital contribution from the project proponent.
- For loans related to project financing, the terms and conditions of the loan are not explained.
- Nominal interest rates are used to calculate interest payments when the analysis is done at constant prices.

6. Economic analysis

- In the economic analysis, a zero cost is given to the opportunity cost of land owned by a local municipality, although it may have value for other uses (for example, it may be leased to local farmers).
- Conversion factors are derived from those used in other countries without justification.
- Tariff revenue is included as an economic benefit in addition to the marginal willingness of consumers to pay for the service rendered.
- The "incremental" economic benefits of the project are not isolated, i.e. benefits that are not displaced from other markets. This is particularly evident in cases where attempts are made to measure secondary indirect impacts.
- With the application of the notional wage on the cost side, the benefits of job creation are included on the benefit side.
- Revenues from the sale of green certificates are included with the external benefit of avoiding greenhouse gas emissions.

7. Risk Assessment

- Risks beyond the control of the project proponent or other stakeholders (i.e. changes in legislation) are neglected in the analysis, although they may contribute substantially to the success or failure of the project.
- Variables that are too aggregated (e.g., overall benefits) are considered in the sensitivity and risk analysis. Therefore, it is not possible to identify the parameters on which prevention and mitigation measures have focused.
- Irrespective of the type of analysis, prevention/risk mitigation measures are not identified.
- The discussion of risks is often too general, with no mention of their causes, probability of occurrence and impacts.

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- There is no identification of the risk "manager", i.e. the function responsible for implementing the identified risk prevention/mitigation measures.

C. AN EXAMPLE OF CBA: THE A507 NORTHERN RING ROAD IN MARSEILLE, FRANCE

❑ Description of the project

Creation of a bypass around the city of Marseille by creating a motorway link between the A7 motorway (North motorway, from Marseille to Aix-en-Provence) and the A50 motorway (East motorway, from Marseille to Aubagne). The L2 bypass is divided into a northern and an eastern section.

❑ Scenario definition

-Scenario 1: Construction of L2 North only

-Scenario 2: Construction of the complete program (L2 North and L2 East)

❑ Scenario 1 - Identification and calculation of the net present value of the costs and benefits associated with the project.

Discounted sum of costs and advance payments

tages per position and per actor in **Me** (2006 constant)	Users *VL∗*	Users *PL∗*	Operators TPC/TPS∗	Communities	Power public	Partner private
Investment incl. VAT					0	-570,2
investment VAT					111,8	
Time saving	3 383,2	323,4				
Toll Gain	157,7					
Security gain				15,3		
Air pollution gain				-32,2		
Greenhouse effect gain				-34,5		
Fuel gain	108,5	55,6				
Vehicle maintenance gain	-137,5	-10,6				
Gain malus discomfort	48,3					
VAT benefits *carburant∗*					9,6	
VAT benefits maintenance *véhicule∗*					-41,9	
Benefits of *TIPP∗*					-30,9	
Benefits on toll revenue			-126,8			
Operating costs					0	-41
Rents						
Discounted profit before investment-	3 560,3	369,4	-126,8	-51,4	-63,2	-41
Discounted profit with investment-	3 560,3	369,4	-126,8	-51,4	-63,2	-611,3

fib
∗: LV: light vehicles, HGV: heavy goods vehicles; TPC: tunnel prado-carénage; TPS: tunnel prado-sud; VAT: value added tax; TIPP: domestic consumption tax on petroleum products.

❑ Scenario 1 - Calculation of socio-economic indicators for the project

Updated investment	-570 **million**
Updated benefits	3,386 **million**
VAN	2816 **million**
Socio-economic IRR	16,9%
Immediate rate of return	11,4%
NPV per euro invested	4,9

❑ Scenario 2 - Identification and calculation of the net present value of the costs and benefits associated with the project.

Discounted sum of costs and advance payments

tages per position and per actor in **Me** (2006 constant)	Users *VL∗*	Users *PL∗*	Operators TPC/TPS∗	Communities	Power public	Partner private
Investment incl. VAT					-672,9	-640
investment VAT					257,3	
Time saving	5 970,7	579,7				
Toll Gain	194,8					
Security gain				26,8		
Air pollution gain				-37,4		
Greenhouse effect gain				-30,2		
Fuel gain	159,8	49,6				
Vehicle maintenance gain	-219,2	-29				
Gain malus discomfort	96,6					
VAT benefits *carburant∗*					17,4	
VAT benefits maintenance *véhicule∗*					-50,9	
Benefits of *TIPP∗*					-38,2	
Benefits on toll revenue			-126,8			
Operating costs					-592,9	-107,1
Rents						
Discounted profit before investment-	6 202,7	600,3	-156,6	-40,7	-664,6	-107,1
Discounted profit with investment-	6 202,7	600,3	-156,6	-40,7	-1 080,1	-747,1

❑ Scenario 2 - Calculation of project socio-economic indicators

Updated investment	**-e1,**313 **million**
Updated benefits	**e** 5,834 **million**
VAN	4,521 **million**
Socio-economic IRR	10,6%
Immediate rate of return	14,2%
NPV per euro invested	3,4

D. DRAFT SOCIO-ECONOMIC ASSESSMENT MODEL PROPOSED BY V. PIRON

TABLE5 - Definition of the types of contracts taken into account in the V. Piron model

Type of contract	Traditional	Traditional and toll	D&B	DBOM	DBOM & toll	PFI	PFI & toll
Task of the private partner							
Design	No	Yes	Yes	Yes	Yes	Yes	Yes
Build	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Finance	No	No	No	No	Yes	Yes	Yes
Operate	No	No	No	Yes	Yes	Yes	Yes
Maintain	No	No	No	Yes	Yes	Yes	Yes
Cost optimization	No	Yes	Yes	Yes	Yes	Yes	Yes

Type of contract	Concession 1	Concession 2	Concession 2	Concession 4	Shadow toll	RABC
Task of the private partner						
Design	Yes	Yes	Yes	Yes	No	No
Build	Yes	Yes	Yes	Yes	No	No
Finance	Yes, partially	Yes	Yes	Yes	Yes	Yes
Operate	Yes	Yes	Yes	Yes	Yes	Yes
Maintain	Yes	Yes	Yes	Yes	Yes	Yes
Cost optimization	Yes	Yes	Yes	Yes	Yes	Yes

TABLE6 - Socio-economic evaluation of a fictitious project for the construction of a new motorway with a budget discount rate of 3%.

Type of contract	Traditional	Traditional and toll	D&B	DBOM	DBOM & toll	PFI	PFI & toll	Concession				Shadow toll	RABC
								1	2	3	4		
Initial estimated budgetary Cost of the main contract (VAT incl.) base case (work period)	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800
Discounted final Cost of the main contract only (VAT incl.) (work period)	-854.93	-854.93	-721.12	-669.08	-669.08	-1268.89	-1268.89	-74.34	-22.30	-22.30	-22.30	-1375.01	-22.30
Discounted Cost of the tasks under Public responsibility (NPV over 35 years period)	-366.59	-366.59	-351.05	-352.59	-352.59	-352.59	-352.59	-286.62	-286.62	-286.62	-286.62	-286.62	-286.62
Discounted Operation and maintenance costs for the State budget (NPV over 35 years period)	-341.19	-383.83	-250.20	-268.68	-311.33	-61.60	-71.38	-71.38	-71.38	-71.38	-71.38	-71.38	-75.03
NPV of end user revenues for SPV during contract life	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1289.64	1233.27	1233.27	1330.70	0.00	1414.33
NPV of end user revenues for the State during 35 years	0.00	1211.52	0.00	0.00	1211.52	0.00	1211.52	0.00	0.00	0.00	0.00	0.00	0.00
Fiscal cost (or benefit) of a WPP with fiscal revenues (NPV over 35 years)	-446.00	1025.76	-213.84	-187.09	1284.66	-630.14	571.61	599.99	592.02	569.75	493.95	-711.90	673.94
Fiscal cost (or benefit) of a WPP without fiscal revenues (NPV over 35 years)	-1562.71	-90.95	-1322.37	-1290.35	181.41	-1734.28	-532.53	-533.67	-541.64	-563.91	-511.61	-1845.56	-472.81
Maximum Fiscal Cost with risks and guarantees	-1562.71	-1302.47	-1322.37	-1290.35	-1030.11	-1887.62	-1584.74	-1143.65	-1133.91	-1108.90	-1068.87	-2015.78	-1147.59
Percentage of grant compared to cost of work and studies	112%	112%	101%	97%	97%	7%	7%	13%	21%	23%	17%	14%	11%
IRR socio economic for the Country	19%	20%	21%	21%	22%	23%	24%	25%	25%	24%	22%	23%	24%
IRR for the private company						14%	13%	16%	18%	17%	17%	14%	14%
IRR for the State budget with fiscal revenues	-3%	7%	-1%	-1%	9%		10%	14%	14%	13%	14%		20%
IRR for the State budget without fiscal revenues		0.01			0.02		-0.02						
Payback for the State with fiscal revenues	Never	18.00	Never	Never	15.00	Never	17.00	10.00	11.00	11.00	11.00	Never	8.00
Financial position for the State End of the works, with fiscal revenues	-1012.08	-1012.08	-893.31	-840.94	-840.94	-159.15	-159.15	-227.11	-235.96	-260.69	-202.59	-181.77	-140.90
Financial position for the State After 5 years of operation, with fiscal revenues	-1020.14	-977.31	-892.41	-840.30	-799.50	-451.34	-191.53	-199.61	-208.59	-233.70	-179.14	-508.90	-112.11

Source: V. Piron

TABLE7 - Socio-economic evaluation of a fictitious project for the construction of a new motorway with a budget discount rate of 0%.
Source: V. Piron

Type of contract	Traditional	Traditional and toll	D&B	DBOM	DBOM & toll	PFI	PFI & toll	Concession				Shadow toll	RABC
								1	2	3	4		
Initial estimated budgetary Cost of the main contract (VAT incl.) base case (work period)	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800
Discounted final Cost of the main contract only (VAT incl.) (work period)	-920	-920	-776	-720	-720	-1928.5793	-1928.5793	-80	-24	-24	-24	-2098.0872	-24
Discounted Cost of the tasks under Public responsibi lity (NPV over 35 years period)	-473	-473	-457	-458.6	-458.6	-458.6	-458.6	-359.4	-359.4	-359.4	-359.4	-359.4	-359.4
Discounted Operation and maintenance costs for the State budget (NPV over 35 years period)	-595.2	-669.6	-436.48	-468.72	-543.12	-151.2	-175.2	-175.2	-175.2	-175.2	-175.2	-175.2	-184.16
NPV of end user revenues for SPV during contract life	0	0	0	0	0	0	0	1289.64	1233.27	1233.27	1330.70	0	1414.33
NPV of end user revenues for the State during 35 years	0	2160.39	0	0	2160.39	0	2160.39	0	0	0	0	0	0
Fiscal cost (or benefit) of a WPP with fiscal revenues (NPV over 35 years)	-121.73	2504.35	188.19	204.67	2830.75	-740.54	1395.85	1186.09	1177.52	1153.56	980.35	-844.08	1260.64
Fiscal cost (or benefit) of a WPP without fiscal revenues (NPV over 35 years)	-1988.20	637.89	-1669.48	-1647.32	978.77	-2593.48	-457.09	-723.64	-732.21	-756.17	-699.89	-2753.81	-663.17
Maximum Fiscal Cost with risks and guarantees	-1988.2	-1522.50	-1669.48	-1647.32	-1181.62	-1887.62	-1347.52	-1143.65	-1133.91	-1108.90	-1068.87	-2015.78	-1147.59
Percentage of grant compared to cost of work and studies	112%	112%	101%	97%	97%	7%	7%	13%	21%	23%	17%	14%	11%
IRR socio economic for the Country	19%	20%	21%	21%	22%	23%	24%	25%	25%	24%	22%	23%	24%
IRR for the private company						14%	13%	16%	18%	17%	17%	14%	14%
IRR for the State budget with fiscal revenues	-1%	7%	1%	1%	9%	-7%	11%	15%	14%	13%	14%	-7%	20%
IRR for the State budget without fiscal revenues		0%			2%		-3%						
Payback for the State with fiscal revenues	Never	16	31	31	14	Never	15	10	10	11	10	Never	8
Financial position for the State End of the works, with fiscal revenues	-977.60	-977.60	-862.40	-811.68	-811.68	-151.83	-151.83	-217.84	-226.41	-250.37	-194.09	-173.92	-134.33
Financial position for the State After 5 years of operation, with fiscal revenues	-968.53	-928.03	-848.20	-798.53	-758.03	-420.86	-178.67	-187.17	-195.74	-219.70	-167.80	-474.92	-103.66

Source: V. Piron