INFRASTRUCTURE AND DEVELOPMENT[1]

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ABSTRACT - The notion of infrastructure is presented as a subset of the notion of capital. Several definitional characteristics of infrastructure are identified and discussed. Curiously, for two centuries, infrastructure as an analytic concept has been practically absent from the economist's tool box.

By contrast, during the 1990ies, a vast body of literature introduced infrastructure as a determinant of production functions, with a view to estimate its contribution to economic growth. The paper reviews the difficulties associated with this enterprise, and the not too clear conclusions that emerge from it. The heterogeneity of the concept is emphasized. Unlike productive capital which is homogenized by market forces, politically-driven infrastructure may —and often does— consist of white elephants as well as of highly useful roads.

Why and how does infrastructure contribute to development ? It is a space-shrinker, it enlarges markets, and operates like the lowering of trade barriers. In urban areas, it can be

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shown that infrastructure contributes to enlarge the effective size of the labor market and of the goods or ideas markets, thus increasing productivity and output.

Institutional and financial regimes have a direct impact upon the socio-economic efficiency of infrastructure. Because infrastructure always has a government dimension and can also have a private dimension, the menu of institutional options available is quite large : from direct government provision (with or without tolls and prices) to unsubsidized concessions, with various forms of public-private partnerships, such as subsidized concessions or shadow tolls. Three mechanisms have to be taken into account : (i) the welfare loss often (not always) associated with tolls and prices, which implies that in such cases, all other things equal, non tolled infrastructure is better than tolled ones, (ii) the cost-advantage usually associated with private production, which implies that, all other things equal, privately managed infrastructure is better, and (iii) the distorsionary impact of taxes, which implies that, all other things equal, toll-financed infrastructure is better than tax-financed one. A small model combining these three mechanisms is developed. A simulation, using reasonable values for the main parameters, is presented. It suggests that the more private options, in particular the shadow toll option, are economically superior to the more government-oriented options. The problem is complicated, however, when one takes into consideration the public finance dimension of the various options.

Forecasting errors and associated risks are characteristic of infrastructure projects. Costs are generally underestimated and patronage overestimated, by large amounts. Errors of 50% or more seem to be the rule rather than the exception. An understanding of the various reasons that explain such errors is useful to allocate the related risks between government bodies and private partners. Substantive risks (risks linked to changes in project design) as well as pure economic risks (risks associated with the macro-economic environment), which are not insurable, should be borne by the public entity. Technical risks (errors in forecasting costs and usage) should be borne by private enterprises. But institutional errors resulting from a strategic behaviour of public and even private agents can only be reduced by changes in institutional design and contracts

Introduction

“Infrastructure” are many and diverse : roads, tunnels, bridges, railways, airports, harbors, canals, subways and tramways, dams, irrigation networks, water pipes, water purification plants, sewers, water treatment plants, dumps and incinerators, power plants, power lines and distribution networks, oil and gas pipelines, telephone exchanges and networks, district heating equipment, etc.

Infrastructure and infrastructure-related services have always been with us, but the word itself is relatively recent, particularly in English. Although *The American Heritage Dictionary of the English Language* writes that “the term *infrastructure* has been used since 1927 to refer collectively to […] roads, bridges rail lines, and similar public works”, it does not appear in the 1952 *Concise Oxford Dictionary*, nor in the 1950 *Real Academia Espanola Diccionario*. The word does not appear in the works of the “pioneers in development” (Meier & Seers 1984) writing in the post-war period. It is, for instance, absent from the standard treatises of Lewis (1955), Higgins (1959) or Bauer (1957). It was just not used then[1].

This contrasts with the formidable success of the word in the 1980ies and 1990ies, when it invaded UN institutions, World Bank organization charts, academic journals, and daily newspapers. The process has clearly been inflationary. The meaning of the word has been extended so much that it no longer means much. As the *American Heritage Dictionary* puts it: “Today, we may hear that conservatism has an infrastructure of think tanks […] or that terrorists organizations have an infrastructure of people sympathetic to their cause”. In this presentation, we will use the word to

[1] As late as 1973, the editors of *Urban Studies* eliminated “infrastructure” from a paper this writer was contributing to this well-written British journal, and replace it with “social overhead capital”.

describe objects like the ones listed above, that have in common all or most of the following attributes.

First, they are capital goods. They are not consumed directly. Rather, in combination with labor, and possibly other inputs, they provide services. Table 1 shows the relationship between infrastructure and the associated services.

Table 1 – Infrastructure and Associated Services

Service	Associated infrastructure
Transportation	Roads, bridges, tunnels, rail tracks,harbors, etc.
Water supply	Dams, reservoirs, pipes, treatment plants, etc.
Water disposal	Sewers, used water treatment plants, etc.
Irrigation	Dams, canals
Garbage disposal	Dumps, incinerators, compost units
District heating	Plant, network
Telecommunication	Telephone exchanges, telephone lines, etc.
Power	Power plants, transmission & distribution lines

Indeed, what matters is the service, much more than the infrastructure used or needed to produce it. Policies should focus on the end, service provision, not on the means, infrastructure endowment. The confusion often made between the two reflects the fact that, in many cases, the role of the infrastructure is predominant in the production of the service, or, to put it otherwise, that these services are very capital intensive.

Second, infrastructure is often very lumpy, as opposed to incremental. The usefulness of dam or a bridge which is eight-tenth built is zero. Since the demand for infrastructure services usually increases gradually, adjusting supply and demand over the course of time is difficult, not to say impossible. Lumpiness also implies that siting and construction often take years.

Third, infrastructure is usually very long lasting. Its life is often measured in decades, if not in centuries. In Europe, there are still in use roads and sewers dating from the Roman empire. Infrastructure are not the only long lasting goods: housing, and some ordinary capital goods, can also have very long lives. Nevertheless, this characteristic has major implications, in terms of financing or maintenance, for instance.

Fourth, infrastructure is space-specific. Unlike most goods, it is generally immobile. A pair of shoes in A is very much like a pair of shoes in B, because it can easily be moved (at a small transportation cost) from A to B. It is therefore quite meaningful to add up the total production of shoes in a country. However, a sewer in A can in no way render services in B. Adding sewers in a country can be misleading if sewers have not been located optimally. In addition, the combination of immobility with long life duration means that infrastructure investments will shape the economic geography, or regional policy, of a country for decades[1].

A fifth characteristics is that infrastructure, or rather the service it renders, is associated with market failures, in the traditional forms of public goods, externalities (including network externalities), decreasing costs (leading to natural monopolies), or merit goods, as shown in Table 2.

Table 2 – Infrastructure Related Services and Alleged Market Failures

Infrastructure-related service	Alleged market failure
Power, gas	Natural monopolies
Water supply & treatment	Natural monopolies, externalities
Telephone	Natural monopolies, externalities
Rail transport	Natural monopoly, merit good
District heating	Natural monopoly
Garbage collection & disposal	Pure public good, externalities
Cable	Natural monopoly, merit good
Roads	Quasi public good, externality

This is usually considered to imply some form of public intervention. Infrastructure, and infrastructure services cannot be left to pure market forces only. This important policy conclusion, which is generally true, must be handled with caution, however.

[1] It has been noted that in some cases, such as harbors, re-use might be an alternative to mobility.

Many market failures are not as clear cut as is often claimed. The notion of decreasing costs leading to natural monopolies, for instance, might make sense for some parts of a service and not for other. In the case of power, for instance, it makes more sense for transportation or distribution that it does for production. In the case of telephone, this notion is wiped out by technological progress.

Then, the existence of market failures is not an automatic justification of government intervention. The opposite view —which has long been dominant— is akin to the attitude of the jury of a beauty contest who would look at the first candidate, and declare the other candidate a winner. The existence of market failures only provides a presumption of the need for government intervention. But in practice, one has to take into account possible government failures, and compare the costs and benefits of both options.

Finally, of course, government intervention, when it is required or desirable, can take many forms. Direct public provision is only one of them, and not necessarily the best one.

Sixth, infrastructure, or the service it provides, is usually consumed by both households and enterprises. It is at the same time a final consumption item, and an intermediate consumption item. It increases welfare (directly), and it increases output. The relative importance of these two types of consumption varies with each infrastructure, and over space and time, but in general, the consumption of enterprises seems to be somewhat greater than that of households[1].

[1] For France, input-output tables data showed that, in 2001, households consumption of infrastructure-related services was exactly one third of the total.

These attributes might be used to define, albeit loosely, the notion of infrastructure. They exclude the so-called "social infrastructure", such as schools, universities, clinics, hospitals, etc. It does not mean that schools and clinics are not important, but rather that they do not share some of the characteristics mentioned. They are not always very long-lasting, and the service they provide owes generally more to labor input than to infrastructure input.

It is not easy to assess the relative importance of infrastructure capital in our economies. This is in part because of the uncertainties attached to the notion, and in part because data on the value of capital stock (as opposed to data on flows) is difficult to estimate everywhere and scarce in many countries. Easterly and Rebelo (1993) produced estimates of "public investment" in a large number of countries and for 1960, 1970, 1980 decades averages. Consolidated public investment, consisting of investments by governments and by public enterprises, represented 43% of total investments (and 9% of GDP). Because the life length of such public investments is likely longer that that of private investments, this would suggest that the stock of "public investments", thus defined, represents around half the total capital stock.

Some countries, like France, publish estimates of the capital stock by type. Government capital stock in 2002 represented 15% of total capital stock, and 47% of GDP. Government capital stock is different from infrastructure. It includes administrative buildings, schools and hospitals, but it ignores the capital stock of public enterprises, in many cases a component of infrastructure. Assuming that these two items cancel each other, this gives us an idea of the relative importance of infrastructure in France, which appears to be much smaller than the Easterly and Rebelo estimates. Table 3 presents this data, and extends it to Brazil and Mexico. The ratio of flow to stock calculated for France has been applied to flow data in order to produce stock data for Brazil and

Mexico. The methodology is very crude, but it produces estimates of the relative importance of infrastructure which are for Brazil similar to French numbers (15% of total stock of capital, 50% of GDP), and for Mexico much smaller (9% of total stock of capital, 7% of GDP).

Table 3 – Infrastructure, Other Capital, and GDP, France, Brazil and Mexicco; 2001-2002

	France 2002		Brazil 2002		Mexico 2001	
	Fow G euros	Stock G euros	Flow G reais	Stock G reais	Flow G pesos	Stock G pesos
Infrastructure	46[a]	718	46	*728*	24	*374*
Housing	73	2101	73	*2097*	67	*1920*
Productive capital	164	1884	164	*1883*	179	*2058*
Total	296	4706	296	*4708*	270	*4352*
GDP	1521	1521	1346	1346	5286	5286

Sources : For France : INSEE. 2003. *Rapport sur les comptes de la nation 2002* for both flow and stock ; For Brazil for flows : ibge.gov.br ; for Mexico for flows : inegi.gov.mex ; for Brazil and Mexico for stock : flow figure multiplied by the stock/flow ratios for France.
Notes : aCapital flow and stock of « government », excluding capital of publicly-owned enterprises such as SNCF or PEMEX or Petrobras.

The concept of infrastructure, and not only the word, has largely, and surprisingly, been absent from the history of economic analysis. Infrastructure, particularly transport infrastructure, play a key role in Adam Smith's vision of economic development. No roads, no transport, no trade, no specialization, no economies of scale, no productivity progress, and no development. Yet, during the 19th century, and much of the 20th century, infrastructure virtually disappears from economics. In Marx, in Walras, in Marshall, in Keynes, in Domar, output is produced only by labor and capital, and the capital these economists have in mind is mostly or only the so-called "productive" capital of private enterprises. This is strange, because in the 19th century, governments in the then developing countries —to-day's developed economies— did invest heavily in infrastructure, particularly in urban areas. This, somehow, largely escaped the attention of dominant, mainstream, macro-economists.

Even in the post world war II period, when development economics appeared as a branch of economics, reference to infrastructure and their role are scarce. "Capital" plays a key role in most growth theories and analysis, but "capital" is undifferentiated. Roads and factories are lumped together in the common concept of capital. The obvious differences outlined above were ignored. And because factories weighted heavier than roads, the discussion of "capital" turned out to be a discussion of factories. Some pioneers, like Rosenstein-Rodan or Singer, were more perceptive than others, and made timid references to infrastructure. Thus, Rosenstein-Rodan, discussing in 1984 his war time views writes: "The third new idea was that before building consumer goods factories, a major indivisible block of social overhead capital or infrastructure must be built and sponsored because private market initiatives will not create it in time" (Meiers and Seers 1984 p. 208). But this is an exception. Until the 1970ies, infrastructure, even under a different name, hardly existed as an analytic concept or category in economic theory and policy.

In the meantime, however, governments were busy building roads or sewers. They felt the need for principles and tools to improve these infrastructure investments. This led to the development of cost-benefit analysis. The intellectual foundations date back to the mid 19th century, with the seminal article of Dupuit on the utility of a non-tolled bridge, and the concept of "surplus". But the key role in the development of cost-benefit analysis —which is mostly applied to infrastructure investments— was played by the New Deal and by the World Bank. In the late 1930ies, the US Federal government financed massive infrastructure investments, but the US Congress prescribed that only projects with sufficient social utility could be undertaken. The Keynesian digging and filling of holes would not qualify. The US Corps of Engineers, and economists like Robert Dorfman carried the required studies and tried to give a content to the notion of "sufficient utility". Similarly, after the war, the World Bank —and with it many other international, bilateral and national institutions— mostly involved in infrastructure financing were required to undertake only projects that would meet the test of a cost-benefit analysis. This led to the development and refinement of project appraisal methodologies, that still continue to date.

The literature on infrastructure, although recent, is enormous. On transportation infrastructure alone, Stough et al. (2002) published a reader supposedly limited to "classics" that comprises 650 pages of fine print. The World Bank itself has published extensively on this topic (its 1994 World Development Report on *Infrastructure for Development*, prepared under the leadership of Greg Ingram, remains a major contribution). Indeed, financing infrastructure for development could be defined as one of the main business, if not the main business, of the Bank. Presenting a paper on this very topic at the World Bank sounds like bringing coal to Newcastle.

This paper will obviously not attempt to cover all the important dimensions of the subject. It will deal only marginally with the issues of privatization and regulation. It will largely ignore the key question of pricing. Relatively few infrastructure are pure public goods that cannot be priced. Most are chargeable. The World Bank, amongst other, has actively argued in favor of charges, for the sake of replicablility. But replicability does not say much about the structure of charges: is marginal social cost pricing really the only and most efficient pricing method? The paper will also neglect the qualitative dimensions of infrastructure supply. Most studies have considered infrastructure endowment in quantitative and dichotomic terms: as present or absent. In reality, in many cases, the problem is not so much to provide the infrastructure as to improve the quality of its service.

Instead, the paper will focus on three issues: the contribution of infrastructure to economic growth; the relationship between financing options for infrastructure investments and economic efficiency; and the magnitude of forecasting errors in infrastructure projects and what they mean in terms of uncertainty and risks.

Contribution of Infrastructure to Economic Growth

How much ?

What is the contribution of infrastructure to economic growth ? The topic, which had been largely neglected until the late 1980ies, became suddenly very fashionable after a seminal (although later much criticized) paper by Aschauer (1989). Dozens of contributions were produced in the following decade[1]. Gramlich (1994), in a survey article, goes as far as talking of "research bubbles here" (*Ibidem*, p. 1189). All of these studies have one point in common: they relate to infrastructure capital, and ignore infrastructure services. The main line of research uses an extended production function, in which output Y is not merely a function of labor L and capital K, but also of infrastructure G:

$$Y = f(L, K, G)$$

Various functional forms were used, particularly Cobb-Douglas type functions, and translog functions. Various notions of "infrastructure" were utilized, more often dictated by data availability than theoretical arguments. Various data sets were used: time series, cross section data, and panel data. The pitfalls of such analysis, however, are formidable.

[1] Even this author added one stone to this monument (Fritsch & Prud'homme 1997).

First, there is the issue of reverse causality. Even if it appears that infrastructure G and output Y are correlated, it does not mean that more infrastructure necessarily produces more output. It can also be argued that more output makes it possible to finance more infrastructure. There is a chicken and egg problem here.

Second, infrastructure investment is a component of output. An increase in infrastructure investment mechanically raises aggregate demand and output, even if it does not contribute to increase productivity and output.

Third, many infrastructure are decided in order to increase welfare, and welfare is only a relatively distant cousin of output or GDP. Many welfare improvements are not or are very poorly reflected in increased GDP. Time savings, the main justification of most transport investment projects, are a case in point. If a new road makes it possible for me to drive faster to visit my aging mother, this is good for me, and for her, but it does not contribute much to the GDP of France. The same is true of many of the services provided by infrastructure and consumed by households.

Fourth, data on the dollar value of the stock of infrastructure is scarce and questionable. It is absent in most developing countries, which is one reason why so few of the many studies done on this topic deal with such countries. Infrastructure, as mentioned above, are often very long-lasting. Permanent inventory methods do not fare well with a 100 years old infrastructure investment. What is the value of the Suez canal? Is it its historic cost, assuming it is known? How should we treat depreciation, and repairs? Or is it what it would cost to build it anew? Any number put on the value of the Suez canal, or of any similar infrastructure, will be highly dependent upon the answers given to such questions, and therefore highly questionable.

Fifth, infrastructure is very heterogeneous from the viewpoint of its relationship to economic development. It includes elements which are likely to contribute much, and white elephants that do not contribute at all. It will be argued that private capital and even labor are also heterogeneous. But this is not true (at least not to the same extent), in the sense that market mechanisms homogenizes these inputs, precisely from the viewpoint of their contribution to output. The marginal utility of a dollar of capital in one form is in principle equal and in practice not very different from the marginal utility of a dollar of capital in a completely different form. These market mechanisms do not operate in the case of infrastructure, which are politically decided. Cost-benefit analysis is supposed to offer an alternative equalizing mechanism. Few practitioners would argue that it fulfills that function perfectly.

Finally, what matters for economic development is infrastructure usage, but what we observe is infrastructure supply. The latter is a very poor proxy for the former. Between the two, there are demand schedules and pricing policies, which are ignored by production function analysis. Let us consider a given infrastructure, such as a bridge. Its contribution to economic development will obviously not be the same if it is free or priced, and if it is over-utilized (i.e. congested) or under-utilized. Here again, the analogy with private sector capital does not hold. In the private sector, over-investment carries heavy cost penalties and under-investment means benefits forgone: they usually do not last for very long. Infrastructure is not subject to similar market discipline. In addition, infrastructure, as mentioned above, is usually more lumpy and intrinsically prone to over-investment, followed by under-investment. The divorce between supply and usage is therefore quite common.

Researchers have of course been aware of these pitfalls, and have done their best to avoid them. They used sophisticated econometric techniques or independent data to deal with the chicken and egg problem, and the common trend issue. They have tried to use physical indicators (such as road length or road space) rather than monetary indicators to bypass the infrastructure valuation difficulty. They have introduced infrastructure usage variables when feasible (see for instance Nadiri and Mamuneas 1994). Variations in prices, however, have apparently been ignored.

The output of this production function industry is therefore somewhat unconclusive. Most studies —not all[1]— suggest that infrastructure contributes to economic development. But the magnitude of this contribution varies from one study to another. The elasticities of GDP to infrastructure differ greatly, but this could merely reflect the different notions of infrastructure used in the studies. More worrying is the fact that the rates of return that can easily be associated with these elasticities also vary significantly, from 0% to 50% or 60%. The overall conclusion that emerges from this important line of research is that infrastructure seem to have a relatively high rate of return —something like 15%— quite comparable or even higher than the rate of return of private "productive" capital. The verb "seem" emphasizes the prudence with which this conclusion should be taken.

When one thinks of the many infrastructure investments that clearly do not contribute much to economic development —empty roads, luxury administrative buildings, etc.— an average of 15% (or even of 10%) is quite encouraging. It suggests that about half infrastructure investments have rates of return higher than 15%. Because the variance of

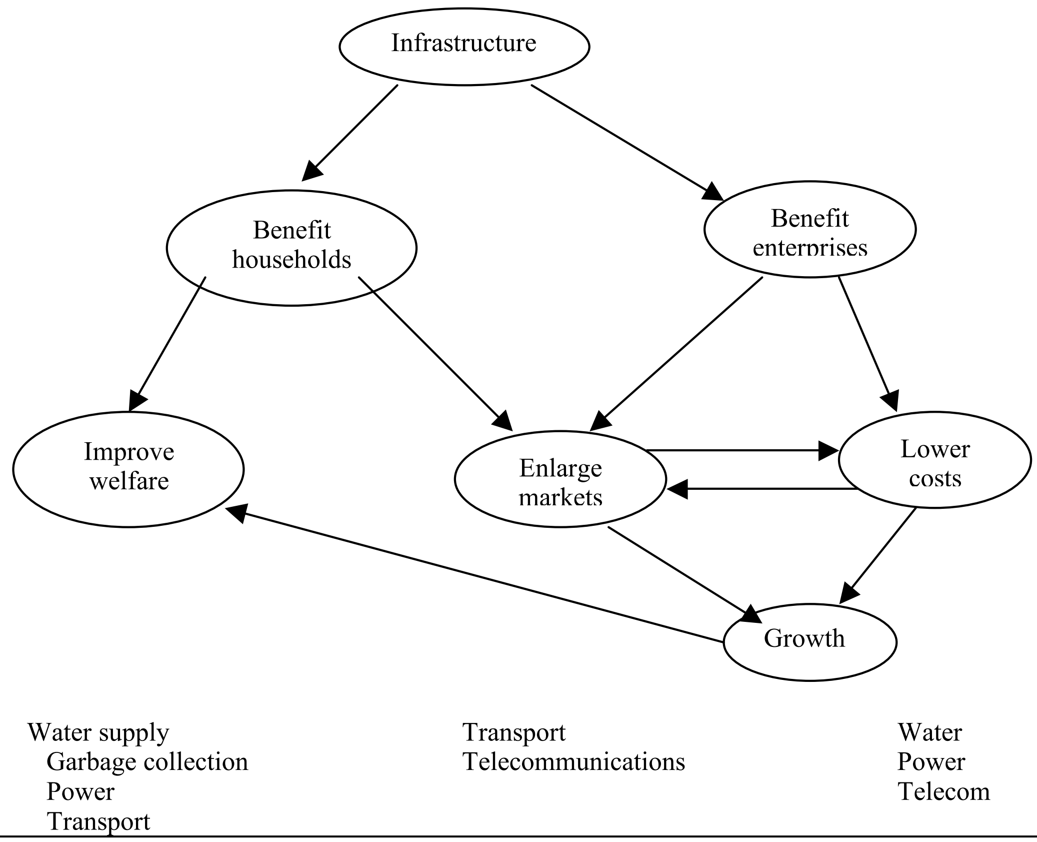
[1] Holtz-Eakin (1994) for instance, on the USA, controlling carefully for State-specific effects finds tht public infrastructurte contributes nothing to private output or productivity ; note however that his definition of « infrastructre » is State and local government capital, ignoring Fedral highways and most privaltely-owned utilities capital.

the distribution of such rates of returns is large —certainly much larger than that of the rates of returns of private "productive" investments— it even suggests that a significant share of infrastructure investments have rates of return higher than 20% or 25%. This would imply that there is underinvestment for certain types of infrastructure in certain areas, as well as overinvestment in other cases.

How ?

Rather than "how much", it might be more useful to ask "how" infrastructure contribute to economic development. Production function analyses are black boxes, with infrastructure as one of the inputs and GDP as an output. Let us try to open the lid of these black boxes. In so doing, we shift from infrastructure capital to infrastructure services.

Figure 1 – How Infrastructure Contribute to Development



As Figure 1 indicates, infrastructure impacts "development" via both households and enterprises, the consumers of infrastructure-related services, and does so through three main mechanisms.

For households, infrastructure-related services improve welfare, and often do it in a dramatic fashion: water supply and sanitation, power supply, transportation change the lives of beneficiaries, particularly in cities. *Stricto sensu*, these welfare improvements do not contribute much to GDP, although one can argue that they improve the quality of the labor force and hence its productivity. Many economists, of course, consider that improving welfare is part of "development", even if it does not contribute to "growth".

The two other mechanisms, which are interrelated, have a direct impact on GDP. First, infrastructure supply lowers the cost of some of the inputs used by enterprises. In power or transportation or communication, it can do so by impressive amounts. In so doing, infrastructure acts exactly like technological progress. Lower input costs mean lower total costs, which mean larger markets, and further cost reductions.

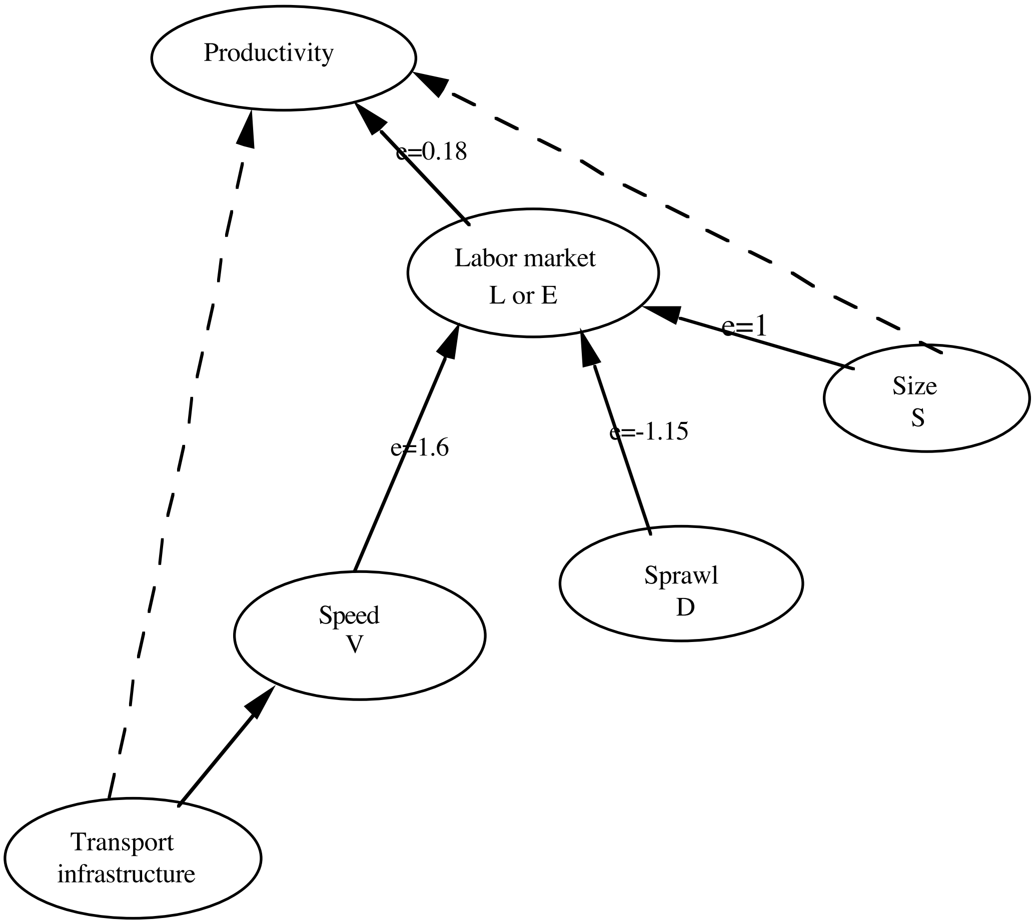
The most interesting, and perhaps the most important, mechanism of the infrastructure-development relationship is market enlargement. It applies to goods markets and to labor markets and even (via telecommunication infrastructure) to capital markets. As noted by Adam Smith more than two centuries ago, transport infrastructure enlarge goods markets, by lowering transport costs, and also by speeding access for perishable merchandises. The progress of telecommunication infrastructure has intensified this enlargement process. With it comes intensified competition, greater specialization, and economies of scale.

Improved infrastructure functions exactly like lower tariffs. It facilitate economic exchanges, and brings the same type of economic benefits. All the analyses that assess the economic benefits due to increased trade can be used to show the contribution of improved infrastructure to economic growth.

Less known perhaps is the impact of infrastructure —in this case urban transport infrastructure— on urban labor markets. In a world in which more than half the population, and a much larger share of output, is located in cities, the efficiency of cities has a macro-economic importance. As is well-know, the productivity (per worker, but also per unit of capital) of a city increases with the size of the city. Why? The most plausible reason is that larger cities have larger labor markets. The larger the labor market, the greater the probability that each individual will find exactly the kind of job that matches his/her capabilities and the greater the probability that each enterprise will find exactly the kind of workers that matches its needs. A larger labor market ensures a better match of labor demand and supply, and this in turn ensures a greater productivity. However, what matters here is not so much the potential size of the labor market (the total number of jobs), but rather its *effective* size (the number of people who can on average access jobs at a reasonable time and money cost). This is where infrastructure enters the picture. For the effective size of the labor market is (more or less mathematically) a function of three factors: the total number of jobs in the urban area, the relative location of jobs and houses, and the speed at which people move to their jobs —which is itself a function of urban transport services, which are themselves dependent upon transport infrastructure capital.

This simple model of urban productivity was tested and confirmed on the case of 22 French urban areas (Prud'homme and Lee 1999). The elasticity of productivity (corrected to eliminate the influence of differences in industry-mix) with respect to effective size of labor market was about 0.18, and the elasticity of the size of the labor market with respect to transport speed was around 1.6. This means that the elasticity of productivity to transport speed was about 0.29. Increasing transport speed by 10% increases productivity and output by nearly 3%. This is illustrated by Figure 2.

Figure 2 — Impact of Transport Infrastructure on the Efficiency of Cities



The relationship between transport infrastructure and transport speed is obvious, although not well known. In a study of the Paris area, we estimated that road investments over the 1983-91 period had increased traffic speed (relative to what it would have been in the absence of such investments) by 5%. Using the elasticity mentioned above, this made it possible to estimate the increased productivity and output due to these road investments, and to derive a rate of return, which turned out to be around 60%. The numbers are certainly fragile, but the causal linkages are probably quite robust.

Financing Options and Economic Efficiency

The question of whether an infrastructure investment should be undertaken or not has usually been discussed independently of who undertakes it and finances it. Yet, it can be shown that the institutional and financial context and constraints have a direct bearing upon the economic desirability of the project, and also on public budgets. Whether it is constructed and operated by the public sector, or contracted out to private enterprises, or jointly constructed, operated and financed by both actors, might make the project more or less valuable. Whether it is paid and financed by users or by taxpayers also has a direct impact on the socio-economic viability of the infrastructure project. In a sense, this discussion is an illustration of the distinction between infrastructure capital and services. In all cases, the physical infrastructure capital is the same; but the services it provides, or the cost at which they are provided, vary with the financing and institutional regime chosen.

A Menu of Options

Let us begin by listing and describing the menu —or rather a menu— of institutional and financing options available, on the example of a bridge or a road. Seven such options are considered.

Pure public option – In the pure public option, the bridge is built in year 1 by a government entity, which operates it, and its usage is free.

Pure private option – In the pure private case, the bridge is built and operated by a private enterprise, in the framework of a contract or concession or authorization granted by a public body. Users pay a toll, the proceeds of which will compensate the private enterprise. There is a toll level that maximizes toll profits, but the effective toll level is usually negotiated with the granting entity. It must be sufficiently high to ensure the financial viability of the private enterprise investment, i.e. meet a financial rate of return constraint.

Public cum toll option – The infrastructure may be built and operated by a public body that imposes a toll on users. Over the course of time, toll proceeds will accrue to government coffers, and it might be assumed that they will substitute ordinary taxes. The toll level may or may not be the same as in the pure private option. It is usually lower, because the financial rate of return constraint for the public body is lower. (There is a variant of the public cum toll option, not considered here for the sake of simplicity, in which the public entity borrows from a bank the money needed for the investment and uses toll proceeds to pay interest on the loan).

Private cum subsidy option – In the private cum subsidy option, the private enterprise that builds and operates the bridge at an agreed toll level argues that it needs a subsidy to meet its financial rate of return constraint, and obtains one. This subsidy can be a percentage of the initial investment and be paid up-front. (There is also a variant, not considered here for the sake of simplicity, in which the subsidy is paid over the course of time, as a percentage of toll proceeds or as a prescribed amount).

Shadow-toll option – In the shadow toll option, the private enterprise builds and operates the bridge. There is a toll, but the toll is not paid by users, for whom bridge crossing is free. It is paid by the granting authority, prorata the number of users. The toll level is also negotiated, and it can be lower than the toll level of the pure private option because the number of users will be greater.

Delayed public option – In the delayed public option, that often prevails when governments find themselves cash-strapped, the bridge construction and operation is simply postponed by n years, but, except for this delay, this option is similar to the pure public option.

Do-nothing option – Obviously, not constructing the bridge, and letting potential users continue to make a long detour to cross the river or not cross it, is always an available option. It is even the reference option, the one to with the other options can and should be compared.

Economic Impact Mechanisms

As is well know, a cost-benefit analysis of this bridge can be synthesized with two indicators : the discounted net value (economic DNV) of the flow of costs and of benefits; and the internal rate of return (economic IRR), the social discount rate that equalizes the discounted value of costs and of benefits. This is not the place to discuss the relative merits of both indicators, which, in practice usually tell very much the same story. The important point here is that the institutional and financial options for the infrastructure considered are not identical from an economic viewpoint. For the same bridge, the cost-benefit analysis of the various options will not produce the same results. There are three reasons for this, three important basic mechanisms.

Users exclusion – The toll charged for the use of the bridge will eliminate some users. Since, the economic cost of supplying bridge service is normally not affected by usage, excluding some users implies a welfare cost. The surplus generated by the bridge is inversely related to the toll level. Since our options carry different toll levels (including zero levels), they affect differently the benefits associated with the infrastructure. If this mechanisms were the only one at work, the pure public and the shadow toll options (both with a zero toll level) would clearly dominate the other options.

Two remarks can be added. One is that the above is only true for a non-congested bridge or road. If, or rather when, there is congestion, then (at least in principle) a congestion charge is appropriate to maximize the benefits from bridge usage. There is little chance that the prevailing toll will be exactly equal to the optimal congestion toll, but the prevailing toll will nevertheless increase rather than decrease the surplus associated with bridge usage.

The other remark is that caution is required to extrapolate this mechanism to other types of infrastructure. Tolls, called fees, are common with many other infrastructure. But the exclusion of users they cause is only a welfare cost when marginal production costs are zero or at least lower than the fee charged, and also when, as in the case of the bridge, there is no congestion problem.

Greater efficiency of private operation – There are theoretical and empirical reasons to expect private operations to be more efficient, that is to consume less economic resources, than publicly managed operations.

One can think of at least four reasons for this greater efficiency of the private sector[1]. First, the incentive system prevailing in the private sector is more effective than the one that prevails in the public sector; for respectable reasons, the people who deliver are better rewarded (and those who do not more punished) in the private sector; there are strong build-in cost minimizing mechanisms. Second, and also for respectable reasons, procurement, accounting and disbursement procedures are more complicated and formal in the public sector; doing things according to the rules is more important that

[1] The dichotomy public-private oversimplifies the issue : in reality, there are also public enterprises, less flexible and responsive that a private enterprise, but more so than a government ministry.

doing them swiftly and efficiently. Third, and somewhat paradoxically, the private often benefits more from economies of scale than the public; this is because the public may consist of relatively small local or regional governments[1], whereas the private often consists of large companies operating in the entire country or even the entire world. Fourth, technical knowledge and innovation, the mother of productivity, is by now more in the private sector than in the public one. These reasons are unfortunately likely to have even more force in developing than in developed countries.

Assuming that maintenance and operation costs are negligible, this means that Ig, the economic cost of a publicly built and operated infrastructure will be higher than Ie, the cost of the same infrastructure done by a private enterprise, by a margin α:

$$Ig = (1+\alpha)*Ie$$

The value of α varies greatly from case to case and country to country. There might be cases when $\alpha<0$, particularly if and when the private entity is an uncontrolled monopoly. But in general, the distribution of αs seems to be centered around a positive value. 20% sounds like a reasonable order of magnitude.

This means that institutional and financial options in which the bridge construction and operation is done by a public enterprise will (all other things equal) have economic costs higher by α —higher than what the costs would be if bridge construction and operation were done by a private enterprise.

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[1] This is not always the case ; in many developing countries, there is a powerful Ministry of Public Works in charge of most infrastructure projects throughout the country, although the progress of decentralisation erodes this potential benefit.

Tax distortions – The third mechanism to be taken into account is related to the economic cost associated with tax financed expenditures. Taxes are generally distortive[1], and modify the incentive system in ways that decrease output, and associated welfare. This deadweight loss, or opportunity cost of tax income, equal to λ*tax proceeds, varies with the tax/GDP ratio and the structure of the tax system. The value of λ might be as high as 20%[2]. This means that when a government entity spends 100 financed by tax income, the economic cost to the economy of this expenditure is something like 120. Conversely, when this government entity raises 100 in he form of tolls, thereby decreasing other distortive tax resources by 100, there is a welfare gain of something like 20.

This has implications for the valuation of the costs and benefits associated with the various options. Costs financed by tax income must be increased by λ, benefits resulting from a reduction of taxation taken into consideration.

Cost-benefit analysis of the various financing options must take into consideration these three interacting mechanisms. The outcomes are hard to predict. General formulations, that quickly become very complex, do not throw much light on such outcomes. We have preferred a simple simulation that produces different IRR and DNV for our different options, and suggest an economic ranking of these options. Before turning to

[1] Lump sum taxes and taxes on negative externalities are exception. Unfortunately lump sum taxes are a textbook curiosity (there are no tax systems consisting only of lump sum taxation) and taxes on externalities are very rare indeed.

[2] There is of course no reason why λ should be equal to α. For the USA, l has bee estimated to be 17% by Ballard and others (1985) and 47% by Jorgensen and Yun (1990).

these numbers, however, we must discuss another dimension of the issue, the budgetary approach.

Budgetary Approach

So far, we have examined the problem in purely economic terms. In practice, the problem has also a budgetary dimension, which is often a dominant one. Ministries of Finance (even when they are not separate from Ministries of the Economy) try, all other things equal —and, at times, even when they are not equal— to minimize budgetary expenditures. This means spending less, and spending as late as possible.

An infrastructure investment, however, when it is successful and produces utility, also produces additional taxes and public revenues. Additional utility is not exactly additional economic output, but it is akin to it, and a large fraction of it. As a first approximation, we can say that, every year, additional tax output ΔR is a fraction γ of additional utility or welfare ΔW:

$$\Delta R = \gamma * \Delta W$$

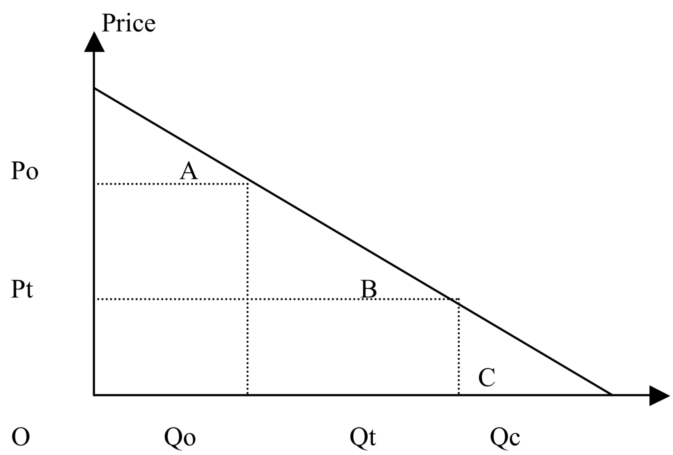
The value of γ varies with the type of infrastructure investment, and with the nature of the tax system. It also varies with the level of government considered. It is much higher for a central government than for a local government, because local government tax rates are much lower than national ones, and also because welfare benefits usually leak out of the area where the investment is made. A plausible order of magnitude could be γ=20%. This would be commensurate with a 30% tax to GDP ratio and a two third ratio of GDP to welfare.

With a value of γ one can figure out, in each of the financing options discussed, the flow of government revenue generated by the infrastructure investment considered, and compare it with the associated government expenditure. This is done by calculating the DNV (Discounted Net Value) with a discount rate. This rate need not be identical to the rate of discount utilized for the economic DNV

Comparing Financial Options

To compare our seven institutional financial options, we can compare the economic IRR, the economic DNV, and also the budgetary DNV associated with each of them. Let P(Q) be the demand curve for the crossing of the river, as shown in Figure 3.

Figure 3 – Demand for River Crossing



Before the construction of the bridge, the price of crossing, Po, which implies a long detour, is high and the traffic Qo is modest. We are in A. After the bridge, with a toll Pt, we move to B, with a traffic Qt. If there is no toll (Pt=0), we move to C. The yearly utility or social benefit associated with the bridge is OPoABQt, or OPoAQo+QoABQt. Let us assume that the bridge is built in one year, in year 1, at a private investment cost of Ie, with α the surcost of public construction and operation, and λ the opportunity cost of tax resources. γ is the ratio of additional tax to additional welfare.

For a given option, the economic IRR is the value or r for which:

$$\Sigma_t Po*Qo_t+\int_{Qo}^{Qt}D(P)dQ_t(1+r)^t-\alpha*\lambda*Ie = 0;$$

the economic discounted net value DNVe is:

$$DNVe = \Sigma_t[Po*Qo+\int_{Qo}^{Qt}D(P)dQ]_t(1+r°)^t - \alpha*\lambda*Ie$$

with r° an appropriate social rate of discount; and the budgetary DNVb is:

$$DNVb = \Sigma_t(Pp*Qp)'_t(1+r')^t + \Sigma_t\gamma[Po*Qo+\int_{Qo}^{Qt}D(P)dQ]_t(1+r')^t - \alpha*Ie - S - \Sigma_t(Pp*Qp)''_t(1+r')^t$$

With (Pp*Qp)' the public toll proceeds (when they exist), S the subsidy to a private enterprise (when there is one), (Pp*Qp)" the toll paid to a private enterprise (when they exist), and r' the social rate of discount for public funds.

To produce orders of magnitude, we used the following values for the parameters utilized. The demand curve for the crossing of the river is assumed to be:

$$P(Q)=15–5*Q$$

$$Q(P)=3-0.2*P$$

This defines a price-elasticity of demand that varies along the demand curve, but which is about –0.5 for P=5, in the lower ranges of P that matter, a realistic elasticity. We assume the initial situation to be Po=10 and Qo=1. The demand curve is assumed to be constant over time.

The cost of the construction of the bridge by a private enterprise Ie is 100. We assume α the public construction sur-cost to be 20%. The opportunity cost of tax resources λ is also assumed to be equal to 20% (but the two values could be different). We also assume γ the marginal ratio of tax income to welfare to be equal to 20% (but γ need not be equal to α or λ). The social rate of discount r° used to calculate the economic DNV is taken to be 6%. The social rate of discount r' used to calculate the budgetary DNV is also taken to be 6% (but here too, the two values could be different)[1]. Both IRR and DNV calculations are done on a 30 years period.

In the pure public and in the shadow toll options, there is no toll, and price P paid by users is therefore 0. Different tolls could be retained for the other options. The profit maximizing toll [the one that equals to zero the derivative of P*Q(P)] is 7.5. This is the toll level that the private enterprise would chose if it were left to decide. But this would lead to a restricted patronage of the bridge and reduce its economic utility to a low level. We assume that the negotiated toll level in the pure private option will be 5. This is consistent with a 9.3% financial internal rate of return for the enterprise, which may be considered sufficient. In the public cum toll option, we assume a lower toll level of 4, because the public entity can function with a lower financial internal rate of return. In the shadow toll option, the toll is paid not by users, but by the government entity to the private enterprise, and because it is paid on all users, it can be lower : we take it to be 3.33 (the toll level that yields yearly toll proceeds equal to the toll proceeds of the pure private option). In the private-cum-subsidy option, the toll remains at 5[2].

Table 3 presents the parameters attached to each option, and above all the value of the indicators produced by the model. Other numbers for the parameters would produce

[1] These values are on the low side, particularly for developing countries.

[2] The private cum subsidy option corresponds to the case in which the financial IRR (9.3%) that prevails in the absence of subsidy is considered too low by the market; A subsidy of 30% is granted that will increase the financial IRR (to 14%) but decrease the economic IRR because of the economic tax cost associated with the subsidy.

different values for the indicators and in certain cases different rankings of the options. Nevertheless, the values shown in Table 3 are not unreasonable, and the rankings obtained deserve attention. They suggest several conclusions.

First, different financial options for the same infrastructure investment (here, a given bridge) lead to different economic IRR or economic DNV, and also to different budgetary DNV. Institutions and finance matter for economics.

Table 3 – Comparisons of Various Financial Options

	Pure public	Pure private	Public +toll	Shadow toll	Private +subsidy	Public delayed
Features :						
α	0.2	-	0.2	-	-	0.2
λ	0.2	-	0.2	0.2	0.2	0.2
γ	0.2	0.2	0.2	0.2	0.2	0.2
P (toll level)	-	5	4	3.33	5	-
Q (Traffic)	3	2	2.2	3	2	3
P*Q (Proceeds)	-	10	8.8	10	10	-
S (Subsidy)	-	-	-	-	30	-
U (Utility)	20	17.5	18.4	20	17.5	20
I (invt cost)	144	100	144	100	100	122
r° (discount rate)	6%	6%	6%	6%	6%	6%
r’ (id for budget)	6%	6%	6%	6%	6%	6%
Financial IRR	-	9.3%	6.1%	9.3%	14.0%	-
Indicators :						
Economic IRR	**13.6%**	**17.4%**	**15.1%**	**17.9%**	**16.3%**	**13.4%**
Economic DNV	**124**	**133**	**126**	**139**	**127**	**95**
Budgetary DNV	**-61**	**+45**	**+49**	**-78**	**+17**	**-53**

Notes : IRR (internal rates of return) and DNV (discounted net values) are calculated over a 30 years period ; in the public delayed option, the delay is 3 years, i.e. the investment is made in year 4.

Then, the two economic rankings are practically identical[1]. The budgetary ranking is different but tells a story which is not basically different from the economic one.

This economic story is that the pure public option does not fare well. It has the lowest economic IRR of all options. It can marginally be improved by the introduction of a

[1] The change from the pure public to pure public delayed options deteriorates significantly the DNV but does not change much the IRR ; Calculations have been made over a 30 years period, begining with year 1, 2, 3, in which nothing happens.

toll: what is lost in terms of consumer' surplus is more than compensated by what is gained through a reduction in tax-associated damage; and in addition, the toll is attractive from a budgetary viewpoint. Delaying the pure public option by a few years is worst in economic (DNV) terms, and not much better in budgetary terms.

The pure private option is —in the example studied— substantially superior to the public options, in economic terms, and also in budgetary terms. Even the combination of a private provision and a subsidy is, in socio-economic terms, more attractive than the pure public option, although it does not fare very well in budgetary terms (it fares better than the pure public option, though, but not as well as the tolled public option).

The shadow toll system is the best system in socio-economic terms. In budgetary terms, however, it fares badly, even worst than the public options.

Finally, in budgetary terms, the do-nothing option, which has evidently a budgetary DNV of zero, is more attractive than the pure public option. This provides a justification for doing nothing. But it is a bad justification. Doing nothing is (in the example studied) the worst option in socio-economic terms; and even in budgetary terms it is worst than either the private options or the public cum toll option.

Forecasting Errors, Uncertainties and Risks

Traditional cost-benefit analysis implicitly assumes that the flows of costs and benefits generated over the course of time by an infrastructure project can be correctly forecasted. This assumption often turns out to be erroneous. The comparison between *ex ante* forecasts and *ex post* events can show enormous discrepancies. Some of the methodological refinements of cost-benefit analysis, that "improve" accuracy of analysis by 1 or 2 percentage points are applied to data that may be off the mark by 30 or 40 percentage points. This is a worrying contrast. More generally, forecasting errors are a measure of the uncertainties that surround the life of infrastructure projects, and of the associated risks. Some might say that there is nothing new here and that most business decisions are taken in the face of uncertainty. But it is a matter of degree, and uncertainty in infrastructure decision is generally much greater than in most ordinary business decisions. Reducing errors, dealing with uncertainties, and allocating risks efficiently, constitute major tasks of infrastructure policy

Magnitude of Forecasting Errors and Uncertainties

Errors in infrastructure projects are defined as the difference between *ex ante* and *ex post* numbers. They relate to costs and completion dates (delays are a major source of additional costs), and to benefits, which, in many cases, and certainly in transportation projects, are closely associated to patronage and traffic.

Systematic studies of such errors are scarce (Pickrell 1990; Flyvbjerg 1997, 2002, 2003; Odeck 2004). They are scarce because they are difficult to conduct. Cost-benefit analysis assumes that there is a well defined project that is analyzed, decided and implemented. This is a fiction. In practice, the story of many infrastructure projects, particularly large ones, begins with a concept, to which a few costs and benefits numbers are attached. It continues with a draft project, in which these numbers are refined. They are further modified, because additional information becomes available, and because additional negotiations are conducted. New numbers appear. Even after a decision has been finalized, there are often further information, negotiations, changes, improvements, additions, etc., producing revised forecasts. The net result is that a simple question like: what was the *ex ante* cost of the project? is often very difficult to answer. In addition to these conceptual difficulties, there are practical difficulties. *Ex* *ante* data might never have existed, or it might have been lost, or those who have it might be unwilling to communicate it[1].

The most comprehensive study of such forecasting errors is the one undertaken at Aalborg University under the leadership of Bent Flyvberg on more than 200 transport projects, located in 20 countries, including both developed and developing countries. The findings of the study are summarized in Table 4. They are very much in line with the findings of other studies. In his pioneering work on ten US rail transit projects, Don Pickrell (1990) found average capital cost overuns of 61% (compare with 45% for rail projects in Table 4), and average ridership overestimates of 65% (compare with 39% in Table 4). Odeck (2004), looking at construction costs of 620 road projects in Norway, finds average overuns of 8% (compare with 20% in Table 4). A Transport and Road Research Laboratory study of subways in developing countries produced construction cost underestimates and ridership overestimates of similar magnitude.

Table 4 – Forecasting Errors on Construction Costs and Traffic Forecasts in Transport Projects

	Construction costs			Traffic		
	Number	Error	sd	Number	Error	sd
Rail projects	58	+45%	(38)	27	-39%	(52)
Road projects	167	+20%	(30)	183	-9%	(44)
Fixed links	33	+34%	(62)			
All projects	258	+28%	(39)	210		

Source : Flyvbjerg 2003, chapter 2 and 3 ; sd = standard deviation

The picture is therefore quite clear and consistent. In transport projects, errors on construction costs and on ridership are very common and very large. They are

[1] Some people believe that refusal to communicate is, in the name of competitive secrecy, more common in the private sector, and they worry that a greater role of the private sector will translate into a greater paucity of data. Other people believe that in many countries, particularly developing countries, public sector secrecy might be even more formidable.

systematically on the "wrong side", with costs underestimated and patronage overestimated. Errors are significantly larger for rail projects than for road projects. There is apparently no progress in the accuracy of forecasting over the course of time. The size of projects do not seem to matter; indeed, Odeck (2004) finds greater errors in small projects than in larger ones. Errors seem to be largely independent of the project country, and equally important in both developing and developed countries.

These conclusions relate to transport infrastructure projects. Studies of cost and patronage forecasts in other infrastructure areas are less systematic (or less known to us), but the available information suggests that similar errors are common.

Explaining Errors and Uncertainties

Why are such massive errors made, and what uncertainties do they reflect ? It might be useful to distinguish four main causes, or four main types of errors: substantive, economic, technical, and institutional.

First, there are errors and risks related to the nature or the *substance* of the infrastructure project. The *ex post* project might not be the same as the *ex ante* project. The project may have started as a 2x2 lanes project and evolved into a 2x3 lanes project. Environmental or safety constraints may have been added to the initial project. In such cases, the drift is not a drift of the costs, but a drift of the project. Similarly, in traffic forecasts, an alternative road, which was not planned and therefore not taken into account, may have been built, changing the context and the nature of the project. Such errors, and the uncertainties they reflect, which are largely specific to infrastructure projects, mean that there are *substantive risks* in infrastructure investments.

Second, there are *economic* errors and risks, that is risks associated with the evolution of the overall economic climate. Most studies of demand and patronage are heavily dependent upon income, and therefore upon income and activity forecasts. The economic development of a country is beyond the responsibility of infrastructure planners. Overoptimistic forecasts usually result in overestimates of patronage. This risk is often called a market risk. It could be argued that a similar risk exists for all goods and services, for instance for toothpaste production. The difference is that in toothpaste production, forecasting errors can be much more easily corrected, because toothpaste production does not involve massive, long-lived, immobile capital.

There are also errors linked to the *technical* difficulty of forecasting costs and usage for an infrastructure project. They come from the fact that many such projects are unique. They are not goods and services which are mass-produced in an easy to predict fashion. They are made to measure. In addition, they are often of a large size. This makes them complex, and their completion might take years, which increases the probability that something might go wrong. Infrastructure projects are exposed to strikes, to flooding, to suppliers bankruptcies, etc. Infrastructure projects are often dependent upon geological unknowns. They often use new, and not yet fully mastered, technologies. For usage forecasts, planners are dependent upon imperfect models and insufficient information, not to mention uncertainties about the economic, social, psychological or political environment. The resulting uncertainties, which are also specific to infrastructure projects, mean that there are *technica l risks* associated with such projects.

Most of these "economic" and "technical" errors, however, could and should play in both directions. They should lead to overestimates as well as underestimates. They should explain the standard error of errors, not the average, which should be zero. They cannot explain fully the systematic errors which are so common.

A complementary, and probably better, explanation is behavioral and *institutional*. Infrastructure developers make errors because they have an interest in making errors.

Errors in public projects - Flyvbjerg and others (2002) put it bluntly: “Underestimating costs in public work projects: error of lie?”. In purely public projects —and most of the projects studied fall in that category—civil servants in the technical ministries involved want very much the projects to be constructed. Their prestige, carriers, power (and in extreme cases, income) are often attached to such projects. Hence an easy to understand tendency to underestimate costs and overestimate utility, in order to ensure that “their” projects will be decided. If things go wrong afterwards, these civil servants are unlikely to be affected.

There is a similar asymmetry with decision-makers, i.e. politicians. They are also quite willing to be misled. They will derive a political benefit from the decision to build, and an even greater benefit from the inauguration of the project. But the potential failure of the project, in terms of over-costs or under-patronage, will probably not be damaging for them. In many cases, they will no longer be in office when this failure becomes apparent. The life cycle of an infrastructure project is usually longer than that of a politician in office. In addition, the benefits of an infrastructure project are often visible and concentrated, whereas the costs are hidden and diluted. On political scales, the former outweight the latter.

Errors in private projects - One would expect privately financed infrastructure projects to be protected from such institutional biases in favor of errors. The private capitalist who underestimates costs and/or overestimates usage is likely to be penalized for his errors, often severely. His employees responsible for the errors will be sacked, unlike what happens in the public sector. In any case, the banks that lend him money will scrutinize the project, and double-check its seriousness, because it is their own money that is at stake.

Yet, it appears that even private infrastructure projects are not immune from errors. The record is not as bad as in the case of public project, but it is far from perfect. The most glaring case is perhaps that of the Channel tunnel, an 8 billion US$ infrastructure investment (1985 prices). It was built with private money, from banks and capital markets, without any public subsidies. Nevertheless, actual costs were 80% higher high as projected costs, and actual traffic is 40% below projected traffic, and the company is on the verge of bankruptcy. Studies of concession contracts in Latin America (Engel et al. 2003; Guash et al. 2003) point out to similar errors. How can they be explained?

In certain cases, cost overruns are of the substantive errors types. Additional constraints were added, that increased delays and costs. This was a major factor in the Channel tunnel case. In other cases, it is reported that the losses of the private infrastructure enterprise were the profits of the construction companies that were often the dominant stockholders of the infrastructure enterprise.

But the main explanation is that there are no pure private enterprises in infrastructure construction and operation. There is always some public entity involved. Some public agency or ministry always intervenes to define the project, to select the private enterprise, to decide on toll levels, to chose the concession period, to grant subsidies in certain cases, etc. When things go wrong, the public sector rarely lets the private enterprise go bankrupt, but usually bails it out and renegotiates the contract. In certain cases (rare it seems), when things go too well, the public sector also intervenes and imposes additional taxes or constraints. The public agent is a very active back seat driver. This does not facilitate good driving.

This is why many of the weaknesses described above apply. Public technicians and politicians want very much —as much as the private enterprises— the infrastructure project to be undertaken, and they are ready to distort (unconsciously perhaps) forecasts and concession contracts in order to achieve their goals.

Traffic forecasts, for instance, are typically prepared by ministries of Transport, and often included in the documentation given to prospective bidders. They are as over-optimistic as if they were intended for direct public provision. In Colombia, note Engel and others (2003, p. 8), "traffic was 40% lower than predicted by Invias" (the public agency responsible for highways). In a number of cases, private enterprises need not care much about the accuracy of forecasts because they enjoy minimum traffic guarantees. If traffic is not what it was forecasted to be, the government will pay a subsidy to the enterprise.

Cost estimates do not matter much either for private enterprises, because in many cases they are *de jure* or *de facto* protected from cost overruns. Legal profit guarantees are not uncommon. And when they do not exist, contracts can often be renegotiated. Indeed, renegotiation seems to be the rule rather than the exception. In other words, private enterprises involved in infrastructure projects generally face soft budget constraints. The reasons they should have (with hard budget constraints) to ensure that their cost and benefit forecasts are accurate are in practice dampened or eliminated.

Engel et al. (2003) go even further and suggest that the recourse to private enterprises in infrastructure projects may be part of a political strategy that implies errors. Politicians, they argue, want infrastructure projects to be done now, before next election. When purely public, these projects are taken into consideration in the budgetary process, where they may be fought by the opposition. Contracting out to private enterprises on an error-ridden basis allows the government to increase infrastructure now, at the cost of bailing out private enterprises later, without increasing apparent debt. Errors in this analysis are the counterpart of a politically convenient hidden debt.

Dealing with Uncertainties and Risks

Whether substantial, economic, technical or institutional, forecasting errors in infrastructure projects are economically damaging. They flout cost-benefit analysis. They mean that projects which have in reality a very low economic internal rate of return or a negative economic discounted net value[1], and should never be undertaken, are made to appear desirable and are actually undertaken.

Every effort should be made to reduce the uncertainties involved in infrastructure projects and the forecasting errors associated with them.

Public projects — For purely or mostly public projects, what does it imply? To reduce substantive risks, and avoid costly changes in project design, focus, objectives and constraints, it is important to involve as many stakeholders as possible right at the beginning. The time spent initially to try to achieve a consensus or at least to engage in an open debate might seem a waste of time and money. If it can contribute to avoid major changes at a later stage, it will actually save time and money.

Technical and economic uncertainties cannot be eliminated. They are a feature of many infrastructure projects, and there will always be uncertainties and therefore forecasting

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[1] In the simulation exercise discussed above, if investment costs increase by 50% and traffic decrease by 40% (relative to forecasts used in the analysis), then for all options the IRR are drastically reduced (to 4% and 6% instead of 14% and 17% for the pure public and the pure private options) and the DNV turn out to be negative (-48 and – 5 instead of +123 and +132 for the pure public and the pure private options)

errors of that type. Several actions, however, can reduce them or their adverse consequences. More publicity should be given to methods used and hypothesis made in preparing forecasts. *Ex post* comparisons should be made (by independent analysts), so that everybody could learn from errors made. *Ex ante* studies should build scenarios, perform sensibility analysis, and produce estimates in the form of ranges rather than in the form of single numbers. Forecasts should not, inasmuch as possible, be done in-house, by the ministry or the agency concerned, but contracted out to outside agencies or independent consultants, or at least submitted to and checked by such outsiders.

It is more difficult to reduce institutional sources of uncertainties, because they involve sovereign decision-makers and their political interests. In many cases, however, they involve decision-makers in one ministry or one agency rather than in the entire government. Involving other agencies or ministries, in particular the ministry of Finance, who do not have as great an interest in seeing the infrastructure done, may be an effective check. Auditing and reporting, when there are independent courts of accounts, can also play a role.

Private Projects — For privately financed projects, market mechanisms provide, in principle, an important check. In practice, as we have seen, such mechanisms are often dampened by public interference, and non-operative. What is the appropriate risk allocation ? Risks are high. If they are entirely borne by the private enterprise, serious and reputable enterprises might refrain from being candidates, or ask for exorbitantly high prices. The choice will be not to do business with these enterprises, and forgo the potential benefit of private participation, or do business with not so reliable enterprises, which might be even worst. On the other hand, if all risks are borne by the public sector, market discipline will not work, as we have seen, and the benefits of private participation will also be forgone. Finding the appropriate balance, the point at which the marginal damage of public risk taking is equal to the marginal benefit of public risk taking, is a delicate task.

It is often argued that privately managed risky projects will be more costly than publicly managed similar projects. The argument is that they will bear an insurance premium that publicly managed projects will not bear, because the public sector is its own insurer. The implication would be that private management may be more efficient, but that in the presence of risk it is also more costly. Or that, if it benefits from a public guarantee, it may not be more costly but because the guarantee will erode the incentives to efficiency, it will not be more efficient. This argument is not convincing. Government is indeed its own insurer, but not paying insurance premium is not the same thing as bearing no costs. Self-insurance is in the end about as costly as commercial insurance

Discussions of infrastructure-related risks in general is probably not very fruitful. We have seen that risks are diverse. The discussion might be helped by a distinction between types of risks.

Technical risks, that is risks that do not arise from public decisions, should be borne by the private enterprises. They include the risk of extra costs because of natural disasters, or of suppliers bankruptcies, and insufficient revenues because of erroneous patronage forecasts. Private enterprises should not be protected from their own mistakes on these types of uncertainties. This is the only way to induce them to minimize such mistakes. In addition, these risks are generally insurable. Minimum revenues guarantees, cost escalation protection clauses, minimum profit provisions, or government-guaranteed loans, should be avoided systematically.

Substantive risks, that is risks created by post contract public decisions, should be borne by the public sector. If the government, for reasons it can only appreciate, decides to increase environmental or safety constraints, it should bear the cost of this change. If it increases drastically road charges, or creates an unplanned alternative road, thus decreasing significantly traffic on the transport infrastructure considered, the public agency should also bear the cost of its unplanned and unpredictable —and in most cases uninsurable— change.

Pure economic risks —associated with forecasting errors caused by errors on the evolution of activity and income— are largely like substantive risks. They are beyond the control of infrastructure developers. They are very hard to insure, because they hit all infrastructure developers at the same time, unlike technical risks. Having the public sector compensate for such risks would not create perverse incentives, and would be desirable.

In practice of course, the border between these types of risks is not always easy to draw, opening the door to litigation and negotiation. Disentangling pure economic risks from economic forecasting errors is likely to be particularly delicate. The more explicit the concession contract, the better. The more open the litigation or re-negotiation process, the better. The more independent the arbiter of potential conflicts, the better: a tribunal or a regulatory agency is highly desirable, not to say necessary.

Because private involvement in infrastructure projects is potentially a great source of savings and efficiency, some people see “privatization” as a panacea. Particularly so when facing a corrupt and inefficient government. But in reality, “private” provision is never pure, and always involve (and should involve) a dose of public decision and control. The efficiency of the private sector is contingent upon the form and magnitude of this public control. Unfortunately, governments unable to deliver efficiently public services are also governments unable to control efficiently private enterprises contracted to do it. And these governments are even more unable to create the independent bodies or regulation agencies needed to arbitrate disputes between public and private. The sad —and well-known— paradox is that usually the countries that would most need a large dose of privatization are also the countries least equipped to inject it properly. Conversely, the countries that are most able to conduct and oversee a privatization process are also those where this process is least needed. Privatization of infrastructure therefore should not be seen as panacea. It is a desirable goal, at the end of a long and arduous road.

Conclusions

This brief paper on a vast subject shows that "infrastructure" do not lend themselves easily to generalities. Although they have a number of common features that distinguish them from ordinary private capital, and provide a justification for the use of a specific concept, infrastructure are very heterogeneous, in type, in context, in financing schemes, in pricing practices, etc.. What is true for road construction might be wrong for power generation; what is true in 2000 might be wrong in 2010; what is true in a bottleneck situation might be wrong in an oversupply situation, what is true for an unpriced infrastructure might be wrong for a charged one, etc. Market failures justify infrastructure as a category. But planning failures deprives the category of the powerful homogenizing forces of the market.

This makes it difficult, if not impossible, to design and recommend "infrastructure policies" in general. We cannot, for a given country define an "optimal" level of infrastructure endowment and say by how much infrastructure investments efforts should be increased or decreased —although in many cases, it is quite clear that more should be better. We cannot identify optimal institutional, financial, pricing, or decentralization designs —even if in many cases, it seems quite safe to suggest that greater doses of privatization, of charges, of decentralization, or of independent regulation, would be appropriate. For each country, we must proceed sector by sector, even project by project, and bring to bear all the resources of public policy analysis. In infrastructure policies, the devil is in the details.

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