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COST BENEFIT ASSESSMENT OF PUBLIC INVESTMENTS

Report of the mission chaired by **Émile Quinet**

SUMMARY AND RECOMMENDATIONS

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Cost benefit assessment of public investments

Final Report
Summary and recommendations

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Foreword

The following pages are taken from The Final Report of the mission chaired by Émile Quinet, *L'évaluation socioéconomique des investissements publics* (volume 1), under the aegis of the Commissariat général à la stratégie et à la prospective (CGSP).

The full report (in French) is available at:
www.strategie.gouv.fr/blog/2013/09/rapport-levaluation-socioeconomique-des-investissements-publics/

A second volume (also in French), offering studies by various authors and experts, is available at:
www.strategie.gouv.fr/blog/2013/10/rapport-l-evalution-socioeconomique-investissements-publics-tome-2/

About the CGSP

Reporting to the Prime Minister's Office, the Commissariat général à la stratégie et à la prospective constitutes a place of exchange and consultation and assists in determining the main directions for the future of the Nation and the medium and long term objectives for its economic, social, cultural and environmental development., it contributes to the preparation of the reforms decided upon by the authorities.

Summary

1. The usefulness of cost benefit assessment

Public spending on investment represents approximately 15% of total investment in France. It concerns sectors essential for the development of our society, such as transport, energy, health and education. Over the long term, sometimes on the scale of several centuries, these investments will shape the fundamental character of the country, the quality of its environment and its ability to meet future challenges. This underscores the importance of making decisions in the most informed manner possible, making the best evaluation of the benefits they will provide and the costs they will engender, especially since their funding is largely based on public funds, a scarce resource in general and even more so today. This explains why the State has long been concerned with developing and regularly revising the methods for carrying out these evaluations.

The commission responsible for the work presented here is part of a long tradition, beginning with the first reports prepared by Marcel Boiteux in 1994 and 2001[1]. This collection of reports established the general doctrine and enabled progress on specific subjects, such as the discount rate, taking risks into account and the shadow price of carbon.

That doctrine is based on simple principles that were conceived long ago *(see box below).* They consist of assessing the effects of each project for the nation as a whole, evaluating the gains in productivity or production capacity made available to enterprises, as well as increases in consumption of products and improvements in quality of life provided to citizens, and comparing these effects with the costs of investment.

The principles of cost benefit project assessment

Cost benefit project assessment seeks to assess the utility of each project for the nation as a whole and to prioritise projects in view of their implementation. For this, we must first identify the agents within the national community that are concerned. We must then analyse the consequences of the project for each of the categories thus identified, and then evaluate these consequences in monetary terms. Finally, we must make a judgment concerning the positive and negative consequences.

(1) Boiteux M. (1994), *Transports : pour un meilleur choix des investissements (Transport: for a better choice of investments)*, Commissariat général du Plan; Boiteux M. (2001), *Transports : choix des investissements et coût des nuisances (Transport: choice of investments and disamenities' costs)*, Commissariat général du Plan, Paris, La Documentation française.

The categories of agents most frequently encountered are the State, which finances all or part of the investment spending and collects taxes and fees; companies, which generally see their costs reduced or their production capacity increased as a result of the investment; individual consumers, for whom the investment will result in lower prices for the products they consume, or an increase in their income (e.g. in the case of an investment in education), or an improvement in their quality of life (e.g. in the case of environmental consequences).

We must then estimate the positive or negative impact on these agents in quantitative terms. For example, environmental impact will be measured by the quantity of pollutants or noise emitted. In the health domain, the effects can be measured by the number of patients cured and the years of life gained.

The monetisation phase follows. When market goods are concerned, statistics can provide a price, observed in the market. But this price does not necessarily correspond to the actual cost of the good for the entire national community. For example, consider a product for sale in the market at a price of 100. If investment allows one additional unit to be produced at constant cost, but subject to a public subsidy of 40, the consumption of an additional unit will provide a benefit – not of 100 – but of 100 - 40 = 60. Investments often have effects that do not pass through the market, such as effects on the environment, for which there is no market price; we are thus obliged to calculate their cost or valuation. Different general methods exist to assess the effects on the environment. A good number of them seek to evaluate, for agents subjected to those effects, how much they would be willing to pay in order to avoid being subjected to them. There is often a difference between market price and cost for collectivity, and it is obviously this later that should be taken into account.

Thus, the evaluation of benefits comes down to determining the gains in productivity and competitiveness for businesses or the augmentation of their capabilities made possible by the investment, and for consumers, the increased consumption and greater welfare resulting from its implementation.

Finally, we must simultaneously consider these costs and benefits to derive criteria for project evaluation. However, the costs and benefits of these investments are spread out over time: roughly speaking, the project has costs at the beginning for its construction and provides benefits throughout its life cycle. We must therefore compare the costs and benefits that take place at different times. This is where we use the discount rate, which expresses the value of euros spent or earned in different years by linking their value to a single date. The discount rate therefore has a central role, since it represents the trade-off between the present and the future: a high rate gives the future a low weight, a low rate signifies heightened concern for future generations.

In this process, the monetisation phase is the most problematic. One sometimes hears the opinion that the market price or the calculations of willingness to pay used in the cost benefit project assessment do not reflect concerns about justice or ethics in the relative valuations of different goods. Economists do not enter into political or philosophical debates. We simply point out that changing the market price of the production system can induce distortions for which the consequences are difficult to predict and may often go contrary to the initial goal. For example, concerns about justice can be addressed by other avenues, such as tax policy. In any case, obtaining information on willingness to pay is useful, if only to evaluate the distortion between the natural balance and values that public authorities may wish to impose. Nevertheless, when there are effects corresponding to a reliable qualitative or quantitative estimate, but which, for ethical or technical reasons, we cannot or will not valuate, it would be improper if those effects were not brought to the attention of decision-makers. That is the view of this report concerning spatial, macroeconomic and distributional effects.

These principles will certainly be acknowledged, but the real challenge is in their implementation, which so far has not delivered on its intentions. Evaluations, carried

out by increasingly diversified providers, have been based on divergent methodologies, thus making comparisons between projects uncertain. Improvements to these methodologies, desirable in themselves, have led to increasingly complex procedures that have not been accompanied by efforts to promote clarity and transparency. Finally, some recent advances in economic analysis, especially in the realms of industrial economics, macroeconomics and spatial economics, have not been taken into account. In sum, we find that the procedures implemented are complex and in certain ways obsolete and insufficiently explained. They do not answer decision makers' questions, and therefore do not gain their support. In addition, such evaluations are being applied in fewer domains; today, they are only used systematically for the transport sector. Given these circumstances, it is not surprising that economic calculations have little weight in public investment decisions.

This report is based on that observation, and it recommends a set of measures to address these shortcomings. The changes and additions recommended in this report concern evaluation techniques, but also governance: the inclusion of these techniques in the decision-making process.

2. Technical recommendations

In technical terms, this report makes four recommendations.

Substantially increase the valuation of amenities

As part of this report's overall revision of unit values, the weighting of amenities has been increased significantly. Therefore, the **value of statistical life**, a parameter used when we evaluate the utility of measures that reduce the risk of accidental death, is increased by nearly 100% compared to previous values. Similarly, the costs of **air pollution** and **noise pollution** are increased by approximately 50%. Also, the **shadow price of carbon** grows more rapidly over time. Finally, this report examines how **biodiversity** can be taken into account and recommends that, given the difficulties in evaluating the impact of biodiversity loss, it should be integrated in the form of the cost of maintaining its current level.

Consider a broader range of effects

This broadening takes several directions. The first concerns the effect of investments on **the level of market competition**: many investments – particularly for transport – have the consequence of reducing market power and increasing competition, largely benefiting consumers who consider that increased market competition is reflected in the prices they pay. The second concerns the **positive externalities**, such as **agglomeration externalities**, which lead to greater efficiency of the production system; but there are many other positive externalities. The effects of public investment on **economic growth and employment** are also of great relevance to decision makers. This report provides guidance of a rather qualitative nature on this subject, and, above all, helps to explain that these effects are limited in time (primarily concerning the construction of infrastructures) and space (surrounding the geographical location of these infrastructures). Finally, this report provides guidelines for considering the distributional effects of investment by focussing on their impact on pockets of unemployment and poverty.

Systematically integrate uncertainties

A previous report[1] defined principles for taking risk into account, yet they have barely been implemented. The present report provides practical tools for their implementation. We must fight against **optimism bias**, the scourge of project evaluations, even if we are perhaps a little less prone to it than many countries are. This report suggests several solutions, based on expertise and lessons learned. We must also better **understand the current risks**, resulting from imperfections in forecasting methods, poor data quality, and uncertainties in the exogenous variables (e.g. economic growth forecasts, changes of certain governing factors in costs, such as the price of oil). Scenario methods widely used by private operators in their financial studies should be brought to bear on the cost benefit assessment. Finally, the **systemic risk** resulting from the links, more or less strong, between the benefits of an investment and economic growth, must be carefully considered because its effects are felt amongst multiple projects: those whose benefits are positively correlated with growth amplify fluctuations, while others have a stabilising effect and should be favoured. This report proposes two methods for considering this: the first, which should be applied to all projects, is to implement in cost benefit assessment methods inspired by those used in finance, thus introducing a **risk premium** in the discount rate; the second, which provides more precise information on the behaviour of large projects, considers a risk premium at the level of costs and benefits flows, based on the use of standardised scenarios.

Evaluate investments in a long-term perspective

Today, we are undergoing, or just beginning, many transitions of various natures regarding ecology, global warming, biology and the digital revolution. Therefore, it is no longer possible, as it once could have been, to extrapolate the future by assuming that development will proceed geometrically. An overall prospective study must be made concerning the future of our society and our long-term development, both in societal and economic terms. Investments must be evaluated in the context of these long-term **reference scenarios** because they determine the evolution of the benefits that each individual project will provide. In order to ensure the best choice of projects, it is essential to deploy these reference scenarios rapidly. The establishment of these scenarios will be based partially, but not entirely, on economic considerations. It is also appropriate, in many sectors, to **extend the horizon of analysis**, often limited to a few decades, in order to make it coincide with, or at least approach, the lifetime of the investments in question, which may sometimes exceed a century. This proposed extension of the horizon is all the more necessary because all analyses show that the **discount rate** which measures the weighting of the future compared to the present must be lower than what was previously the norm. This report provides values for the risk-free rate and recommends that they be implemented. That rate is **2.5% for the next few years and decreases to 1.5% in the distant future.**

(1) Gollier C. (2011), *Le calcul du risque dans les investissements publics (The calculation of risk in public investment)*, Centre d'analyse stratégique, Paris, La Documentation française.

3. Recommendations on governance

This report's recommendations on governance can be grouped into three categories.

Improve the reliability of evaluations

To this end, we must first address the technique used for calculations. The commission therefore recommends the development of **independent second opinions**, the only method capable of verifying the correct execution of complex procedures and sophisticated techniques. In the same fashion, when complex models are used, as is often the case, their expert vetting and **certification** would be a useful procedure, highlighting their advantages and limitations as well as their domains of application. In more complex situations, or when phenomena for which our experience is limited must be taken into account, running several models in parallel can be a useful procedure to reduce uncertainties. The situation also calls for new **communication efforts**, which have not been made until now, probably because communication was less crucial when the decision was essentially in the hands of a central authority.

Improve integration in the decision-making process

Insofar as the decision-making process relies increasingly on dialogue and consensus, a cost benefit assessment, if it wishes to influence that process, must be understandable. The calculations must be capable of **being explained in plain language**. This represents a radical change: a communication effort that is even more imposing because the techniques used in cost benefit assessments are becoming increasingly sophisticated. The actual communication and, even more, the education, are long-term processes and require significant resources. But the stakes are high: improving the efficiency of our public policy, particularly concerning infrastructure investment. One way to facilitate this integration is to avoid the "black box" effect, which results, in particular, from presenting a single numeric result (such as rate of return) to characterise the cost benefit assessment of a project. This report recommends presenting a **detailed breakdown of the costs and benefits** involved, and provides a project fact sheet template that addresses this concern. That breakdown of the effects should be accompanied by an **evaluation of the level of confidence** associated with each of them, even in the case of qualitative or expert advice. Finally, investment decisions should not be taken piecemeal but rather should be subject to an **overall view**, including project prioritisation, an implementation calendar and a regular revision process. This report provides the methods for establishing these priorities.

Expand the field of application for cost benefit assessment

More generally, cost benefit assessment is currently very limited in its field of use. Ideally, it should enable the comparison and ranking of all public investments. In practice, its application is limited to a small number of sectors, mainly transport and energy, and even there, often restricted to investment choices, whereas it should be able to give information for other decisions, such as those concerning regulations or pricing. Currently, it is only present very sporadically in other sectors, thus disregarding the contribution it could make to improving public decision-making. Independent of the **expansion of economic calculation to other sectors**, another expansion deserves

attention: decisions concerning **maintenance choices**. France is endowed with a public infrastructure capital that is growing as a result of investments and, given the financial constraints it is subject to, an increasingly difficult arbitration is emerging between the creation of new infrastructures and the maintenance in good operating condition of existing infrastructures. Since maintenance is not subject to economic analysis, and since patrimonial accounting is not carried out on public infrastructures, we have no objective tools to determine whether maintenance is performed at an appropriate level, and whether the creation of new infrastructures is accompanied by the destruction of existing capital, even if expert opinion suggests that is the case in numerous sectors. These considerations argue for the launch of an entirely new project: applying economic analysis to the maintenance and preservation of existing infrastructures.

4. A starting point and not a culmination

The commission's work should be considered as a starting point and not as a culmination. It should first be **converted into operational terms, providing project planners with the general principles** established in this report. This conversion should take into account both the sector and sub-sector, and the scale of the projects under evaluation: major projects or ones that are actually programmes consisting of a group of projects require heightened attention and should be subject to special procedures. **These principles should be expressed in everyday language** stripped of jargon and accessible to non-expert opinion. This constitutes both a way to use common sense to purify complex techniques, and an assurance that these techniques are understood and will provide the basis for dialogue. Finally, to ensure ongoing development of cost benefit assessment, the following elements should be put in place: a monitoring process for the progress of studies and research, an analysis of lessons learned from ex-post evaluations, among others, and a **downstream steering process for studies and research** to address the shortcomings revealed by the monitoring and analysis.

Introductory overview

Cost benefit assessment of investments is an ongoing preoccupation for public authorities. Long enshrined in the legislation concerning certain sectors[1], this requirement has been quite recently extended to all public investment in civil investments by the French *Loi de programmation pluriannuelle des finances publiques* (LPPFP, multi-year public finance planning act) of 31 December 2012[2].

France has a long tradition in this regard. On several occasions, under the aegis of the *Commissariat général du Plan* (CGP), and the Centre d'analyse stratégique (CAS) and, today, the Commissariat général à la stratégie et à la prospective (CGSP), commissions met to define and improve evaluation procedures. Their findings were then converted into instructions and directives issued by the competent authorities.

Only looking back over the past twenty years, a commission chaired by Marcel Boiteux in 1994 set down the doctrine that makes project evaluation an integral part of the doctrine of economic calculation, including the statement, still topical today, that "economic calculation, despite its shortcomings, remains the best way to evaluate investment projects." The corresponding principles have been successfully applied to environmental externalities analysis[3], setting the discount rate[4], total carbon value[5], biodiversity[6] and risk consideration[7].

(1) e.g. for transportation, the *Loi d'orientation des transports intérieurs* (LOTI, law on inland transport).
(2) The LPPFP for 2012 - 2017 stipulates in Article 17 that "civil investment projects financed by the State, public establishments, public health facilities or health cooperation organisations are subject to a preliminary cost benefit assessment. "The law also specifies that" when the total cost of the project and the share of funding provided by these public bodies exceeds the thresholds set by decree, this evaluation is subject to a prior independent second opinion." The government must submit these evaluations and the corresponding independent second opinions to Parliament.
(3) Rapport Boiteux I (1994), *Transports : pour un meilleur choix des investissements (Transport: for a better choice of investments)*, Commissariat général du Plan ; rapport Boiteux II (2001), *Transports : choix des investissements et coûts des nuisances (Transport: choice of investments and disamenities'/nuisances' costs)*, Commissariat général du Plan, Paris, La Documentation française.
(4) Rapport Lebègue (2005), *Le prix du temps et la décision publique (Valuing time in public decision-making)*, Commissariat général du Plan.
(5) Rapport A. Quinet (2008), *La valeur tutélaire du carbone (The shadow price of carbon)*, Centre d'analyse stratégique, Paris, La Documentation française.
(6) Rapport Chevassus-au-Louis (2009), *Approche économique de la biodiversité et des services liés aux écosystèmes (An economic approach to biodiversity and ecosystem services*), Centre d'analyse stratégique, Paris, La Documentation française.
(7) Rapport Gollier (2011), *Le calcul du risque dans les investissements publics (The calculation of risk in public investment*), Centre d'analyse stratégique, Paris, La Documentation française.

This report is therefore the continuation of a long series of studies based on the use of economic calculation, which have gradually adapted and enhanced it. The proposals herein respond to the mission statement that established the working group. They focus on revising the recommendations of previous reports, seeking to enhance the evaluation, leveraging advances in economics concerning domains like spatial analysis, the problems of governing evaluations and the extension of cost benefit assessments beyond their traditional sectors of application, transport and energy.

These proposals reflect the major changes affecting our economy: increased globalisation, the emergence of new economic players, the need to drive transitions in energy and the environment, concerns about the forms and instruments for public intervention in a context where regulation via competition is becoming increasingly important. These are the reasons behind a renewed evaluation of investments, which must take into account two major, and certainly long-lasting, features of the current situation.

The first is the limitation of public budgets. Numerous proposed projects significantly exceed the available funding; this motivates their cost benefit assessment. Errors are less easy to remedy; their consequences are more serious. It is imperative to justify the benefits expected from the use of public resources and the losses incurred: all factors that the economic calculation is particularly capable of assessing.

The second feature is the reduction in competitiveness of our national production apparatus. From this point of view, the cost benefit assessment is an irreplaceable tool. In essence, it evaluates the productivity gains that the project affords to the whole country[1]: in the energy sector, the cost savings for companies; in transport, widespread cost reductions for business travel and for freight shipments.

Yet, despite these arguments for expanded application of cost benefit assessment, we find that its use is limited. Experience shows that in France this assessment only takes place systematically in the transport sector[2]. It is also used to a lesser degree in the energy sector. Where it is used, wide variations are encountered in its implementation; this makes comparisons between projects difficult. The results also lack transparency and clarity, and are therefore ill-suited to advise decision makers and inform the public. As a result, decision-making processes rarely use these calculations, as vividly demonstrated during public debates. As stated in the explanatory memorandum to the aforementioned LPPFP of 31 December 2012: "Public investment is a key factor driving growth and competitiveness. Because it is also a guarantee of high-quality public service, decisions concerning public investment must be made with attention to reconciling development with the control of public finances. Investment choices today are insufficiently justified. The evaluation and decision-making procedures do not always make it possible to prioritise projects and retain the ones that will be most useful to the community".

These characteristics are found, more or less, in foreign countries and organisations studied by the commission: Germany, the United Kingdom, the Netherlands, Sweden and Norway, and the European Investment Bank (EIB). Everywhere, except perhaps at the EIB and in the United Kingdom, cost benefit assessment is expanding solely in the

(1) It thereby differs from financial evaluation, which focusses on the financial consequences of the project on one of the concerned parties, in general the infrastructure manager.
(2) This is confirmed by the inventory of civil investment projects carried out by the *Commissariat général à l'investissement* (CGI, general investment commission) at the end of 2012.

sector of transport infrastructures. The problems of transparency and clarity are also found in similar proportions, as well as reduced influence on decisions. But we also note that, in these countries, these defects constitute incentives to improve the tool, both in technical terms (obtaining more complete and reliable evaluations) and in terms of its integration in decision-making processes (making it more persuasive and more operational). There is also a trend in these countries to expand the scope of cost benefit assessment to sectors other than transport, in particular energy and health.

The following proposals target these same objectives. Above all, they are intended to ensure the technical quality of the estimates. This requires revising the numerical values being used (much of which is nearly a decade old) to take into account developments in our society and current expectations. The modalities for using the data must also be specified, to make them more consistent and to adapt them to new situations. Finally, the traditional cost benefit assessment should be enhanced so that it can benefit from advances in economic theory in several domains where decision makers have particularly strong expectations.

The rest of the proposals concern project governance. This has changed considerably under the influence of factors already visible at the beginning of the century; today their effects are combined: the increased number of players in the project development process, the growing complexity of decision-making due to public debate and multi-funding. Cost benefit assessment procedures have not completely followed the developments to which they must now adapt.

Finally, these proposals must be consistent with two major transitions to which we are committed: energy and ecology. This makes it both more difficult and more imperative to develop a long-term strategy. It is essential for project evaluation and will orient the modalities of its implementation.

These points will be developed using the transport sector as a primary example, since economic calculations are most widely used in that sector, even if the energy and health sectors will sometimes be considered. Many of these discussions can be applied to other sectors.

1. Revising and enhancing the calculation techniques

1.1. Revising unit values

The official guidelines for carrying out cost benefit assessments stipulate numerous unit values. Some are common to all sectors. This is the case for all valuations concerning health: value of human life, morbidity costs, etc. Others are more specific to each sector, such as the value of time, a fundamental parameter in the transport sector. These values vary over the years, in response to economic changes and improved knowledge, so they must be revised regularly.

These unit values play a fundamental role in project evaluation. Firstly, they assist the person performing the evaluation. They allow him to avoid having to carry out his own research on varied subjects in which he cannot be expected to have expertise. Also, they facilitate comparisons between evaluations of different projects.

They are diverse by nature. Most merely reflect agents' willingness to pay; they should therefore be calibrated in view of economic behaviour analyses, such as studies of revealed preferences or contingent valuation. Therefore, in the transport sector, the commission is proposing a new set of reference values for the valuation of travel time, consistent with the most recent studies in France and abroad. It incorporates more detail to better track the improvements in traffic forecasting models; it supports, for inter-urban travel, the increased valuation of time as a function of travel distance. It now distinguishes the values by mode and purpose for inter-urban travel and by purpose for urban travel. This report also introduces a starting point for considering parameters related to reliability and comfort, previously ignored in evaluations. We know that these parameters play an increasing role in users' behaviour and in the evaluation of many projects, particularly in public transport.

Parameters related to the public finance system also fall in this first category. They are designed to take into account imperfections in the tax structure and the shortfall of public resources. These last factors are particularly important in view of today's budget constraints, and they are therefore the object of special attention in this report, together with the revision of the opportunity cost of public funds, which measures the inefficiency in the structure of the tax system. It also focusses on the methods for prioritising projects in times of limited budgets when, for a given tax structure, tax revenue does not provide sufficient resources for public spending on all projects that merit it. This report proposes methods that are more robust than the criteria in current usage, which have lower relevance in case of strict financial constraints or when the projects being compared are of different types, as is increasingly the case. To take into account that constraint, it suggests, in particular, the introduction of a "scarce public funds" coefficient, which applies to public spending, and which should be used when public funds are insufficient to carry out all worthwhile projects[1].

A second category of unit values reflects collective choices of a political or ethical nature. The valuation system for health falls in this category (e.g. the value of a statistical life, the value of a statistical life year). Of course, the choice under consideration takes into account observed behaviour, such as decisions by agents vis-à-vis situations involving a risk of death. But it is also based on ethical aspects, such as the equality of all citizens with respect to health, or political aspects that result in emphatic public decisions, notably battles for highway safety or against smoking. The consequences of these two viewpoints converge on the choice of a single value, identical for all citizens[2], and significantly higher than previous values. The commission proposes to increase the guideline value in this domain, the value of statistical life, to 3 million euros, against 1.9 million currently[3]. It also proposes to pursue research for a qualitative evaluation of the level of health, for example using the QALY[4], as many

(1) We stress the difference between the opportunity cost mentioned above and the scarcity cost, both of which are related to public funds. The opportunity cost depends on the tax structure, regardless of its level: as the distortive effect of these taxes increases (reducing the incentive for economic activity), so does the opportunity cost. The scarcity cost depends on the level of public funding for investment: as the difference between the funds for investment and the volume of worthwhile investment increases, so does the scarcity cost. The opportunity cost applies to the project's expenditures and revenues; the scarcity cost only applies to public expenditures.
(2) This means that the community is obliged to spend the same amount to reduce the risk of death, no matter which member of that community benefits from it.
(3) This value of 1.9 million euros corresponds to the mere update in 2010 of the value recommended in 2004 and published in the circulars of the Ministry of Transport.
(4) *Quality-Adjusted Life Year*.

countries do. This evaluation would be particularly useful to better judge the utility of actions concerning health.

The choice of the value of statistical life has a direct impact on the valuation of environmental effects such as air pollution and noise pollution, to the extent that these effects have a significant impact on health. The revision that was made concerning the transport sector was based on the most recent studies, the result of international cooperation. These studies are based on *"bottom-up"* methods, which are more accurate than the *"top-down"* methods previously employed. Portability of data to the French context has been ensured. The costs of air pollution are higher than in previous estimates. In addition, this report introduces a higher differentiation related to the density of areas where the infrastructure is built. Thus, the values of pollution in dense urban areas (between 1,500 and 4,500 inhabitants per square kilometre) and very dense ones (in excess of 4,500 inhabitants, e.g. the inner ring in the Paris region) are multiplied respectively by 2 and 10, taking into account as carefully as possible impacts on both the emission zone and nearby areas affected by airborne propagation. This report also provides an initial evaluation of "upstream and downstream" effects concerning pollution emitted in the manufacture of fuel consumed for transport.

However, in terms of biodiversity, it does not appear possible, given the current state of knowledge, to provide a project-level monetary evaluation of the benefits of the resulting services – or the costs if they are reduced – despite the advances made in the Chevassus-au-Louis report[1]. In this domain, the key priority is to clearly identify the major issues related to the preservation of biodiversity at each stage of project development and public dialogue. Monetisation of services stemming from biodiversity will be based on the costs it entails in the framework of the "avoid, reduce, compensate" decision sequence that governs its management via environmental evaluation. This leads to a call for proper coordination between environmental and cost benefit assessments: the same definition of the project or programme being evaluated, the same traffic forecasting model, the same time intervals, etc. These are all quite natural conditions, but they are not always respected. It also leads to a call for additional studies and research that will permit valuation of the services resulting from biodiversity and permit the comparison between their value and the cost of obtaining them.

1.2. Standardising procedures for using unit values

Particular attention is given to the use of these unit values to calculate the surplus; this is actually the main reason for determining them. Increasingly, this calculation poses difficult problems, which we will address in the context of transport. In this sector, projects affecting several modes or sub-modes are becoming more common. Dupuit's fundamental formalisation of marginal utility, with its well-known trapezoidal graph, which concerns only one item (here a mode or itinerary), is no longer sufficient. More precise and rigorous methods must be implemented. Their robustness and accuracy must be ensured in order to avoid the risk of serious errors. This report makes proposals in that regard, which are also pertinent since the method of calculating the benefits presented by a given project are currently lacking in transparency.

These proposals concern other aspects of evaluation and are intended to standardise them and make them more transparent. They are concerned with choosing the

(1) Chevassus-au-Louis B. (2009), *op. cit*.

reference option against which the project is evaluated; this choice is often insufficiently justified, although it is crucial because it can affect evaluation indicators by an order of magnitude. The SE-NPV (Socio-Economic Net Present Value) criterion does not yield the optimal project but simply indicates if the project option chosen is better or worse than the reference option. In addition to choosing the reference option judiciously, it is recommended that the search for projects to be compared be as wide as possible, and not neglect the possibility of solutions that use existing infrastructures (improvement, operation, pricing, etc.).

1.3. Enhancing the economic calculation

Above and beyond this indispensable revision, cost benefit assessments can and should be enhanced in view of the changing world of economics to which they apply and advances in our knowledge in positive economics. Four directions will be explored here. They are designed to overcome the limits of the standard economic calculation, as explained in the box below.

The standard cost benefit assessment and the identification of effects

Cost benefit assessment as practiced today constitutes a partial analysis. It only considers the gains and losses of players in the market concerned by the investment: for a highway project, this means the users, the contractor, the State. But these gains and losses, incurred in an initial phase by those players, will spread throughout the entire economy, changing land rents, and prices and production quantities for multiple goods. Thus, the time savings for residents of the areas that benefit will be partially offset by an increase in the price of land, in favour of landowners. Similarly, a reduction in the cost of transport for goods will lead to a decline in the price of goods transported, in favour of the consumers of these goods.

It is only at the price of rather strict assumptions, which basically assume a perfect market economy, that the standard calculation of the initial beneficiaries in the market affected by the project provides the exact value of the sum of surpluses of the final beneficiaries. Thus, at the cost of these assumptions, the numeric result provided by the standard calculation is correct, but it says nothing about the final breakdown between the agents.

We draw several implications from this. The first is that, when the assumptions of perfect competition are not met, the traditional cost benefit assessment must be modified to integrate these market imperfections. This is what has long been done to integrate environmental externalities and imperfections in the tax system (via the opportunity cost of public funds); this is what this report recommends regarding agglomeration externalities and imperfect competition.

The second consequence is that, in order to understand the macroeconomic effects of a project and their time path, to identify the beneficiaries and accurately assess the redistributional effects, we must go beyond the traditional cost benefit assessment, which provides only a numeric result, and use models that provide a description of the economic mechanisms and their operation in the wake of the project's implementation.

A common feature of these directions is to include some increasingly visible features of our economic world. They also allow a better representation of projects' effects, going beyond the production of a single numeric result, and thereby responding to common requests from stakeholders in the decision. Our goal is to take them into account with the utmost rigour and to indicate the degree of uncertainty that is currently associated with their determination. We must recognise the uncertainties surrounding these new

methods, which are less proven than those in standard use, and remain judicious. But it would also be a mistake of another kind to reject consideration of the results of the economic analysis that produces them. Some of the conclusions we reach can be integrated into the cost benefit assessment: this is, as we shall see, the case for agglomeration externalities and changes in the market power of companies. Others cannot, or cannot yet, be integrated, such as effects on employment, growth or redistribution. Still others are descriptive by nature, such as the consequences of an investment on the spatial distribution of activities. When there are effects for which the qualitative or quantitative estimate is reliable, but which, for ethical or technical reasons, we cannot or do not wish to valuate, it would be an error to fail to inform the decision makers of this, if only to avoid misconceptions about these effects or to draw attention to particular consequences that economic analysis can point out. The implementation of these directions must be designed in a dynamic perspective, following a process that includes controlled experiments, reconciling progress with prudence. Although they can now provide some initial results that can be immediately integrated in the cost benefit assessment and in the decision process, these findings strongly call for studies and research to clarify and extend those first results.

Imperfect competition

First of all, particularly following structural reforms of many essential services, operators are more dynamic when faced with their competitors' decisions[1]. They develop strategic interactions that deviate from the assumption of perfect competition, adopted until now in the implementation of economic calculations, leading to situations that are generally described as imperfect competition: companies make changes in their product line, prices or quality in response to competitors' changes in these same areas. Progress in industrial economics allows these effects to be better taken into account, and to be integrated in the economic calculation. They also allow improved measurement of the benefits that consumers derive from a reduction in market power. We must take this path, as several neighbouring countries have done. This report recommends making this commitment. It shows that it is possible to enhance the surplus calculation and increase its rigour on these issues by making a few additions and modifications to the standard calculation for the collective surplus. It also shows, in the transport sector, that if the strategic reactions of players are properly taken into account, we can better understand the traffic and better design the sizes of infrastructures and rolling stock. However, this is only a first step; research and studies should be actively undertaken on this subject.

Spatial effects

Economic geography has made great progress over the past twenty years. Its results have now reached a level of maturity sufficient to make it possible, or even necessary, to integrate them with economic calculations. It would be an error not to take them into account. Economic geography can localise trends resulting from the implementation of an infrastructure. It is thus possible to describe in detail the spatial consequences of a project, e.g. in the form of maps, and thus meet the needs of citizens and their local representatives. Two types of resources enable this approach: first, the use of mechanisms that it has brought to light, including the phenomena of polarisation, which can characterise the direction and magnitude of phenomena, and second, spatial models that involve either urban areas with LUTI models *(Land Use Transportation*

(1) In technical terms, we say that they behave less and less like *"price takers".*

Integration) or intercity spatial models (such as CG-Europe or the interurban applications of the Tranus model).

One of the best-substantiated results from an econometric point of view concerns agglomeration externalities and their measurement. Numerous statistical analyses concur that there is causality between the geographical density of jobs and productivity. Thus, the concentration of activities that infrastructures facilitate results in density changes, and thereby affects the productivity of the companies concerned. This report indicates the methods to be implemented and the precautions to be taken in order to evaluate these effects and to integrate them into the economic calculation as an additional term of the standard surplus calculation. That seems particularly advisable when dealing with very large projects and programmes.

Macroeconomic consequences

Amongst the key questions raised by stakeholders are the project's effects on employment and growth. Today, we can only respond in a qualitative, partial and approximate manner; however, these themes are so important that we must seek better answers through positive economics, which utilises two sources.

First, the general lessons drawn from economic analysis and statistical studies such as those based on the *ex-post* study of the effects of infrastructures. These indicate that the construction phase should be distinguished from the operational phase. In the construction phase, infrastructure investments have effects on economic activity and employment, as well for the infrastructure portion as for rolling stock in mass transit projects. These effects can be important, particularly for specific territories, such as pockets of unemployment, or for specific sectors in difficulty. But these direct local or sectorial effects have impacts on economic activity and employment at the national level that depend on the position in the business cycle: the repercussions of additional public investment (in transport or other sectors) are favourable, by means of a "multiplier", when the economy is depressed, but they are unfavourable, by means of the crowding out of private investment or inflationary pressures, during the high part of the cycle. Nevertheless, this indirect national effect is difficult to assess when deciding upon an investment, whose implementation will take place five to ten years later, in an unspecified phase of the cycle; these effects are inherently transient. As for effects occurring during the long-term use of the infrastructure, analysis indicates that GDP gains resulting from a new infrastructure directly result in productivity gains for businesses included in the economic calculation. At the national level, there are currently few results sufficiently robust to conclude that investments in infrastructure have a positive impact on growth outside of that corresponding to the surplus of the economic calculation, including the spatial effects seen above.

The second source of understanding for macroeconomic effects is the use of models. France currently has no macro-economic models adapted to the transport sector. Yet they would provide general information about the consequences of investment (construction and operation) on growth and employment and would help answer more specific questions such as the effects on public finance and foreign trade. They could also provide valuable insights regarding dynamics, describing how relevant variables change over the years.

According to their architecture, such models could help provide some answers – not provided by the traditional calculation – concerning identification of beneficiaries. This

approach provides good overall results in terms of social surplus, but does not indicate exactly how the agents of the community in question are impacted. The box above explains this point and highlights the fact that the identification of end effects implies having overall economic models describing the economic mechanisms that the project will implement and the effects on the different agents.

This report recommends the development of such models under a strategy adapted to the situation under study: there is no single all-purpose model that can answer every question.

Redistributional effects

A final aspect is the redistributive consequences of investments. Traditional methods of calculation do not address this important subject. Yet it is a subject of interest to decision makers. To completely understand this aspect, we would need to have computable general equilibrium models, as mentioned above, which are the only way to identify the ultimate beneficiaries. This is another reason to hope that such models are developed as soon as possible. As we await this development, proposals for criteria that are easier to implement, but less specific, are presented in this report.

2. Improving project governance

Since about fifteen years ago, project governance has evolved considerably under the influence of trends already apparent at the end of the last century, which today are fully combining their effects: the proliferating number of players in the production of projects, the growing complexity of decision making in view of the increasing importance of public debate and the diversification of funding.

2.1. The proliferating number of players in the production of projects

Decentralisation has increased over the last thirty years, especially in the transport sector, giving rise to a proliferation in the number of project managers and reducing the scope of the projects for which national guidelines for project evaluation are compulsory. In view of the liberalisation measures taken in France at the instigation of the European Union, large management organisations have been broken up.

In the transport sector, operators of specialised infrastructures – very broadly speaking, EPIC[1] – have been created to handle different types of infrastructures and have been given increasing responsibilities in the design and conduct of projects; they have gradually gained independence and expertise. They have a major role in guiding infrastructure policy: we know that decision-making power for projects is highly dependent on the capacity to propose solutions. In their relations with the national government, subordination has given way to dialogue and negotiation.

In the energy sector, the introduction of competition has resulted in the disintegration of vertically integrated monopolies that were formerly bastions of a normative economic calculation, ensuring, in principle, the consistency of the decision chain from the choice of production equipment to the development of tariff structures for the final customer.

(1) EPIC: *Établissement public à caractère industriel et commercial* (industrial and commercial public establishment).

Working in the common interest, the regulator and the managers of the network, as a natural monopoly, still follow the normative economic calculation. The situation is more heterogeneous for manufacturers-suppliers: the normative economic calculation gives way to a financial calculation where the consideration of externalities (risk of default, CO_2 emissions) occurs *via* the anticipation of market prices. It becomes the State's responsibility, through a community-based approach, to address what is known as "market myopia", through regulation or distortions of market mechanisms that are considered lawful (e.g. taxation, financial incentives, tariff distortions) in the framework of energy efficiency policies, development of renewable energy, limitation of greenhouse gas emissions – in brief, the implementation of an indispensable, long-term energy transition. As these policies are developed, it could be useful for the economic calculation to play a more important role.

Therefore, we find in the energy sector, more than in the transport sector, the emergence of a multiplicity of players with different objectives. This leads to the development of phenomena that economists call "information asymmetries". The operators act in favour of their own strategy in a theoretical framework of the "principal-agent" type (the public authorities in a broad sense on one side, the private and public operators on the other). To remain manageable, this type of organisation requires greater consistency; the public cost benefit assessment can contribute significantly to that.

In recent years, each of the players described above has developed its specific models and evaluation methods whereas everything was previously done in a single framework developed by state-run services. These tools are more numerous and more complex, including the use of large computerised databases. Like all large models, the details of their operation are very difficult to understand. They are significantly more opaque, especially since they utilise software developed by private software companies with confidential technology.

2.2. Recourse to independent second opinions

However, there is an increased need to ensure the robustness and accuracy of the results that these models provide, in an environment where stakeholders are more demanding. It is important for decision makers and their staff to understand these models, including their scope and limitations. To advance in this direction, we recommend that the most commonly used models be evaluated by external experts independent of the project managers and stakeholders in the decision, its study or its implementation, as well as of their competitors, and to establish standardised fact sheets to facilitate dialogue with decision makers.

The same type of external expertise should also be used on the most major projects to check the results of cost benefit assessments and make them more robust, and improve their credibility with external stakeholders, in particular those participating in public debates. This is consistent with the requirements of the law of 31 December 2012 referred to above, which systematically requires a second opinion for major projects. Here again, a standardised fact sheet would allow a better understanding of the key points for the evaluation of each project.

The evaluation mentioned above must be carried out by high-level experts drawn largely from the pool of international experts and/or the academic world, chosen to ensure the independence of the evaluation and to have the most qualified contributors

for the more advanced topics. This evaluation should of course be carried out in accordance with ethical standards for this kind of activity, particularly with regard to confidentiality and conflict of interest.

In the case of projects where modelling presents significant challenges, concerns over comparison, reliability and certification of results could also be addressed by subjecting the same project to several alternative models.

In all cases, each project should be accompanied by a fact sheet that summarises its main characteristics in terms of cost benefit assessment. This fact sheet[1] should show the traffic forecasting model that was used, the method of calculating the user surplus and a breakdown of project benefits. This is an opportunity to indicate the degree of confidence associated with each element of this breakdown.

2.3. Data quality

The quality of the evaluation depends directly on the quality of the data is it based on. The commission considers that we are suffering from a serious deficiency in this regard, as shown by the comparisons that it has made with several foreign countries. The commission calls for a more ambitious policy for gathering and disseminating statistical information. Furthermore, the quality of the data must be appraised in the same manner and under the same conditions as the quality of the models used.

This data is a standard public resource and its transparency must be ensured when it is needed for the evaluation of projects involving public funds or for second opinions on those projects. It must be defined and disseminated under the conditions and limits defined by regulations. For example, in the transport sector, we must ensure the effective implementation of legal provisions defining the terms of provision of statistical data held by railway operators[2]; the same requirement should certainly apply to other modes of transport.

Currently, data needs for the project evaluation are dealt with appear case-by-case, project-by-project, without consolidation measures that could help to formulate and express structural or persistent needs to potential suppliers. This slows down data systems' evolution (sources, contents, diffusion and exploitation modes) toward a better quality of data for projects evaluation. The issue of data needs' structuration and expression should be managed at a national level. From the data provider's side, this could be added to the list of topics treated in transversal reflections about data systems' evaluation and for the transport projects' side it could be treated with the issue of feedback governance.

(1) A proposal is provided in the general recommendations in Chapter 2, Section 3.5.
(2) Section I.-1 of Article 1 of Law No. 2009-1503 of 8 December 2009: "In the exercise of these duties, the State and the other public entities mentioned above have access to information relating to railway traffic and economic data needed to conduct studies and research to facilitate the implementation of the objectives assigned to the transport system. Where disclosure of such information may compromise trade secrets, its holder may request that its distribution to these public entities be handled by the Minister of Transport. In this case, the latter shall designate the services authorised to carry out that distribution, and shall specify the terms and conditions of that distribution to ensure respect for those trade secrets, and shall specify the nature of the information that can be made public".

2.4. Promoting consideration of cost benefit assessments in the decision-making process, particularly in public debates

Changes in the decision-making process, including the prominence of public debate, call for efforts to improve clarity.

Discussions and surveys on infrastructure projects are nothing new; the public enquiry process has existed for over one hundred years. But this classic step occurs far downstream in the decision process, when the project is sufficiently well defined for the cost benefit assessment to be carried out in full. The public debate, strictly speaking, is quite different. It comes at a much earlier stage, when the project is not yet precisely defined, focussing on the opportunity and the principal characteristics of the project, as the Council of State requested in its 1999 report[1]. The resulting public debate generally gives rise to numerous reactions from associations and stakeholders. This often leads to significant changes, reorientations or even rejections. Since the project is not yet defined with great precision, its economic evaluation remains partial and incomplete. In addition, at this stage, communication regarding the cost benefit assessment is today poorly viewed by the public, as amply illustrated in the part of the Council of State report on this subject. As a result, the cost benefit assessment, sometimes barely mentioned in the project file, does not satisfactorily inform the arbitration of the various interests related to the project under debate, in the words of the Council of State.

Every effort should be made to remedy this situation; cost benefit assessments, carried out properly, should be able to make their full contribution to informing public decision-making at this stage, provided that their limits can be specified. First, the content of public debate must be adapted. This report provides recommendations in this regard. A campaign to increase awareness of the cost benefit project assessment could be conducted, in particular, with participants in public debates, including with the *Commission nationale du débat public* (national commission for public debate, CNDP). But the cost benefit assessment should also strive to respond in the best possible way, and as early as possible, to questions from project stakeholders. However, they are not satisfied with a simple numeric value, such as the internal rate of return or the net present value of the project, as the results of cost-benefit analysis have been traditionally presented. The acceptance of cost benefit assessments could be promoted by improving how all the effects of a project are taken into consideration. Work remains to be done in this regard. The public, as well as elected officials and all stakeholders, is sensitive to the quality of a balanced and well-documented approach. Stakeholders in the debate want to know the detailed consequences of the project, an understandable request when the participant is a local resident or one of its representatives. When a mayor wants to know the effects of a project on the development of a particular area of his city, it is difficult to respond that it does not concern him. The economic calculation, if highly aggregated, can give the impression of a definitive result on which politicians and citizens would have no further input, but disaggregated, it may instead give rise to an informed dialogue on the basis of clearly-defined referents. These directives specifically mobilise economic knowledge corresponding to the themes targeted by the

(1) The Council of State has noted that the legal concept of public utility, originally intended to protect private property and to balance public and private interests, should now allow arbitrage between competing public interests, as legitimate as they are varied, and that the corresponding public enquiry takes place much too late to permit that. It therefore proposed that, for large-scale operations, an initial consultation phase be conducted concerning the expected functionality of the project, its rationale and its objectives; Council of State (1999*), L'utilité publique aujourd'hui (Public utility today),* Les études du Conseil d'État, Paris, La Documentation française.

enhancement of the calculation recommended above; they should certainly be complemented by actively conducted research, for which this report defines the terms of reference.

In a more general fashion, the economic calculation requires a detailed analysis of all the possible consequences of a project, their uncertainties and their probable development. The consequences that can be evaluated in terms of quantities and values are included in a calculation that takes into account the uncertainties inherent in any forecast. Those that cannot be taken into account in the calculations for any given reason should be indicated, analysed, evaluated, and brought to the attention of decision makers or the public, so that each party can use it to draw the conclusions that it considers justified.

2.5. A strategy favouring communication and education

The situation also calls for new communication efforts. These efforts have not been made until now, probably because communication was less crucial when the decision was essentially in the hands of a central authority. Insofar as the decision-making processes rely increasingly on dialogue and consensus, cost benefit assessments, if they wish to influence that process, must be convincing. The calculations must be capable of being explained in plain language. This represents a radical change: a communication effort that is even more imposing because the techniques used in cost benefit assessments are becoming increasingly sophisticated. This communication effort should be carried out during the phases of public debate. But its scope should be much broader than that.

First, under the terms of the Aarhus Convention[1], there should be a continuity of information and consultation with the public, including a presentation of revised cost benefit assessments, at each step of the project, and not just during the public debate and the public enquiry process, especially if a long time elapses between them.

Moreover, communication cannot be effective unless it is accompanied by a general education effort targeting all participants in the decision. It should familiarise the public with “socio-economic” vocabulary and evaluation methods, so that its language becomes a means of communication and a vehicle for debate, rather than a useless esoteric veneer, as is often the case today.

The actual communication and, even more, the education, are long-term processes and require significant resources. But the stakes are high: improving the efficiency of our public policy, particularly concerning infrastructure investment.

2.6. An overall approach to planning

The State participates in the financing of the largest-scale projects and is responsible for the decision to authorise the expropriation of local residents occupying the land. It also has the responsibility to remain consistent at the national level, in transport policy, for example; the State is the ultimate decision maker. In this regard, we can only recommend that the review of projects should not be carried out only individually, but

(1) Signed by 39 States on 25 June 1998, the Aarhus Convention has resulted in numerous directives on project evaluation and decision-making, which modified and strengthened Directive 85/337/EEC.

rather for sets of projects, in the context of multi-year programmes. This would avoid "races" between projects, of which we have seen unfortunate examples in past years. In these races, one is never sure that the approved project is really more efficient than all those that have not yet been examined. In calling for this type of planning, this report provides technical tools to prioritise projects that are candidates for planning. These tools consider the current environment, which is marked by financial discipline and the energy and environmental transitions.

3. Adapting cost benefit assessments to the ecological transition

Even if we are fully committed to the transition of governance discussed above, we are only at the beginning of the ecological transition. Many public decisions demonstrate awareness in this area. Yet, even if we are already noting some effects of global warming, for example, it is only decades from now, or even towards the end of the century, that future generations will be fully confronted with them.

3.1. The need to envisage the long term

For infrastructure investments, and in particular for transport, a few decades constitute a very short horizon: major infrastructure decisions currently taking place will likely be commissioned around 2020 at the earliest, with lifetimes on the order of several decades, or even centuries in certain sectors. Therefore, on average, these projects will be in operation until around the end of the century. In order to correctly assess the utility of infrastructures, projections should therefore examine that period.

This simple observation has several consequences. First, it is likely that in such a term, at risk of befalling the natural disasters that are the subject of a relatively broad consensus within the Intergovernmental Panel on Climate Change (IPCC), we must reduce our emissions of greenhouse gases in proportions made much more significant in view of the extent to which the trajectories set down by international agreements are not being respected. We will also need to face, under conditions yet to be defined, a recasting of our energy policy. It is also likely that we will need to reduce the land take and sealing of soils, at the risk of biodiversity loss. While we have an idea of the solutions to be implemented over the next fifteen to twenty years, the outlook is much more open-ended for longer horizons, from 2040 to 2080. Different approaches are possible, for which we can easily measure the consequences on infrastructure policy. For example, in the transport sector: reduced mobility, a massive modal shift, a change in spatial organisation that reduces the length of trips, technical progress linked to a modification of vehicle performance, and finally and more likely, a combination of all these approaches, yet to be found.

Certainly, depending on the chosen approach, the rate of return for individual projects can be very different. How can it be evaluated when we do not know whether 50 years from now, the user base will continue to grow, or conversely, will shrink? This report does not attempt to answer this question, which goes well beyond the cost benefit project assessment, because it involves major policy choices; we will simply list the factors to consider in terms of the limited objective that it addresses, and outline options for implementation.

3.2. The need for a strategic framework

This situation illustrates why project evaluation cannot be implemented in the absence of a strategic framework. France was able to get by without it during the "Trente Glorieuses" post-war boom, when the continuation of habitual behaviour passed for strategy. We were still able to manage the economy in that way until the end of the last century, despite the slowdown in growth and recurrent crises. We simply considered growth to be slightly weaker and more uncertain. But now we can wait no longer before developing a long-term strategic framework. And it is clear that this strategy is only partially dependent on infrastructure policy, which often is more a consequence than a driving force. It must be primarily based on macroeconomic growth prospects and respect for the environmental and energy commitments we are making for future generations, via price signals (energy and transport pricing, taxation and subsidies concerning construction and property) and regulations (e.g. vehicles and traffic, urbanisation). In addition, it must consider trends in lifestyles and demographics.

Of course, beyond the national strategy whose rationale and methods are discussed above, the same requirement for a strategy exists at other geographical scales, such as urban areas or regions, for projects that concern them, and with the accompanying problems of strategic consistency at different levels.

3.3. The discount rate and risk

The answers to these questions are neither simple nor even unique. A significant amount of uncertainty surrounds them, especially when they are extended over the long term. This shows the importance of the choice of systems for discounting and for taking risk into consideration.

The Lebègue and Gollier reports[1] made recommendations regarding analyses of risks specific to each project, as well as the understanding of systemic risk, which correlates with overall economic development. Due to the law of large numbers, individual risks not correlated to economic development are compensated for across the entire set of projects. This differs from systemic risks, whose effects are cumulative.

Regarding non-systemic risks, this report repeats the recommendations of the Gollier report. It particularly spotlights optimism bias, the scourge of project evaluation. Even if *ex-post* analyses show that, in France, we are perhaps slightly less subject to it than in many other countries, all possible efforts should be made to eradicate it. Project supervision and auditing, coupled with lessons learned and expert opinions, provide methodological possibilities that are today being actively researched and should be attentively monitored. This report also recommends using Monte Carlo analysis for other non-systemic risks.

Systemic risks, on the other hand, lead to a reduction in the value of the expected investment benefits if these benefits are positively correlated with economic activity, in which case they increase fluctuations, and *vice versa* if the correlation is negative, in which case they have a beneficial stabilising effect. There are two ways to handle these effects technically: taking them into account directly in the net benefit flow (the

(1) Lebègue D. (2005) *Le prix du temps et la décision publique (Valuing time in public decision-making),* Commissariat général du Plan, Paris, La Documentation française; Gollier C. (2010) *Le calcul du risque dans les investissements publics (The calculation of risk in public investment),* Centre d'analyse stratégique, Paris, La Documentation française.

"numerator" method) or by adjusting the discount rate depending on the level of risk (the "denominator" method).

In the latter approach, and under certain simplifying assumptions, the corresponding effect can be measured by the traditional product $\varphi\beta$, where φ is the risk premium, a parameter common to all projects, and where β measures the correlation between project benefits and economic activity, a parameter specific to each project. With these notations, a reduction in project benefits is easily expressed by an increase in the discount rate applied to them, which becomes, for each project, $r = rf + \varphi\beta$, where r is the risk discount rate for the project, rf is the risk free rate, and $\varphi\beta$ is the project's risk premium[1].

These concepts are well known and commonly used in financial analysis. The analogy with the financial calculations is, above all, formal, and even if the comparison with the financial markets provides useful information, the parameter values in cost benefit assessment are different from those used in finance: in particular, in the present state of art and available data, the parameters can hardly be calculated project by project, but only by project class.

The "numerator" method promotes dialogue with decision makers. It also helps to better judge the specificities of a project and may help adjust its beta parameter within its project class. This approach presupposes that standardised, contrasting and validated scenarios have been defined. The commission has furnished templates for them, which must be completed. The commission recommends that this method be implemented whenever possible, in order to support and complement the first method, which must be used for all projects, since it may be implemented much more easily.

This report proposes a risk free rate of 2.5%, decreasing to 1.5% after 2070[2] and a risk premium of 2%, increasing to 3% after 2070. This choice is proposed in view of considerations that integrate lessons from the markets, macroeconomic considerations and long-term intergenerational concerns. Due to the innovative nature of these provisions, this report also recommends carrying out calculations with a unique discount rate of 4.5% during a transitional period that will be devoted to studying lessons learned regarding the system, specifying the methods concerning project eligibility and fine-tuning the parameters that the new system brings to bear.

This report provides initial estimates of the beta values for major transport project categories and calls for the application of risk consideration methodology, especially the methodology used to calculate “socio-economic” betas, to other investment sectors. These approaches should certainly be refined, and their validity and consistency should be checked considering project specificities.

(1) If the project does not pose a systemic risk, a benefit a(t) in year t would now have the value $a(t)/(1 + r_f)^t$ where rf is the risk free rate. If the project presents a systemic risk whose correlation with the activity is measured by β, the benefits in year t are reduced to $a(t)/(1 + \beta\varphi)^t$ and their present value at year 0 is: $[a(t)/(1 + \beta\varphi)^t]/(1 + r_f)^t$, which is roughly equivalent to $a(t)/(1 + \beta\varphi + r_f)^t$: it is as if the discount rate used were $r = r_f + \varphi\beta$, known as the risk rate, which is project dependent for the $\beta\varphi$ part.
(2) The reader might be surprised that this recommendation induces a discontinuity in 2070. But he should consider that this discontinuity applies only to the elements taken into account after 2070, which aim is to determine a residual value. And this discontinuity occurs at a long term horizon that largely exceeds the potential construction dates of investments considered today.

Finally, this report addresses the development of project eligibility methods that are consistent with this new system for discounting and consideration of systemic risk. The principle (maximising the net present value) is the same as before, but its inclusion in an arbitrary framework significantly affects the modalities of its implementation, which are similar in formal terms to financial practices. This report provides initial proposals on this subject and recommends rapidly conducting further work in this regard. It would be desirable to obtain the first results before the end of the transitional period referred to above.

4. Extensions

4.1. Enlarging the field where cost benefit assessments are used

While the cost benefit project assessment can only be done within a framework of long-term strategic prospects, the development of this strategy, symmetrically, can, and indeed must, benefit from the contributions that it can bring to the economic calculation.

More generally, we note that cost benefit assessment is currently very limited in its scope of use. Ideally, it should enable the comparison and ranking of all public investments. In practise, its application is limited to a small number of sectors, mainly transport and energy, and even there, often restricted to investment choices, whereas it should be able to inform other decisions, such as those concerning technical regulations or pricing. Currently, it is only present very sporadically in other sectors, thus disregarding the contribution it could make to improving public decision-making. This will be illustrated below by presenting progress made in the health sector. We are pleased that the law of December 31, 2012, mentioned above, will expand its use to all civil investment.

Independent of the extension of economic calculation to other sectors, another extension deserves attention: decisions concerning maintenance choices. France is endowed with a public infrastructure capital that is growing as a result of investments and, given the financial constraints it is subject to, an increasingly difficult arbitration is emerging between the creation of new infrastructures and the maintenance in good operating condition of existing infrastructures. Since maintenance is not subject to economic analysis, and since patrimonial accounting is not carried out on public infrastructures, we have no objective tools to determine whether maintenance is performed at an appropriate level, and if the creation of new infrastructures is accompanied by the destruction of existing capital, even if expert opinion suggests that is the case in numerous sectors. These considerations argue for the launch of an entirely new project: applying economic analysis to the maintenance and preservation of existing infrastructures.

4.2. A major coordinated research programme

This report proposes that a number of large research programmes be undertaken. We would like to emphasise the utility of coordinating these programmes and orienting them towards the evaluation objectives that they are intended to inform. Patterned on the system used in many other countries, a standing committee composed of scientists and professionals should follow the progress of research projects, having been oriented concerning identified needs, while giving priority to the numerous subjects on

which we are currently obliged to resort primarily to foreign studies, in the absence of data or analyses best fit to possible national specificities. A pool of experts should be established to provide assistance, as needed, to that committee, or to be contacted in connection with a particular study. This would make it easier to revise evaluation guides. Best practices would be constantly integrated into the evaluations being currently carried out. Periodic review of the overall methodology for project evaluation would be much easier and more effective.

5. Organisation of this report

The following portion of this report reviews the various issues addressed in this summary, presenting them analytically. Each chapter is itself a summary of points elaborated in Volume 2[1], providing the justification for the position taken and the recommended values, which are presented in sufficient detail to make it possible to follow how they are calculated[2].

This report focuses on the transport sector, where the cost benefit assessment is in widest use, in particular for infrastructure decisions. Additionally, it provides a more general analysis of the energy sector, where profound changes in governance have restricted the possible choices in public investment concerning the TEN (Trans-European Network), whereas the insights it can provide go well beyond this type of choice. It presents a panorama of the progress and developments in the health sector, which also go beyond issues of investment choices and focus more on aspects of health care policy. It also presents some applications in the hydraulic sector (protections against floods).

Preceded by a summary of the principal operational recommendations, Chapter 1 begins by examining issues common to all sectors, such as the discount rate, risk consideration and the cost of public funds. Chapter 2 provides detailed recommendations on transport, by far the sector where cost benefit assessment has been most developed. Finally, Chapter 3 is composed of short presentations on the energy and health sectors, as well as a specific application regarding flood control projects.

(1) Volume 2 is available for download on the CGSP website, in French version: www.strategie.gouv.fr/blog/?p=2332.

(2) Concerning the precision with which certain parameters are expressed: the number of significant figures that accompany these values does not constitute a judgment of their accuracy; it is rather the result of a concern for numerical consistency. It is good practice to perform calculations with a precision that may be superfluous, and provide a comment on their accuracy once the final result is obtained.

Principal operational recommendations

This chapter reiterates, in summary form, all the operational recommendations contained in this report. For details of the specific values and methods of implementation, the reader is referred to the corresponding sections of the report.

1. General recommendations: Evaluation criteria and indicators

Opportunity costs and scarcity of public funds:

- multiply public spending on construction and maintenance and public budget revenues by the opportunity cost of public funds. The recommended value is 1.2;
- multiply public spending on construction by the shadow price of scarce public funds. It would be appropriate to recalculate this figure frequently to reflect current conditions, but it can be set by default to 0.05 (0.07 in the case of a flat discount rate of 4.5%).

Calculation horizon: calculations will be carried out by explicitly considering changes in traffic and unit values until 2070. After that, calculations will take a residual value into account, corresponding to the discount over 70 years (until 2140), when benefits will stabilise traffic and unit values, except for carbon, for which we will continue to calculate changes in the unit price according to established rules, and considering spending on maintenance and replacement that will occur because of the technical life-path of the projects[1].

Rules for eligibility of projects during a transitional period: they must reflect decisions concerning revisions. This is a new system, which separates the risk-free rate and the systemic risk. Under this system, the commission recommends performing calculations using a risk-free rate of 2.5%, a risk premium of 2% (respectively 1.5% and 3% after 2070) and the beta values found in this report for the transport sector.

(1) It should be noticed that this recommendation leads to evaluate all the projects until the same fixed date, whereas before, they were evaluated on the same life-path starting at their respective construction dates. The previous practice induced a bias (it led to increase the socio-economic profitability when delaying the project) and the new one too, in the opposite direction (it leads to under-estimate the profitability of the distant projects). But, given the lengthening of the evaluation period, this second bias is very reduced for the projects which date of construction is not too distant.

Because of the novelty of this system, we should also carry out, during a transitional period, calculations based on the old system with a single rate set at 4.5%.

Under the new system, eligibility rules during the transitional period are as follows: the "green light" for a project should be envisaged when, at the time of deployment resulting from the implementation delay following the "green light," the calculated immediate rate of return is equal to 4.5%. Next, we must verify that the NPV calculated for this completion date is positive. In the NPV calculation, we will update the costs and benefits with their respective betas (often, we can use a single overall beta value for benefits, unless the effects of CO_2 emissions are significant, which is usually the case in the long term; we will then use a beta of 1 for the price of CO_2, as indicated in Chapter 1, Section 9); then we use the standardised betas. However, we must update the construction costs using their own beta, set to 0.5 for civil engineering and construction works. If the resulting NPV is positive, the project should be carried out for the date mentioned above; otherwise it should not be carried out. The dossier will be reviewed again later, in case costs or benefits have shifted for unpredictable reasons.

Under the old system where a unique rate is fixed at 4.5%, the traditional, well-known rules (referred to in the corresponding sections) apply. We note that under these conditions, with both systems in parallel, the date of commissioning is identical. We must also verify that the NPV is positive, via the traditional calculation.

It is possible to calculate variants based on the risk-free rate and the risk premium (e.g. with values of 3.5% and 1% respectively), or on benefit growth.

During the transitional period, eligibility conditions must be robustly defined and the parameters on which they depend must be estimated, in particular assessing their relative importance. All of this requires an investigation and a better understanding of the stochastic processes and utility functions involved. Reference scenarios supporting long-term developments should also be specified.

Finally, two indicators should be calculated: the immediate rate of return, and the net present value for the optimal construction date (or equivalently for the optimal first year of operation). These two indicators have to be calculated taken into account the opportunity cost of public funds and the shadow price for scarcity of public funds.

Following the transitional period. After this transitional period, it will be possible to confirm, and perhaps adjust, the values of the discount system (risk-free rate and risk premium), provide values for the other parameters involved in the calculation and determine the definitive eligibility rules to be applied.

Systemic risk and the "numerator" method. The double discount rate system reflects the systemic risk using the "denominator" method. That system can also be analysed using the "numerator" method, in which the behaviour of the project's NPV is analysed under different scenarios of economic growth. The two methods are not coincident, but are complementary. The denominator method should be applied to all projects because it allows comparison and ranking consistent with economic theory. The numerator method is more meaningful to the decision maker and is conducive to dialogue; it can also allow a better understanding of the behaviour of each project vis-à-vis uncertainty, provide "stress tests" and thus drive the refinement of the project's beta values. We recommend implementing this method as broadly as possible, particularly for large projects. This should be done based on standardised scenarios that are sufficiently differentiated (an illustration of the structure of such scenarios is

provided in Volume 2 of this report, for transport); it is preferable that the risk-free discount rate and the implicit risk premium generated by the numerator method be of similar magnitude to those generated by the denominator method.

Diversified risks. The numerator method is part of the family of scenario analyses, probabilistic or not, that should be utilised for the analysis of diversified risks. This report emphasises their importance and the care that must be exercised in handling them.

Enhancing the traditional calculation: see details in the French report.[1]

2. General recommendations: Procedures

- Translate this report's recommendations into operating procedures or software adapted to the sector, the projects' maturity level and their importance.

- Carry out evaluations or certifications for the models that participate in the cost benefit assessments, particularly demand models, and the procedures used to calculate the surplus.

- Draft fact sheets showing the scope and limitations of these models.

- Define reference scenarios that will serve as a framework for projects' cost benefit assessment; these long-term scenarios will include general and sectorial projections.

- Establish, for each project, fact sheets including the following information:
  - description of the project;
  - description of the reference option and its justification;
  - description of the alternatives under consideration;
  - description and justification, if applicable, of the choices made in terms of pricing for the services provided to the users;
  - evaluation of the cost of construction, updated for the programming year, as well as costs of maintenance and subsequent replacement, with dating, and, if possible, comparison with the costs of similar types of infrastructure;
  - evaluation of the benefit for the programming year, and its decomposition according to the different stakeholders: user surplus, effects on operators' revenues, effects on the environment and other effects, indicating the degree of confidence assigned to each category;
  - the same information for the year 2070;
  - decomposition of benefits between those serving the production system and those serving individuals;

[1] CGSP (2013), *L'évaluation socioéconomique des investissements publics*, volume 1. www.strategie.gouv.fr/blog/2013/09/rapport-levaluation-socioeconomique-des-investissements-publics/.

- evaluation of growth in demand: demand for the programming year and in 2070; comparison, if possible, with the demands of similar situations;
- reasoned description of the possible effects of reduced market power, the impact on employment and growth, the effects of spatial distribution, redistributional consequences, etc.;
- the optimal date for first year of operation and the immediate rate of return for the first year of operation ;
- the net present value (NPV) calculated referring to the year of programming, with a 4.5% discount rate, and including the opportunity cost of public funds and the shadow price for scarcity of public funds;
- the NPV calculated referring to the year of programming, with the public discount rate increased by the risk premium and the recommended beta, including the opportunity cost of public funds and the shadow price for scarcity of public funds;
- the results of sensitivity analyses (NPV) to various parameters including the beta and the risk rate for the project ; complementary risk studies performed (for example, test of extreme scenarios).

For the largest projects, obtain an independent second opinion concerning the cost benefit assessments.

Develop reference scenarios composed of general scenarios applicable to all projects, supplemented by sectorial scenarios.

3. Unit values shared by the different sectors

3.1. Values concerning health/safety/morbidity

- Value of statistical life (VSL): 3 million euros in 2010.
- Value of a statistical life year (VSLY): 115,000 euros in 2010.
- Value of serious injury: 15% of the VSL, or 450,000 euros in 2010.
- Value of minor injury: 2% of the VSL, or 60,000 euros in 2010.

Projection rule

These values should increase at the same rate as GDP per capita.

3.2. Carbon value

- Initial value: 32 euros 2010/tCO_2
- 2030 value: 100 euros 2010/tCO_2

Projection rule

- From 2010 to 2030, the carbon value will grow at 5.8% per year.

- After 2030: the projection rule follows the Hotelling principle (growth of the carbon value at the discount rate) or 4.5% (with beta carbon price = 1, discount rate = 2.5% + 1 x 2% or, after 2070: 1.5% + 1 x 3%).

4. Specific values for the transport sector

4.1. Values of time

a) Passenger transport

In urban areas, all modes (in €2010/h in 2010)

Trip purpose	All of France	Île-de-France (Paris region)
Professional	17.5	22.3
Home-workplace/school/day-nursery	10.0	12.6
Other (shopping, care, visits, leisure, tourism, etc.)	6.8	8.7
No reason given	7.9	10.7

Interurban trips (in €2010/h in 2010)

Mode	Reason for trip	For distances less than or equal to 20 km	For distances between 20 and 80 km			Values at 80 km	For distances between 80 and 400 km				For distances greater than or equal to 400 km			For an unspecified distance (value for mean distance)	Average distance for mode (km)
Road – passenger car	All reasons	7.9	0.090	x d +	6.1	13.3	0.006	x	d +	12.8	15.2			14.4	266.7
	Professional	17.5	0.202	x d +	13.5	29.6	0.016	x	d +	28.4	34.8			32.7	
	Personal-holiday	6.8	0.031	x d +	6.2	8.7	0.012	x	d +	7.7	12.4			10.9	
	Personal-other	6.8	0.067	x d +	5.5	10.8	0.019	x	d +	9.3	17.0			14.4	
Road – coach	All reasons	7.9	0.166	x d +	4.6	17.9	-0.019	x	d +	19.3	11.9			13.9	293.8
	Professional	17.5	0.153	x d +	14.5	26.7	0.004	x	d +	26.3	28.0			27.6	
	Personal-holiday	6.8	0.031	x d +	6.2	8.7	0.003	x	d +	8.4	9.8			9.4	
	Personal-other	6.8	0.067	x d +	5.5	10.8	0.006	x	d +	10.4	12.8			12.1	
Rail	All reasons	7.9	0.246	x d +	3.0	22.7	0.011	x	d +	21.8	26.2			25.4	331
	Professional	17.5	0.429	x d +	9.0	43.3	0.000	x	d +	43.3	43.3			43.3	
	Personal-holiday	6.8	0.250	x d +	1.8	21.8	0.000	x	d +	21.8	21.8			21.8	
	Personal-other	6.8	0.265	x d +	1.5	22.7	0.000	x	d +	22.7	22.7			22.7	
Air	All reasons										0.001	x d +	53.2	54.2	1208.9
	Professional										0.000	x d +	72.9	72.9	
	Personal-holiday										0.000	x d +	52.2	52.2	
	Personal-other										0.000	x d +	53.4	53.4	
All modes	All reasons	7.9	0.155	x d +	4.8	17.2	0.021	x	d+	15.5	0.006	x d +	21.6	19.1	
	Professional	17.5	0.218	x d +	13.2	30.6	0.029	x	d+	28.3	0.020	x d +	32.0	36.2	
	Personal-holiday	6.8	0.055	x d +	5.7	10.1	0.022	x	d+	8.4	0.005	x d +	15.1	11.2	
	Personal-other	6.8	0.215	x d +	2.5	19.7	0.003	x	d+	19.5	0.008	x d +	17.3	23.0	

Waiting time, walking time before and after transport, connecting time

Type of time outside vehicle	Equivalent minutes
Waiting time	1.5
Walking time before and after transport	2
Connecting time	2

Note: one minute of waiting time is perceived, in equivalent minutes, as 1.5 minutes of travel time.

Projection rule

Time values should increase with per capita GDP, with an elasticity of 0.7[1].

b) Freight transport

in €2010/h in 2010

Type of merchandise	Value of travel time
Freight with high added value *Approximate value: > 35,000 €/t* *Examples: combined transport, shipping containers, parcel service, refrigerated transport, "rolling road", roll-on/roll-off cargo*	0.60 €/t
Ordinary Freight *Approximate value: between 6,000 and 35,000 €/t* *Examples: other rail, sea and river transport*	0.20 €/t
Freight with low added value *Approximate value: < 6,000 €/t* *Examples: bulk materials, aggregates*	0.01 €/t

Projection rule

Freight time values should increase with GDP per capita.

c) Comfort

Real time weighting according to the vehicle's load factor

Location of the user in the mode, all modes combined (tram, metro, bus, commuter rail)	Changes in the real-time multiplier K(p) depending on the number of standing passengers 'p' per m^2 in the vehicle	
	For situations where permanent seating is available	For p > 0
Seated	K(p) = 1.00	Ka(p) = 1.00 + 0.08*p
Standing		Kd(p) = 1.25 + 0.09*p

Note: a user, standing during a journey where an average of 3 people/m^2 is also standing, is assumed to perceive his travel time (multiplied afterward by the value of time concerning his motive for travel) multiplied by 1.29 + 3*0.09 = 1.52.

(1) The value of time for passenger varies rather in relation to the final consumption of households per capita, but, in order to simplify, final consumption of households per capita and GDP per capita are supposed to evolve identically.

Method for taking comfort into account: see details in the report.

Projection rule

Comfort and reliability values should increase as the time values.

d) Reliability *(see details in the report)*

4.2. Environmental costs

a) Pollution

Population density of areas crossed by the infrastructure

inhabitants/km²	Intercity	Diffuse urban	Urban	Dense urban	Very dense urban
Range	< 37	37-450	450-1,500	1,500-4,500	> 4,500
Average density	25	250	750	2,250	6,750

Official reference value

Official reference value proposed for road transport (emissions from combustion and wear)

€2010/100 vehicle.km	Very dense urban	Dense urban	Urban	Diffuse urban	Intercity
PC	15.8	4.3	1.7	1.3	0.9
Diesel PC	20.4	5.5	2.2	1.6	1.1
Petrol PC	4.5	1.3	0.6	0.5	0.5
LPG PC	3.6	1.0	0.4	0.3	0.2
LCV	32.3	8.7	3.4	2.4	1.6
Diesel CV	33.7	9.1	3.5	2.5	1.6
Petrol CV	6.3	1.9	0.9	0.8	0.8
Diesel HGV	186.6	37.0	17.7	9.4	6.4
Motorcycle	8.7	2.5	1.0	0.8	0.5
Bus	125.4	24.8	11.9	6.3	4.2

NOx, SO_2, COVNM and PM2,5 emissions costs by EURO standard category due to combustion by PC and LCV.

PC: passenger car; LCV: light commercial vehicle; CV: commercial vehicle; HGV: heavy goods vehicle.

Official reference value proposed for rail transport

€2010/100 train.km	Very dense urban	Dense urban	Urban	Diffuse urban	Intercity
Diesel passenger train	881.5	293.8	97.9	32.6	3.3
Electric passenger train	negligible	negligible	negligible	negligible	negligible
Diesel freight train	750.5	250.2	83.4	27.8	2.8
Electric freight train	negligible	negligible	negligible	negligible	negligible

Official reference value proposed for river transport

€2010/100 boat.km	**Very dense urban**	**Dense urban**	**Urban**	**Diffuse urban**	**Intercity**
River craft	18,900	6,350	2,150	750	140

Official reference value proposed for air transport

	Urban	**Diffuse urban**
Movement *(€2010/100 mov.)*	Between 8,700 and 17,200	Between 2,900 and 3,050
Flight *(€2010/100 flights.km)*	Between 14.3 and 16.5	Between 12.3 and 13.3

Projection rule

Air pollution values should change taking into account trends in GDP per capita, in the active fleet and in individual emissions (these are estimated at -6% per year over the period 2010-2020 for road mode). After that time, the coefficient will be set based on emission scenarios for the fleet active in the medium and long term.

b) Upstream effect

Official reference value proposed for certain upstream and downstream effects related to the movement of transport vehicles.

€2010/100 vehicle.km	***Official reference value* for atmospheric emissions from upstream processes**
Road transport	
PC	0.90
Bus	2.83
Motorcycle	0.42
HGV	2.96
LCV	1.14
Rail transport	
Electric passenger train	25.64
Diesel passenger train	136.35
Electric freight train	30.50
Diesel freight train	143.51
Air transport	
Aircraft	58.38
River transport	
River craft	96.61

Projection rule

Update the values of the upstream and downstream effects as according to the evolution of GDP per capita.

c) Biodiversity

Take into account, in the cost benefit assessment, costs related to the implementation of the "avoid, reduce, compensate" decision sequence.

d) Noise pollution

Official reference value by exposure level: see detail in the report.

Average values by type of traffic:

Values for cost of noise pollution, expressed in €2010/1000veh.km, for a light traffic, in an average day, for road mode

Type of population	Type of infrastructure	Average cost of noise pollution in €$_{2010}$/1000veh.km, used when the traffic composition is unknown[1]	Average cost LV	Average cost HV	Marginal cost LV	Marginal cost HV
Rural	Motorway	0.78	0.5	1.9	0.03	0.1
	Trunk road	3.35	1.9	13.6	0.12	0.8
	Secondary road[2]	16.75	10.5	115.2	0.63	6.9
Semi-urban	Motorway	3.14	2.0	7.8	0.12	0.5
	Trunk road	7.35	3.3	23.4	0.20	1.4
	Secondary road	35.08	16.9	168.6	1.01	10.1
Urban	Motorway	8.99	5.6	22.5	0.34	1.3
	Trunk road	9.75	5.7	39.7	0.34	2.4
	Secondary road	48.45	31.5	314.6	1.89	18.9
Dense urban	Motorway	13.24	8.3	33.1	0.50	2.0
	Trunk road	15.72	9.1	64.0	0.55	3.8
	Secondary road	58.41	37.9	379.3	2.28	22.8
Very dense urban	Motorway[3]	22.40	14.0	56.0	0.84	3.4
	Trunk road	28.96	16.8	117.9	1.01	7.1
	Secondary road	66.29	43.0	430.5	2.58	25.8

(1) The average costs, without distinction by type of vehicle, are valid only if the relative shares of light vehicles and heavy vehicles on the considered road are consistent with the hypothesis of repartition used in the calculation ; they should be used only if the relative shares LV/HV are unknown, and supposed close to the previously mentioned repartition.
(2) Due to insufficient data on rural secondary roads, the costs appearing in this line have been extrapolated homothetically from those used for semi-urban zone.
(3) For very dense urban zones, the value for motorways has been calculated using a sample involving only three cases. The values are low since the share of the population affected by noise levels between 70 and 80 dB is low, thanks to noise-protection walls or geographic location of the infrastructure (in industrial zone for example).

Marginal cost of noise pollution, expressed in €2010/veh.km for rail mode

Vehicle type	Time of day	Traffic	Urban	Semi-urban	Rural
Passenger train	Day	Dense	0.31	0.014	0.017
		Light	0.61	0.027	0.033
	Night		1.02	0.045	0.056
Freight train	Day	Dense	0.55	0.027	0.034
		Light	1.3	0.052	0.065
	Night		2.2	0.088	0.11

Average cost of noise pollution for rail mode

	€/ 1000 tonne.km or 1.000 passenger.km	€/train.km
Passenger train	2.64	0.57
Freight train	6.12	2.29

Projection rule

Noise pollution values should increase at the same rate as GDP per capita.

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