

Large infrastructure investments: financing mechanisms and incentives in decentralized countries^{*}

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Abstract

Infrastructure services (such as transport, telecommunications or water services) crucially affect the competitiveness, efficiency. However, though infrastructure investments are essential in modern economies, they usually require important amounts of public funds. In decentralized countries, regional governments cannot usually afford large infrastructure projects so co-financing from the central government is required.

The aim of this paper is to demonstrate the influence of the central government financing mechanisms on the contract to be offered by the regional government for the construction, maintenance and operation of the infrastructure. In particular, we prove that if the central government uses certain financing mechanisms, the regional government may have no incentives to offer an efficiency contract to the firm.

Key words: co-financing, incentives, infrastructure project.

JEL Classification: D82, H77, H50.

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1. Introduction

Infrastructures are essential in modern economics. They are crucial for the operation and efficiency of them (World Bank, 1994) and they require important amounts of public funds. Often, such amount of money cannot be financed just with national (regional) funds. For this reason, it is necessary to co-finance the investment with supranational (national) government,¹ who decides about the appropriateness of the project and the need of co-financing.

We can distinguish two levels in the investment relationships that involve co-financing mechanisms. We will concentrate in the first level that studies the relationship between the two levels of government -supranational (national) planner and national (regional) government- i.e., the institutional design through funds are obtained by national (regional) government. The second level studies the relationship between the national (regional) government and the firm that finally receives the funds, used for the construction, maintenance and operation of the infrastructure, i.e. the type of contract (de Rus and Socorro, 2010).

Although most of the literature concentrates on the second level,² the first level is important regarding incentives. Actually, governments are not benevolent and they are not only worry about the wellbeing of the society, so their objectives can influence the first level. Institutional design affects incentives and affects the relationship between the firm and the corresponding government.

¹ The relationship is also possible between a local government and a regional government.

² Menu of contracts is the suggested solution by the most of the economic literature of the second level in order to deal with asymmetric information problems. But they are rarely used in practise. Contracts are variants of simple fixed-price and cost-plus contracts (Bajari and Tadelis, 2001). For a review of the literature that analyzes the problem of incentives in principal-agent models by economic theories of procurement use mechanism design see Laffont and Tirole (1993).

Other important aspect that makes important the institutional design is the differences in real and forecasted cost and demand figures. Mismatches between prediction and reality in cost and demand estimations are common (Flyvbjerg *et al.*, 2003; 2004; 2005; Skamris and Flyvbjerg, 1997).

Although one reason for these differences can be the current unperfected forecasting techniques, other reason is the institutional design and the contracts signed. It generates incentives that can be the answer to these differences between real and forecasted figures (and it can be a more important reason).

For this reason, a correct institutional design and the type of contracts may mitigate these differences between real and predicted cost and demand, because it affects incentives and the behaviour of economic agents who have different objective functions (for example affecting the level of effort to minimize the cost).

This paper tries to find the variations in the incentives that previously have a government that receives support from a superior level in a context of asymmetric information problems. We know that the different types of contracts on the second level generate different results because it creates incentives in different ways. But we should take into account that if we choose different financing mechanism these incentives are affected.³ We can find some literature with related aspects.

On one hand, in relation with decentralization we can find the following papers: Holmstrom and Milgrom (1991) and Macho-Stadler and Perez-Castrillo (1998) which analyse two different aspects of decentralization that we have to take into account: how to allocate optimally the agents to different tasks depending on the incentives provided by the principal for each one; and in which situations decentralized structures

³ We would like to highlight that we only want to find the effects of financing mechanism in terms of incentives, and not the optimal way of financing or optimal grant.

are superior to centralized ones in a moral hazard environment and vice versa. There are other papers whose aim is to find how to obtain private information from the agents (see for example Melumad *et al.*, 1995).

On the other hand, in relation with multi-government environment, Caillaud *et al.* (1996a) study the elements and problems between decentralization and centralization. First, it presents the arguments in favour of decentralization. In the second part, it develops a model of organization in the EU context, analysing the incentives and remarking the problem of more information and less bargaining power of the national authority respect to central authority. On the same line is Caillaud *et al.* (1996b), that addressed the issue of optimal decentralization. Huber and Runkel (2006) develop a theoretical model in order to find an explanation a government finances to other governments (in a lower level) with some types of grants or others.

Two papers closer to our work are the following. Cella and Florio (2009) study the effects of co-financing in the European Union Regional Policy with a multi-government model. They focused in optimal grant and ex-ante and ex-post evaluators. de Rus and Socorro (2010) show the effects of the type of mechanism design in terms of politicians' incentives, but they only consider two levels (national government and supranational planner), so the national government is who decides and carries out the investment. Our work deals with a multi-government model we try to analyse how the previous incentives that a government has can be affected because of co-financing by a superior level of government, i.e., with a hierarchical organization with two levels.

The rest of the paper is organized as follows: in Section 2 we develop a model that analyses the effects of different contracts between a regional government and the firm. Next we introduce in the model the National Government in order to find the co-financing mechanism effects. In Section 3 we show some examples of co-financing. Section 4 concludes.

2. A simple theoretical model

Let us consider a country with two levels of government: the regional government (R) and the national government (N). The regional government has a large infrastructure project that may be financed completely or partially by the national government. Once the national funds are obtained, the regional government contracts a firm to construct the infrastructure.

Let us denote by K the real investment cost paid by the firm, which may take two values: K^G (good) or K^B (bad) with $K^B > K^G$. The level of the investment cost depends on the effort exerted by the firm and on a random component. Since the value of K depends on these elements, it is also a random variable. So we can write the probability of the value of K conditional on the effort exerted by the firm (e), which can take two different values: e^L or e^H , with $e^L < e^H$. Formally:

$$\left. \begin{array}{l} \text{Prob}(K^G / e = e^H) = P_G(e^H) \\ \text{Prob}(K^G / e = e^L) = P_G(e^L) \end{array} \right\} P_G(e^H) > P_G(e^L)$$

$$\left. \begin{array}{l} \text{Prob}(K^B / e = e^H) = P_B(e^H) \\ \text{Prob}(K^B / e = e^L) = P_B(e^L) \end{array} \right\} P_B(e^H) < P_B(e^L)$$

where:

$$P_G(e^i), P_B(e^i) \geq 0; \quad i = L, H$$

$$P_G(e^H) + P_B(e^H) = 1$$

$$P_G(e^L) + P_B(e^L) = 1$$

The previous ideas have the following assumptions. On the one hand, the higher the effort exerted by the firm is, the lower the real investment costs are.⁴ On the other hand, during the construction of the infrastructure, the firm may have to pay unexpected costs (Flyvbjerg, 2007; Flyvbjerg *et al.* 2002; Siemiatycki, 2009). In short, we may see K^G because the firm has exerted a great level of effort or just because, even though it has exerted a low level of effort, it had good luck.

Let us denote by $c(e)$ the cost of the effort exerted by the firm, with $c(e^L) < c(e^H)$, that is, the cost is increasing in the level of effort. Since the regional government cannot observe the level of effort, it faces a *moral hazard* problem.

The timing of the game is as follows: First, the national government decides the type of financing mechanism to offer the regional government. Second, given this financing mechanism, the regional government offers the contract to the firm that maximizes its budget. Finally, the firm decides the level of effort it will exert in order to maximize its utility.

The way the national government finances the regional government may have important consequences in terms of incentives. We cannot have a naïve point of view and believe that the introduction of a superior government in a contract signed by a firm and a regional government leave this relationship unaffected. Actually, the way of financing generates a chain of incentives that affect the achievement of results and allocation of public funds if there are asymmetric information problems. Decisions in the first level affect the behaviour in the second level.

In order to analyse the consequences of the national financing mechanism on the regional government's incentives in an asymmetric information framework, let us start

⁴ Formally, this implicates First-Order Stochastic Dominance of $P_G(e^H)$ and $P_B(e^L)$ over $P_G(e^L)$ and $P_B(e^H)$, respectively (see Milgrom, 1981).

analysing as a benchmark the case in which there is no national financing. Later, we introduce in the model this national financing in order to answer the question: how the institutional design affects the incentives that previously have the regional government?

2.1. Benchmark case: no national financing

In this subsection we will just consider the relationship between the regional government and the firm. The former decides the contract to offer the firm. The latter pays the investment costs and decides the level of effort. We will consider just to kind of contracts: a cost-plus contract and an incentive contract.⁵

2.1.1. Cost-plus contract

With a cost-plus contract, the regional government pays the real investment cost plus an amount of money (T) that guarantees that the firm obtains at least its reservation utility for any level of effort (participation constraint). In other words, the firm pays the investment, receives the same amount of money plus T and the firm exert the corresponding effort. Formally:

If the firm exert a high level of effort:

$$E(K / e = e^H) - E(K / e = e^H) - c(e^H) + T \geq \bar{U}, \quad (1)$$

But if the firm exert a low level of effort:

⁵ We do not consider a fixed priced mechanism here because we would need an additional supposition. Specifically, our entire model has to take into account the relationship between the differences in cost investment with high and low effort and the cost of exert these efforts ($E(K/e=e^L) - E(K/e=e^H)$ and $c(e^H) - c(e^L)$).

$$E(K / e = e^L) - E(K / e = e^H) - c(e^L) + T \geq \bar{U}, \quad (2)$$

where:

$$\left. \begin{aligned} E(K / e = e^H) &= P_G(e^H)K^G + P_B(e^H)K^B \\ E(K / e = e^L) &= P_G(e^L)K^G + P_B(e^L)K^B \end{aligned} \right\} E(K / e = e^H) < E(K / e = e^L).$$

So the value of T that satisfies both expressions (1) and (2) is given by:⁶

$$T \geq \bar{U} + c(e^H). \quad (3)$$

We can see that if $T = \bar{U} + c(e^L)$, (1) is not satisfied since $c(e^L) < c(e^H)$.

Lemma 1: If the regional government chooses a cost-plus contract, it is more profitable for the firm to exert the level of effort e^L .

Proof: Given the value of T in expression (3), it is more profitable for the firm to exert the level of effort e^L , since $E(K / e = e^H) < E(K / e = e^L)$.

Finally, the profit of the regional government under a cost-plus contract π_{CP} is given by:

$$\pi_{CP} = -E(K / e = e^L) - T = -E(K / e = e^L) - c(e^H) - \bar{U}. \quad (4)$$

2.1.2. Incentive contract

Under this type of contract, the regional government pays an amount of money depending on the result of the project. In this way, regional government pays a greater amount of money if it observes a good result (K^G) instead of a bad result (K^B). Let

⁶ Recall that the regional government cannot observe the level of effort exerted by the firm, and thus the value of T should satisfy both constraints.

us denote by T^G the payment received by the firm if regional government observes K^G , and T^B if it observes K^B .

In this case, the participation constraint must guarantee that the firm receives a level of utility with the project greater than the reservation utility (\bar{U}):

$$P_G(e^H)(-K^G + T^G) + P_B(e^H)(-K^B + T^B) - c(e^H) \geq \bar{U}, \quad (5)$$

If we call:

$$\left. \begin{aligned} E(T / e = e^H) &= P_G(e^H)T^G + P_B(e^H)T^B \\ E(T / e = e^L) &= P_G(e^L)T^G + P_B(e^L)T^B \end{aligned} \right\} E(T / e = e^H) > E(T / e = e^L)$$

and we can rewrite equation (5):

$$-E(K / e = e^H) - c(e^H) + E(T / e = e^H) \geq \bar{U}. \quad (6)$$

In order to induce a high level of effort e^H the regional government must guarantee that with this level of effort, the firm receives greater benefits than the benefits receives if the effort exerted is e^L . This condition is the incentive compatibility constraint. Formally:

$$\begin{aligned} P_G(e^H)(-K^G + T^G) + P_B(e^H)(-K^B + T^B) - c(e^H) &\geq \\ P_G(e^L)(-K^G + T^G) + P_B(e^L)(-K^B + T^B) - c(e^L). & \end{aligned} \quad (7)$$

We can rewrite equation (7):

$$-E(K / e = e^H) - c(e^H) + E(T / e = e^H) \geq -E(K / e = e^L) - c(e^L) + E(T / e = e^L). \quad (8)$$

The profit of the regional government in this case (π_{IC}) is given by:

$$\pi_{IC} = -E(T / e = e^H) = -E(K / e = e^H) - c(e^H) - \bar{U}. \quad (9)$$

Proposition 1: *The profits of the regional government are higher with an incentive contract rather than with a cost-plus contract.*

Proof: If we want to proof that the Regional Government prefers an incentive contract than a cost-plus contract, we should compare (4) and (5):

$$\begin{aligned} \pi_{CP} &= -E(K / e = e^L) - T = -E(K / e = e^L) - c(e^H) - \bar{U} < \\ \pi_{IC} &= -E(T / e = e^H) = -E(K / e = e^H) - c(e^H) - \bar{U}, \end{aligned}$$

because:

$$E(K / e = e^L) > E(K / e = e^H).$$

Corollary 1: *If there is no national financing, the regional government chooses an incentive contract and induces the higher level of effort for the firm.*

2.2. National financing

Let us now introduce a third element in the model. Suppose first the national government totally or partially finances the regional government's infrastructure project. Second, the regional government decides the contract to offer the firm. Finally, the firm exerts an effort and pays the investment costs of the project. Similarly to subsection 2.1, we consider just two types of possible contracts: a cost-plus contract and an incentive contract. As far as the national financing mechanism is concerned, we consider three possible mechanisms: a total cost coverage financing mechanism, a fixed-priced financing mechanism and partial cost coverage financing mechanism.

In each case we should keep in mind the benefits of the regional government (the amount of money received from the national government minus the amount of money that it pays to the firm) in order to analyse the incentives of the regional government to induce the high level of effort for the firm.

2.2.1. Total cost coverage financing mechanism

Though a total cost coverage financing mechanism, National Government finances all the cost that Regional Government says it has. If National Government uses this mechanism of financing the Regional Government, the last will obtain always the same benefits (zero) because it report to National Government the “bill” and it pays, i.e., it does not matter the contract that Regional Government sign with the firm. For this reason, Regional government is indifferent between the two mechanisms.

Proposition 2: *If the national government uses a total cost coverage financing mechanism, the regional government has no incentives to induce the high level of effort for the firm.*

Proof: If regional government choose a cost-plus contract, regional government benefits are the amount of funds received from the national government minus the amount of funds that given to the firm:

$$\pi_{CP} = \left(E(K / e = e^L) + c(e^H) + \bar{U} \right) - \left(E(K / e = e^L) + c(e^H) + \bar{U} \right) = 0.$$

In contrast, if it chooses an incentives contract:

$$\pi_{IC} = \left(E(K / e = e^H) + c(e^H) + \bar{U} \right) - \left(E(K / e = e^H) + c(e^H) + \bar{U} \right) = 0.$$

We can see that under both contracts benefits for regional government are the same (0), so it is indifferent to one or the other.

2.2.2. Fixed-priced financing mechanism

Under a fixed priced mechanism National Government gives to Regional Government a fixed amount of money that is independent of the project results. For this reason, Regional Government is worried about the transfer that it has to give to the firm, because its benefits are depending on it.

If the firm choose a low level of effort (which is induced though a cost-plus contract) investment costs are high and we have seen that the transfer to the firm is more costly to Regional Government. For this reason, benefits of Regional Government are higher with an incentives contract since whether Regional Government induces a high level of effort the amount of money that it gives to the firm is smaller.

Proposition 3: *With a fixed-priced financing mechanism, the regional government always has incentives to induce e^H .*

Proof: Regional Government benefits are:

$$\pi = T_N - T_F,$$

where:

T_N : National Transfer to Regional Government.

T_F : Regional Transfer to Firm.

T_N is always the same (fixed) but T_F are always greater with a low level of effort according to equation (4) and (9), so Regional Government Benefits are greater if it induces e^H .

2.2.3. *Partial cost coverage financing mechanism*

Finally, let us consider that the national government finances a percentage of the investment cost of the project. The parameter $\alpha \in [0,1]$ indicates the percentage of the real investment cost financed by the national government.

It is interesting to see that if the value of α tends to the extreme values, the partial cost coverage financing mechanism tends either to the total cost coverage financing mechanism or to the fixed-price financing mechanism: if α tends to 0, the type of mechanism tends to fixed price, and like we have seen before, the effort exerted by the firm will be e^H ; in contrast, if α tends to 1, the type of mechanism tends to cost-plus and for this reason the effort exerted by the firm will be e^L . In short:

$\alpha \rightarrow 0 \Rightarrow$ Fixed-priced: e^H

$\alpha \rightarrow 1 \Rightarrow$ Cost-Plus: e^L

The national government pays an amount of money equals to the proportion α of the total investment cost to the regional government, while the Regional Government pays the contract to the firm. Let us see these benefits under the two levels of effort induced by the regional government:

- If the Regional Government induces e^H

If Regional government induces e^H , it pays to the firm the expected value of the transfer given that $e = e^H$ ($E(T / e = e^H)$), but it receives a proportion (α) of this amount of money. Formally:

$$\begin{aligned}
& \alpha \left[E(K / e = e^H) + c(e^H) + U \right] - E(T / e = e^H) = \\
& = \alpha \left[E(K / e = e^H) + c(e^H) + U \right] - E(K / e = e^H) + c(e^H) + U = \\
& = -(1 - \alpha) \left(E(K / e = e^H) + c(e^H) + U \right).
\end{aligned} \tag{10}$$

- If Regional Government chooses the sunk-cost contract (e^L)

In contrast, if Regional government choose the sunk-cost contract, it pays to the firm the expected value of the transfer given that $e = e^L$ ($E(T / e = e^L)$), but it receives a proportion (α) of this amount of money. Formally:

$$\begin{aligned}
& \alpha \left[E(K / e = e^L) + c(e^H) + U \right] - E(K / e = e^L) + c(e^H) + U = \\
& = -(1 - \alpha) \left(E(K / e = e^L) + c(e^H) + U \right).
\end{aligned} \tag{11}$$

As we can see, the Regional Government benefits are equal to the proportion $(1 - \alpha)$ of the total transfer to the firm.

Proposition 4: *If the national government chooses a partial cost coverage financing mechanism, for any $\alpha \neq 1$ the regional government has incentives to induce e^H .*

Proof: If α is equal to one (the national government pays the entire “bill”) the regional government will obtain the same benefits under any effort exerted by the firm.

$$-(1-\alpha)(E(K / e = e^H) + c(e^H) + U) = 0$$

$$-(1-\alpha)(E(K / e = e^L) + c(e^H) + U) = 0$$

But with $\alpha \neq 1$, Regional Governments obtain greater benefits with a high level of effort because:

$$E(K / e = e^H) < E(K / e = e^L)$$

Table 1. Summary of the relationship between the three parties

National Government	Cost-Plus		Fixed-Priced	Partial cost coverage financing mechanism	
Regional Government	Cost-Plus (indifference)	Incentives	Incentives	$\alpha = 1$	$\alpha \neq 1$
Effort	e^L	e^H	e^H	e^L	e^H

Corollary 2: If the National Government finances the Regional Government and wants the firm to exert a high level of effort, the financial mechanism must be either a fixed-price method or a partial cost coverage financing mechanism. A cost-plus mechanism generates no incentives to exert a high level of effort.

3. Discussion

Most countries have a decentralized model of financing large infrastructures projects.⁷ In these countries is easy to see the mentioned financial mechanisms. In this section, we will see some examples of specific financing mechanism used by countries or supranational planners.

3.1. Rail Investment in Spain⁸

Infrastructures co-financing is a very common practise in Spain. In “Strategic Plan of Infrastructures and Transport” words for the funding strategies of the planned activities within it: “counting on the participation of the regional and local government on the funding of concerted actions”.⁹

A clear example of co-financing in transport infrastructure project is the follow. The frame of the regulation of the relationship between the Central Government and the Regional Government is called “Financing Agreements of Railway Infrastructures”. It is for co-finance the investments in railway infrastructure in a given geographical area.

Though these agreements, the Central Government co-finance the third part of the costs of the works in some projects. Up to 1995, only investments that were considered as “priority” were financed. However, since 1995 there has been a move towards co-financing investments provided they do not exceed a specified amount of money and that the rest are co-funded by regional governments. The problem is Central Government is financing investment and it cannot clearly distinguish which projects are really socially optimal.

⁷ For example, a reference about the characteristics of local financing in the European Union see Bosch and Espasa (2006).

⁸ The information is extracted from Socorro (2009)

⁹ PEIT (2004)

3.2. Co-Funding Rate¹⁰

The “funding-gap” (the basic mechanism to co-finance infrastructures in the European Union) consists in the difference between the present value of project investment costs and the net present value of revenues during the project life, i.e., the part of the project that cannot be financed itself.

This method is used for two main reasons (European Commission, 2006):

- The project needs to have enough resources to be implemented (and it is not over financed).

- To ensure a minimum level of profitability to borrow.

The co-funding rate can reach the 80 per cent of the financial net present value of the project. The higher the investment costs or the lower the net revenues are, the higher is the total amount of funds. For this reason, it is a kind of sunk cost-plus financing mechanism and the problem is that it penalizes revenue generating projects.

3.3. State Fund of Local Investment (Spain)¹¹

In 2008, in response to the economic world crisis, Spanish Government creates the “State Fund of Local Investment”.¹² With this plan, the Government has the intention of create jobs and activate the economy. In law words: “Urgent actions in the municipal area for specially generating investments of employment.”

¹⁰ de Rus and Socorro, 2010.

¹¹ For further information, visit www.economiasostenible.gob.es/balance-del-plan-e/

¹² Real decreto-ley 9/2008 (available at www.boe.es/boe/dias/2008/12/02/pdfs/A48125-48130.pdf)

This plan consist of the destination of 8,000 million € of the Spanish budget to local governments. Works have the following characteristics: works of local governments' competence, they should be new and should start immediately and the value of them has to be lower than 5 million €.

In summary, the plan is a type of cost-plus financial mechanism since the central government finances the entire project cost investment of local governments. The endowment of the Local Investment fund will be distributed in a proportional way to the numbers of population corresponding to every Municipality.

In 2009 Spanish Government creates a new plan similar to the previous one.¹³ The objectives and conditions are almost the same, so the effects are also equal.¹⁴

3.4. Transportation Investment Generating Economic Recovery (USA)¹⁵

Also in response to the financial crisis, in 2009 President Obama signs the American Recovery and Reinvestment Act that includes the Transportation Investment Generating Economic Recovery (TIGER). The latter had the objective of “including measures to modernize our nation's infrastructure, enhance energy independence, expand educational opportunities, preserve and improve affordable health care, provide tax relief, and protect those in greatest need”.

¹³ Real decreto-ley 13/2009 (available at www.boe.es/boe/dias/2009/10/27/pdfs/BOE-A-2009-17001.pdf)

¹⁴ In law words: The new found is “destined to finance the accomplishment for the Council Tows of investments of municipal competition that generates employment and actions of social nature, which contribute to the economic, social and environmental sustainability”. The new concept is the introduction of “sustainability”.

¹⁵ For further information see www.dot.gov/recovery/ost/ or Federal Register/Vol. 74, No. 115 (<http://edocket.access.gpo.gov/2009/pdf/E9-14262.pdf>)

The fund was \$1.5 billion and States and Local Governments could apply for it. The fund received may be used for up to 100% of project costs (but priority must be given to projects for which Federal funding is required to complete an overall financing package that includes non-Federal sources of funds).¹⁶

Like the Spanish case, the financial mechanism used is a cost-plus mechanism if the funds received by the State or Local Government are 100% of total cost.

4. Conclusion

In decentralized countries both central and regional governments usually finance large infrastructure projects. Then, regional governments use contracts for the construction, operation and maintenance of the infrastructure.

Central governments may use different financing mechanisms to co-finance large infrastructure projects, such as a total cost coverage financing mechanism, a fixed priced financing mechanism, or a partial cost coverage financing mechanism.

In an asymmetric information framework, the central government financing mechanism may have important consequences in terms of incentives. In particular, in this paper we prove two important results:

a) If there is no national financing, the regional government chooses an incentive contract and induces the higher level of effort for the firm.

b) If the National Government finances the Regional Government and wants the firm to exert a high level of effort, the former must not use a cost-plus financial mechanism

¹⁶ In the end of 2009, Department of Transport (DOT) was authorized to award \$600 million in TIGER II Discretionary Grants. This appropriation was similar to TIGER.

because it does not generate the correct incentives. The mechanism chosen must be either fixed-priced or a percentage of the investment.

The use of certain central financing mechanisms will affect the regional governments' incentives to offer efficient contracts. Efficient contracts imply lower costs and higher revenues for the project and they should be taken into account in a cost-benefit analysis.

Although in this paper we use a very simple theoretical model we may be able to recommend decentralized countries not to use cost-plus financing mechanisms to co-finance large infrastructure projects such as the economic measures that some countries have used during the present economic crisis.

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