To what extent are rail investments desirable for tackling climate change?

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Climate change has increased the opportunities to invest in rail transport. However, the impact of the shadow price of carbon on the socioeconomic evaluation of projects is far more pronounced for freight than for passengers.

Public investments are not driven exclusively by maximising financial returns. A benevolent authority should also consider the welfare implications of its decisions, notably the impact on externalities. During the last few decades, pressure has grown on policy makers to tackle climate change. Rail services are relatively efficient in terms of carbon emissions and they can play a critical role in achieving climate change mitigation. In this article, we investigate whether rail investments are an economically desirable means of limiting climate change. The first section of the paper briefly presents the long-tradition of cost-benefit analysis (CBA) in France. The second section exhibits the role of climate change in the traditional CBA. The third section highlights the rising role of climate change in socioeconomic analysis. Finally, the fourth section points out two factors that may counterbalance this evolution.

I. Cost-Benefit Analysis in France

For economists, CBA is a common way of assessing the social desirability of a project or a public policy. In France, the practice of CBA has a long-standing tradition. Jules Dupuit, the nineteenth-century French engineer, is considered as the precursor of modern cost-benefit analysis. CBA is also a well-established practice for transport infrastructure and it is mandatory for major public investments.

From a technical point of view, CBA is based on complex engineering that estimates the total costs and benefits of an investment for the society. Of course, given the long-term impacts of transport investments, this calculation is realized for a long period (N years). Moreover, it not only considers the market consequences of a project, but also internalises a broader variety of impacts. For a transport infrastructure, it notably considers non-monetised costs and benefits like time savings or environmental externalities. Hence, this calculation requires a framework that sets the monetary value for these externalities. In France, CBA is regulated by a common framework, set by the government, for every transport investment (rail investment, airports, or highways).

This framework is regularly reassessed by reports commissioned by the French Government. This is why there is a collection of reports, beginning with the reports prepared by Marcel Boiteux in 1994 and 2001, that establishes the doctrine of the French cost-benefit analysis.

This framework has been updated by a series of thematic reports focusing on discounting (Lebegue, 2005) or on the shadow price of carbon (A. Quinet, 2009). More recently, a commission chaired by E. Quinet (2013) pursued this tradition reviewing the practice of cost-benefit in France. Thereafter, the French Government published a new framework for cost-benefit analysis at https://www.ecologique-solidaire.gouv.fr/evaluation-des-projets-transport. In 2018, a commission chaired by Alain Quinet was initiated to review the shadow cost of carbon.

II. The Traditional Role of Climate Change in CBA

Historically, climate change has only had a marginal impact on CBA. This is particularly true for investments in high-speed lines as illustrated by the economic appraisal of the new line between Vaudrecourt and Strasbourg (Figure 1). This project, which has been underway since December 2016, is the second phase of the high-speed line between Paris and Strasbourg. It represents 106 km of railways and costs €2.1 billion. The modal shift from air or car transport to rail provides a benefit in term of greenhouse gases emissions. According to the framework in force in 2004, this benefit only represents 1.4 percent of the total cost of investment. In other words, modal shift provides a reduction of greenhouse gases emissions, but only has a marginal impact on CBA.

However, carbon emission reduction can have a significant impact on CBA for investments in a certain type of rail services. This is notably the case for investments dedicated to freight services. Figure 1 illustrates this point with

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the project between Serqueux and Gisors. This project, which is estimated to cost €230 M, consists of enhancing and electrifying an existing regional line in Normandy (approx. 50 km). It will improve the quality of the railway for freight trains between Le Havre, one of the main French maritime ports, and the Paris region. For this project, the benefit in terms of greenhouse gases emissions is significant and represents 25 percent of the cost of investment.

However, regarding the controversy over the value of the public discount rate, this commission did not take the side of those who estimate that discounting is not ethical. The arguments advanced by the commission were based on market considerations. More specifically, the value recommended by Lebegue (2005) was derived from the standard Ramsey (1928) formula:

\[ r = \delta + \gamma \mu \]

where \( r \) is the social discount rate, \( \delta \) is a combination of pure time preference \((\delta = 1\%)\), under which the future affects would be eliminated or severely altered, \( \gamma \) is the elasticity of marginal utility of consumption \((\gamma = 2\%)\) and \( \mu \) the economic growth rate \((\mu = 1.5\%)\).

More recently, a report by E. Quinet (2013) reassessed the social discounting rate used for CBA. It recommended the use a constant social discount rate of 4.5 percent, including a risk premium (which was not the case in the previous rate). This rate is currently considered for public evaluation in France.

B. The Shadow Cost of Carbon

Like any non-market good, the inclusion of the climate change in CBA supposes a monetisation of this damage. The recognition of this issue was progressively completed during the last two decades. Many developed countries have defined a social cost of carbon for CBA. In the United States during the 2000s, for instance, a wide range of values were used by governmental agencies such as the Department of Transport (DOT), the Department of Energy (DOE) or the Environmental Protection Agency (EPA) to take into account this element in economic appraisal. These divergences ended in 2009 with an interagency process that provides an assessment of the social cost of carbon.

In France, a first set of value for the shadow price of carbon was defined by a French official guideline at the beginning of the 2000s (Boiteux, 2001). Since then, this value has been reconsidered by a specific working group commissioned on this topic chaired by Alain Quinet (2009).

This commission did not apply the standard Pigovian approach to estimate the social cost of carbon (that is, the present value damages of the marginal emission). Instead, it applied an alternative method, also known as the cost-effectiveness method, in which the shadow price of carbon is set on the basis of exogenously determined emission reduction objectives, namely carbon neutrality. In this approach, the shadow price of carbon is the value of carbon that is

### Figure 1. Climate change benefits

(Source: Authors’ own compilation (using the CBA framework of 2004))

<table>
<thead>
<tr>
<th>Benefit in M€</th>
<th>% of Invest.</th>
</tr>
</thead>
<tbody>
<tr>
<td>New high-speed line Paris–Strasbourg</td>
<td>35 M€</td>
</tr>
<tr>
<td>Electrification of Serqueux–Gisors line</td>
<td>72 M€</td>
</tr>
</tbody>
</table>

In conclusion, according to the traditional CBA, rail investments are generally not an efficient means of tackling climate change. These investments are very costly compared to their return in greenhouse gases savings. The main socioeconomic benefit of high-speed lines is time savings. However, there are some exceptions; for instance, the impact of climate change may be noticeable for freight projects since there are no equivalents to time savings for this kind of project.
necessary to introduce in order to achieve the emission reduction objective.

Given the French objectives in terms of CO\textsubscript{2} reduction, the commission chaired by Alain Quinet (2009) recommended considering a social value of carbon of €100\textsubscript{2008}/tCO\textsubscript{2} in 2030. A new commission, also chaired by Alain Quinet, is currently reviewing this value after the 2015 Paris Climate Agreement. According to this Commission, the shadow price of carbon should increase significantly (€250/tCO\textsubscript{2} in 2030).

C. The Optimal Path of the Cost of Carbon

Climate change also raises questions about the evolution of the social cost of carbon in the long-term. Indeed, in the CBA, the effect of discounting may offset the evolution of the social cost of carbon.

The literature has offered different contributions on this issue recently. One of its propositions is to extend a seminal model developed by Hotelling, which states that the optimal evolution of a nonrenewable resource is the discount rate. This was a notable conclusion of the commission chaired by Alain Quinet (2009) devoted to the shadow price of carbon.

Thus, greenhouse gases emissions can be treated as a non-renewable resource. The objective of Paris agreement is to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels. A greenhouse gases concentration level can be defined in order to correspond to this objective, and greenhouse gases emissions forbidden above this level. Therefore, the optimal rule for carbon emissions is the application of Hotelling principle: the percentage change of the social cost carbon should equal the discount rate. This practice has been institutionalised for CBA in France.

D. The Assessment Period

CBA was traditionally performed for a limited time period. An infrastructure investment was generally assessed for a period of 30 or 50 years. The benefits for the collectivity upon this period were not considered. With the increasing sensibility of society over the issue of greenhouse gases emissions, which are a long-term pollution, several authors have suggested that we should adapt CBA and value the long-term effects of policies and investments.

In this context, the French guideline for CBA has been recently adapted. The commission chaired by E. Quinet (2013) suggested enlarging the period of assessment. It proposes calculating the costs and benefits until 2070 and, upon this date, valuing a residual value of the investment, which corresponds to the net present value of benefits for the next 70 years; that is, until 2140. In order to be consistent with the Hotelling rule, this residual value should be calculated stabilising the unit price of all costs and benefits while the social cost of carbon will continue to increase like the discount rate.

E. Application

During the last decade, socioeconomic methods have been adapted significantly in order to increase the role of carbon emissions in CBA. With this new framework, climate change represents a non-negligible impact for CBA (Figure 2). For instance, the reduction of greenhouse gases can represent 50 percent of the total cost of high-

\begin{tabular}{|l|c|c|c|c|c|}
\hline

\hline
8% & 4% & 4% & 4.5% & 4.5% \\
\hline

Shadow price of carbon & & & & & \\
\hline
in 2010 & €32/tCO\textsubscript{2} & €32/tCO\textsubscript{2} & €32/tCO\textsubscript{2} & €32/tCO\textsubscript{2} & €32/tCO\textsubscript{2} \\
in 2030 & €58/tCO\textsubscript{2} & €58/tCO\textsubscript{2} & €100/tCO\textsubscript{2} & €100/tCO\textsubscript{2} & €250/tCO\textsubscript{2} \\
in 2050 & €104/tCO\textsubscript{2} & €104/tCO\textsubscript{2} & €180/tCO\textsubscript{2} & €180/tCO\textsubscript{2} & €775/tCO\textsubscript{2} \\
\hline

Long run growth of the shadow price of carbon (\% p.a.) & 3% & 3% & 4% & 4.5% & 4.5% \\
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Period of assessment & 50 years & 50 years & 50 years & Until 2140 & Until 2140 \\
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\end{tabular}

Figure 2. Evolution of socioeconomic methods

Source: Authors’ own compilation
The above can lead to the conclusion that rail investments are very desirable in order to achieve carbon neutrality. However, such a conclusion may be fallacious. The opportunity of rail investment is counterbalanced by two issues: the inclusion of construction phase emissions and the evolution of emission factors.

Firstly, a series of studies recently highlighted that the construction of a new high-speed line is responsible for massive CO₂ emissions. In certain circumstances (such as large tunnel sections and low traffic sections), these emissions may offset the reduction of emissions provided by modal shift. For CBA, it suggests that we should also take into consideration the construction phase emissions, which have often been ignored until now. There was no rationale for this practice except that environmental issues were not monetised in CBA or their value was very low. Nowadays, this is no longer the case. Environmental externalities are not negligible, so it is essential to value their cost during both the operation phase and the construction phase.

Secondly, the objective of a strong reduction of CO₂ emissions questions the reference scenario of the CBA. In accordance with the Paris Agreement, France aims to cut off its greenhouses gas emissions by achieving carbon-neutrality in 2050. In this context, the sector of transport will have to change drastically. The road transport, aviation, and maritime industries will have to significantly reduce their contributions to climate change. For instance, the generalization of electric vehicles can reduce the environmental footprint of road transport.

This yields to a relatively counter-intuitive conclusion for socioeconomic analysis. Public transport would have no advantage in terms of CO₂ emissions relative to private decarbonised cars. Therefore, carbon neutrality would reduce the opportunity to invest in low-carbon infrastructures. Figure 4 presents the result of CBA assuming that road transport reaches carbon neutrality in 2050. In these circumstances, the impact of modal shift in terms of CO₂ emissions reduction is less obvious. Hence, investing in rail transport is less desirable.

V. Conclusion

Ultimately, this analysis suggests that rail investments are not necessarily an efficient means of tackling climate change, notably if road transport is decarbonised.

However, one should note that there is considerable uncertainty when looking at long-term emission factors. The evolution of dirty modes of emission factors is very uncertain. Replacing fossil fuels by decarbonised energy is challenging, notably for aviation or maritime transport. This complexity stresses out the importance of the reference scenario for CBA. Traditionally, this was been a critical topic because of the impact on CBA of the macroeconomic context (prices, GDP). With climate change, the evolution of emission factors becomes a critical issue of the reference scenario.

Moreover, we should also point out that rail investments may be an efficient policy for certain services. It is likely that time savings remain the principal advantage of CBA for high-speed investments. However, rail investment can play a role in tackling climate change for certain services, such as freight transport. For these services, the decarbonisation of alternative modes (such as maritime transport) is less obvious. Therefore, rail investment may be an efficient means of reducing the impact of freight transport on climate change. This notably includes several enhancement investments on the existing network that are much more environmentally friendly in the construction phase than a new line.
References


