Financing the economy in debt times: the crucial role of public-private partnerships

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Centre d'Études
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International

CERDI WORKING PAPERS
2022/1

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To cite this working paper:

Amedanou, Y.M.I. (2022) "Financing the economy in debt times: the crucial role of public-private partnerships", CERDI Working Papers, 2022/1, CERDI

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This work was supported by the LABEX IDGM+ (ANR-10-LABX-14-01) within the program "Investissements d'Avenir" operated by the French National Research Agency (ANR).

CERDI Working Papers are available online at: https://tinyurl.com/2xwfzw8s

Director of Publication: Grégoire Rota-Graziosi
Editor: Catherine Araujo-Bonjean
Publisher: Aurélie Goumy
ISSN: 2114 - 7957

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Abstract

This paper aims to show that there is a great interest for countries to rely on Public-Private Partnerships (PPPs) as a tool for financing the economy, especially in times of debt. First, we conceptualize through game theory a better risk management between the public and private sectors in case of co-investment. Second, building on Iossa & Martimort (2009), we demonstrate that PPPs investments produce greater economic and social gains than pure public investments by providing incentives and transferring risks to the private sector. The implications of the model are diverse: financing the provision of public infrastructure through PPPs allows for sharing the associated risks, improves the quality and reduce the costs of the provision of public goods. The model has been empirically tested on 14 Sub-Saharan African countries over the period 1990 − 2017. The impact of PPP investments is significantly higher than that of pure public investments. The evidence also shows that the positive impact of PPP investments strengthens economic growth as the public debt grows to a point where there is no longer any significant pro-growth impact.

Keywords

Public-private partnership, Pure public investment, Cooperative game, Risk management, Economic growth, Public debt, Fiscal constraints

JEL Codes

L33, H54, C71, G32, O40, H63

1. Introduction

Number of countries are showing a growing interest in Public-Private Partnerships (PPP) contracts that involve collaboration between a government agency and a private entity that can be used to design, finance, build and operate projects, such as social and economic infrastructure. Financing development is a real challenge for developing countries. To face this, public entities are stepping up partnerships with private companies to finance infrastructure projects in the form of PPPs (Eggers & Startup, 2006) mostly in developing countries which have registered a significant increase in private sector participation in funding and building infrastructure since the 1990s (Iossa & Martimort, 2009). More broadly speaking, the use of PPPs provides a larger mobilization of financial resources towards the funding of public infrastructure, which are crucial links in the potential for long-term growth.

From an economic point of view, PPPs are justified by their ability to efficiently allocate risks between public and private partners, and hence provide incentives for better public infrastructure delivery. Additionally, PPP contracting can allow savings to be reallocated to long-term investments for the financing of the real economy. In the latter case, Arezki et al. (2016) confirms that matching long-term savings with bankable PPP projects will optimize resource allocation and stimulate economic growth. These arguments suggest that public-private co-investments constitute an alternative source of financing for economic growth. Guerguil and Keen (2014) and Abiad et al. (2014) made the remark that since the early 1990s in both middle and low income countries, PPPs have raised as an alternative source of financing to scale up public capital stock.

Economic theory recognizes the provision of public goods and services by government (Musgrave, 1959) given the inability of markets to provide public goods, internalize externalities and cover costs in cases where significant economies of scale exist. Such public goods and services cannot be provided by the market because private operators do not have the skills to exclude free riders or to charge users a competitive price. Thus traditionally, governments have built, maintained and rehabilitated physical infrastructure such as roads, ports and airports, as well as telecommunications and electricity networks, which are essential for most economic activities. For this purpose, governments finance economic and social infrastructure out of public investment by levying taxes, or when difficulties arise in increasing tax revenues, they resort to debt to support public investment and boost economic growth.

The needs for infrastructure in developing countries are currently, especially in emerging economies. Yet, developing countries face an unresolved challenge in infrastructure provision and its funding: large economic and social infrastructure needs, weak tax mobilization and a high level of public debt. It is clear from the foregoing that the latter two limit the sources of funding for public investment. Faced with such a complex equation, governments are increasingly turning to public-private partnerships, directing private sector funds towards the financing of public goods and services. It is worth noting that Hammami et al. (2006) have already drawn

attention to the fact that PPPs tend to be more common in countries where governments suffer from heavy debt burdens. Moreover, Watts et al. (2000) have confirmed that the use of PPPs for funding social infrastructure projects will help reduce the overall level of government borrowing and help governments maintain and improve current service levels.

However, it is important to keep in perspective that PPPs do not always avoid long-term debt overhang. In general, PPPs allow governments to avoid or defer infrastructure spending without giving up their benefits. It may therefore be particularly attractive for governments that are limited in their current ability to finance infrastructure spending to use PPPs to bypass spending controls and move public investment off-budget and debt off the government's balance sheet. But it consequently forces governments to face potentially high budgetary costs in the medium to long term so that in the long term the risk of over-indebtedness is not spared. And furthermore, where debt sustainability is not a concern, there are other considerations that need to be taken into account in order to ensure the efficiency of infrastructure services, including (i) the legal framework governing PPP contracts, (ii) the processes for selecting and implementing PPPs, and the role of the ministry of finance in this context, and (iii) the contractual obligations that underpin PPPs and that directly determine the fiscal risk incurred by the government (Akitoby et al., 2007). Moreover, governments should also strive for transparent tax accounting and full disclosure of all fiscal risks involved in PPPs.

Public-private partnerships (PPPs) constitute arrangements in which the private sector takes over infrastructure assets and services traditionally provided by governments. They are mostly contracted for a wide range of social and economic infrastructure projects including transportation infrastructure, telecommunication, water plants, financial support, innovative financing, general public services as well as hospitals, schools etc. So, should we still be asking whether PPP investment can be an alternative source of funding for productive governments expenditures? Obviously, in view of developing countries' current fiscal constraints, one can only answer in the affirmative.

Economic growth is driven by investment and occurs when aggregate output increases, offering and expanding employment opportunities that allow for increased income and mobility for individual workers, thus improving the standard of living. Hence, one of the most important questions that can be asked is whether PPPs allow for a more efficient allocation of resources and lead to an increase in country's productivity? The existing literature have yielded widely different estimates of the impact of infrastructure investment on economic growth (Estache & Garsous, 2012; Dintilhac et al., 2015; Arezki et al., 2016), particularly efficient transport infrastructures that enhance competitiveness and boost economic growth by raising the marginal product of labor and capital, thereby the overall efficiency of the productive mix (Aschauer, 1989) and strengthen the attractiveness of certain areas towards new production facilities, which are reflected in self-reinforcing growth processes (Messina, 2008). Even if empirical studies prove that the economy is positively boosted by PPP investments, the real question is: can PPP investment be a credible alternative funding instrument to traditional public investment?

While many theoretical arguments are put forward to support the potential economic benefits of PPPs contracts, often claimed to be far greater than those of traditional public goods provision, empirical evidence has very rarely compared the economic and social gains of funding through public or PPP investments. This paper draw on theoretical and empirical studies to looks at the policy implications of PPP's impact on country's economic growth, focusing on 14 Sub-Saharan African countries, most of which are facing funding deficits and growing needs for socio-economic infrastructures.

According to the results, the economic and social gains from infrastructure and services financed by PPP investments are higher than those from pure public investments. If the debt level is already high and reaches an unsustainable level, there is a diminishing effect of PPP investment on growth. As such, in order to meet the growing needs for infrastructure development, given their budgetary constraints, governments should engage in co-investment with the private sector. But beware, reforms aimed at making public debt levels sustainable would be a guarantee for positively higher returns from financing socio-economic infrastructure through public-private partnerships (PPPs).

Our paper contributes to the relevant literature on two strands. First, it looks at the impact of PPP investments on economic growth. A large part of the literature finds that the extent and type of PPP contracts are drivers of economic growth (Shediac et al., 2008; Zangoueinezhad & Azar, 2014; Oluwasanmi & Ogidi, 2014 and Mofokeng, 2019) even if some have assessed this effect when looking at the macro-economic benefits of PPPs (Checherita, 2009; Lee et al., 2018; Uddin & Akter, 2021). Others have rather shown that private sector participation accelerates growth through productivity gains, such as La Porta and Lopez-de Silanes (1999); Trujillo et al. (2002) and Brown et al. (2006). Second, a large part of the literature, including the latest extensions of the neoclassical growth model as well as endogenous growth theories, has pointed to the role of public investment in economic growth (see, for example, Romer, 1986; Barro, 1991; Barro & Lee, 1993; Fischer, 1993). One view holds on the importance of public investment in long-term economic growth because it not only generates positive spillovers in the economy through physical infrastructure and services, but also attracts private investment, thereby enhancing economic growth (Arrow & Kurz, 1970; Barro, 1990, among others). In another segment of the literature, several other authors have argued that public investment does not necessarily have a pro-growth impact on the economy (Khan & Kemal, 1996; Devarajan et al., 1996; Ghani & Din, 2006) or even on the level of output per worker (Milbourne et al., 2003).

The paper is structured as follows. In section 2 the theoretical framework is presented. Section 3 provides an empirical preliminary testing of the model. Section 4 discusses the empirical findings. And, the last section concludes and derives some economic policy implications.

2. Theoretical framework of infrastructure financing

The simulation model is based on the Solow–Swan economic growth framework of Solow (1956) that has been broadly used in literature on public infrastructure and long run economic growth (e.g. Devarajan et al., 1996). Further, we assume that public capital is a public good and that the production function has constant returns to scale in the private inputs. The aggregate production function is assumed to take the following Cobb-Douglas form:

$$y_t = \Lambda_t Z_t^{e\phi} K_t^{\theta} L_t^{1-\theta} \text{ with } \phi \geq 0 \text{ and } \theta < 0 \tag{1}$$

where y denotes total output (or GDP) of the economy, K is the private capital, L the labour force, ϕ and θ being respectively the productive infrastructure and private capital share, Λ_t denotes a measure of productivity that is assumed to be exogenous. Z^e is the productive infrastructure that can be procured by pure public investment or public-private partnerships (PPP) investment since public infrastructure can be financed by each of these forms of investment.

We can therefore isolate both *pure public investment* I_{pp} and *public-private partnerships (PPP) investment* I_{ppp} and compare their corresponding effects on total output. Thus we distinguish ϕ_1 and ϕ_2 such that ϕ_1 is the associated effect of public infrastructure funded by pure public investment and ϕ_2 is the one associated if the infrastructure is funded by a public-private partnerships (PPP) investment.

$$y_t = \begin{cases} \Lambda_t Z_t^{e\phi_1} K_t^{\theta} L_t^{1-\theta} & \text{if} \quad Z_t^e(I_{pp}) \\ \Lambda_t Z_t^{e\phi_2} K_t^{\theta} L_t^{1-\theta} & \text{if} \quad Z_t^e(I_{ppp}) \end{cases} \tag{2}$$

Under our testing intuition, we expect $\phi_2 > \phi_1$, stating that PPPs investment is more productive and efficient than pure public investment, such that the estimated coefficient of PPP investment is greater than that of the pure public investment, as it should be since PPP contracts do not impact the public infrastructure and services provision in the same way.

There are a number of reasons that have been advanced in the literature that make the hypothesis of $\phi_2 > \phi_1$ seem feasible. Public-Private Partnership (PPP) is a form of collaboration between government and private sector aiming at realisation a project or supplying public services (European-Commission, 2003). In other words, as defined by Blöndal (2005), PPPs refer to arrangements whereby the private sector designs, finances, builds, maintains and operates (DFBMO) infrastructures assets provided traditionally by the public sector. Such contracts are made attractive, not only by the constraints on public funds, but also by efforts to improve the quality and efficiency of public services. However, the provision of these types of infrastructure is inherently high-risk, and this is actually why, as Uzunkaya (2017) pointed out, risk sharing is one of the conditions listed for private sector participation. In these types of contracts, both government and private sponsors achieve some gains adequate to level of realising by them particular assignments. In case responsibilities are allocated so that each sector does what it can do best, public services or infrastructure can

only be provided more efficiently. Hence, PPP agreements are based on the goal of sharing the risks of providing public infrastructure and services, so that each player manages the risk it can best control. Then, PPPs contracts can be considered as a game in which public and private partner are the players and each has two strategies *vis-à-vis* risk during the project life cycle.

2.1. Gaming the risk allocation in PPPs contracts. — According to Scharle (2002) the relationships among PPP participants can also be described in the language of 'gaming', where the government G and the private company C are considered as two players in a co-operative game. Each player has two strategies to make facing the risk: either take and hence *manage* (m) or *transfer* (t). We discuss the risk allocation among PPP contractors through the following payoff matrix:

G, C	$manage$	$transfer$
$manage$	(G_m, C_m)	(G_m, C_t)
$transfer$	(G_t, C_m)	(G_t, C_t)

•(G_m, C_m) corresponds to the scenario in which both the government and the private company feel able to manage the risk. In this context the two parties can jointly manage the risk or let one party manage it by negotiating.

•(G_t, C_t) corresponds to the scenario in which both the government and the private company feel unable to manage the risk. Here we can distinguish two options: either (i) the risk is transferred to the insurance companies, or (ii) is jointly managed on the basis of a negotiation between the two parties.

•(G_m, C_t),(G_t, C_m) corresponds to the scenario in which each party expects the partner to manage the risk on its own.

In the model, government and private company are acting on the basis of compromise and cooperation. The game in its presented form does not allow for a possible Nash equilibrium to be defined in this matrix. A numerical approach would be required for that purpose. Nash equilibrium is a situation in which no player has incentive to change a preferred choice knowing the decision of the opponent. As in all games, several Nash equilibria or none are possible. In any case, any changes in conditions and external environment of the projects, often pushing the cooperators towards renegotiation for example, leads to a modification in their expected payoff. As a result, both players will change their initial choice to a better strategy, and thus the Nash equilibrium changes accordingly. Since PPPs are essentially long-term contracts, they are often vulnerable to various external changes that stem from political, social and economic environments. When this happens over the duration of the contract, both parties engage in renegotiation based on risk allocation, as any change in the PPP contract may alter the allocation of risks.

In fact, the government or the private partner do not face the same risk throughout the PPP project's cycle, and moreover do not have the same management and implementation skills. Therefore, the risks should be allocated to the parties who are able to manage them properly, and this is because the payoff will be greater the

more one party can successfully handle the risk and therefore accept to take the risk. The choice of the government or the private sector to *manage* or *transfer* the risk is based on their respective expected benefits which in turn depend on the external environment and project characteristics.

A key point to remember here is that PPP relationships evolve in a context of imperfect information, e.g. once the PPP contract is concluded the government and the private operator are both in a Principal-Agent relationship. And hence, no one knows whether the other will make sufficient efforts to maximize their partner's payoff. Generally each party acts to optimize its own payoffs. Consequently, there are opportunistic behaviors on the part of contractors in PPPs contracts witch ranges from rent-seeking behavior on the part of the private company to maximizing the chance of re-election [(1)] on the part of the government in place. Therefore, it is important that the two parties cooperate along the life cycle of PPP project, maximising their bargaining power in order to increase their access to information and better address the risks involved. It is for this reason that Kargol and Sokol (2007) states that the detachment of decision making and decision executing, and unclear assignment of responsibilities between government and private company raises the risk associated with PPPs.

PPP contracting has risk-sharing advantages in terms of risk diversification by operators according to their risk management skills. This places the onus on the government to take on the risks it can manage, such as political, legal and institutional risk, and the liability for cost overruns that may occur with delays in awarding permits. The demand risk is also a matter for the government. As for the private partner, it has the responsibility to furnish the management skills and expertise necessary to operate and deliver the most efficient public infrastructure. However, it is clear that government should not substitute the market as an alternative mechanism for the provision of public goods and services, nor *vice versa*, in addressing social problems. Co-investment in terms of Public-Private Partnerships (PPP) allows using advantages both public and private sectors in increasing of social welfare.

As such, under the PPPs contracting, the coefficient related to productive infrastructure ϕ in equation (1) is likely to be higher on the basis of the foundations stipulating that risk allocation and management induce a greater impact ϕ_2 than the traditional provision of public goods and services via pure public investment ϕ_1, making the testing intuition $\phi_2 > \phi_1$ plausible.

2.2. Welfare gains in Public-Private Partnerships (PPP) contracts. — Consider an economy consisting of two sectors: public and private, each with a desired level of welfare. We assume that the public sector utility function is related to both economic and social gains and their linked, while the private sector utility function is assumed to only related to economic gains. The public sector represented

1. Public authorities may use PPPs for reasons other than economic and social efficiency, such as electoral goals. Engel et al. (2009) consider that the probability of the government being re-elected is high, as much as the infrastructure investments made during the mandate are high. Thus, a government may involve in PPPs to overcome their short-term budget constraints by using private funds to finance public infrastructure (Checherita, 2009; Engel et al., 2009; Basílio, 2017).

by the government (G) relies on a private company (C) to provide public infrastructure i and services j covering k sectors such as energy, transport, water and sewerage, telecommunication, and municipal solid waste. The cost of payments to the contractor is borne by the users. User demand in each sector $[Q_j^1(p), Q_j^2(p) \ldots, Q_j^k(p)]$ is defined by assuming that in all sectors, C exerts the same level of effort in quality of infrastructure $(\theta_i^1, \theta_i^2 \ldots, \theta_i^k)$ and effort in service quality $(\Psi_j^1, \Psi_j^2 \ldots, \Psi_j^k)$. The demand function for services $Q_j^k(p)$ is stochastic and depends on the quality of the infrastructure and the effort of the company in providing the service. The users demand function is assumed to be inelastic and defined in terms of a price level p_0 such that:

$$Q_j^k(p) = \begin{cases} 0 & p > p_0 \\ q_0 + q\theta_i + \psi_j + \mu \quad if \quad p \leq p_0 \quad \forall \ k \end{cases} \tag{3}$$

where the demand risk is assumed to be exogenous and is captured by the random μ with a normal distribution, $\mu \sim \mathcal{N}(0, \sigma^2)$. $q_0 \geq 0$ represents demand that can not be reduced, i.e the level of demand when no effort is made by C, and the marginal gain of the agents' efforts are positive in particular $q \geq 0$. Note that the quality effort induces a diminishing in the satisfaction without any coast disadvantages for the agent to enhance efforts. In monetary values, the desutility associated to the effort in infrastructure quality is counted of $\frac{\theta_i^2}{2}$ and the one in service quality is counted of $\frac{\Psi_j^2}{2}$. Hence, the expected income (R) of the company C can be expressed as follows:

$$E_\mu(R) = E_\mu[p_0 Q_j^k(p)] = p_0 E_\mu[Q_j^k(p)] \quad \forall \ k$$

$$E_\mu(R) = p_0 E_\mu\big(max\{q_0 + q\theta_i + \psi_j + \mu, 0\}k\big) \approx p_0\big(q_0 + q\theta_i + \psi_j\big)k,$$

where the approximation above holds when σ^2 is small enough compared to the base size of demand q_0. In order to make our analysis simpler, we ignore any incentive issue on the cost side and suppose that there are no marginal costs of service delivery.

As mentioned in section 2.1, from the time the PPP contract has been signed between the government and the private company, the provision of infrastructure and services to the community occurs in a situation of moral hazard. However it is not possible to verify both θ_i and ψ_j. Faced with this context of asymmetric information coupled with moral hazard, the government (G) should provide incentives [(2)] for private company (C), thereby increasing efficiency in infrastructure and services quality, and allowing access to services at a lower coast than it was the case under the traditional public sector provision. In some situations, service quality may be

2. This statement is based on the idea that moral hazard is the only source of incentive issue (Iossa & Martimort, 2009) and that, both buyer and seller are confronted with similar uncertainty about transaction costs and demand conditions in many procurement contexts, or otherwise, only the realized demand that is observable can be used ex ante at the contracting stage between G and C (Bajari & Tadelis, 2001).

observable, so PPP contracts can set targets up front and provide incentives for the private company to invest in achieving them, either through bonuses or penalties. Yet in cases where the quality of services cannot be observed, and therefore cannot be targeted and contracted, problems of moral hazard prevail to a greater extent. To achieve our objective [(3)], we will focus on the latter case, and consider that efforts in infrastructure quality and service quality are not observable. This assumption implies that in this context, PPP contracts take place in an imperfect information environment, which increases the risks associated with PPPs and therefore requires cooperation between government and the private company to better manage the risks, shared according to the competences of each or mutually managed.

Let consider the size of the realized demand Q as an indicator of quality and Φ as the incentive given by the government G to the private company C with respect to quality levels. G is considered to be risk-neutral. Therefore, G maximizes its expected social welfare function measured by the social gain of the service net of the costs and incentive payment granted to C. The private company C for its part maximizes its expected gain while being risk-averse with constant absolute level of risk-aversion $\pi > 0$.

2.2.1. *Under the Pure Public investment.* — In this scenario, the government builds or purchases physical assets, retains ownership of them, and uses public sector employees or private contractors to provide the required service. The equilibrium is solved in three steps.

In the first step, the government contracts the builder of the infrastructure, and then the operator, which is separate from the builder. This operator is rewarded by a rule of rent-sharing $h(R)$. As already shown in Bajari and Tadelis (2001) and Iossa and Martimort (2009), we follow their lead and also restrict our analysis to linear contracts of the form

$$h(R) = w + \Phi R$$

where $\Phi \in \{0, 1\}$ can take on only two extreme values, and w represents a fixed payment or subsidy awarded to the company. Φ is the share of the profits that is left to the company and the rest $\lambda = 1 - \Phi$ is carried by the government. Notice that $\Phi = 0$ is a fixed payment contract with the fee payment of $w > 0$ meaning that the government mandates the operator to provide the services in exchange for a fixed payment that does not depend on the actual level of usage of the services, such that the government is bound to assume all demand risks. Otherwise, $\Phi = 1$ and there is

3. The objective is to show that there is an additional payoff in funding socioeconomic infrastructure through co-investment between the public sector and private partner compared to funding through traditional public investment. While much has been investigated in the economic literature about the impact of both public and Public-Private Partnership (PPP) investments on the aggregate output of countries, to our knowledge, this is not yet the case for the comparative effects of PPP and pure public investments in financing national output. Our presumption seems to be that the nature of the financing (whether it involves private participation or not) could lead the two parties to cooperate in order to reduce the sources of inefficiencies that may exist in the provision of public infrastructure and services which are the main channels through which these investments affect national output.

no additional compensation fee payment, i.e. $w = 0$. In this case, the operator earns its revenue by charging the end users of the infrastructure directly and controls all demand risks.

Now, let's consider that the operator receives a fixed incentive payment [4] that depends rather on the demand achieved Q. The builder has no incentive to put any effort into the design of the project, as the fee he receives is fixed and does not cover the efforts made to improve the quality of the building, hence:

$$\theta^k_{i/tr} = 0, \quad \forall \quad k \tag{4}$$

Second, let's look at the operator's side. The incentives constraint under the assumption that provider will maximise the certain amount of its expected utility by accounting for the builder's effort, is given by:

$$\psi^k_j = \sum_k \left[\text{argmax}_{\tilde{\psi}}\, w + \Phi p_0 \big(q_0 + \tilde{\psi}_j\big) - \frac{\tilde{\psi}_j{}^2}{2} - \frac{\pi\sigma^2\Phi^2 {p_0}^2}{2} \right] = k\Phi p_0 \tag{5}$$

Remember that to simplify the analysis, we had previously assumed that the company exerts the same level of effort regardless of the sector k. In this scenario, an increase in the share of profits Φ left to the company C encourages the effort to improve demand and consequently a greater operational risk which is transferred to C i.e. a premium risk that can be quantified by $\frac{\pi\sigma^2\Phi^2}{2}$. If a government has up-front negotiating power with the builder and provider, it will be tempted to take all their profit, making its partners indifferent between delivering the service and securing their standardized external opportunities at zero. Then, the payment amount of fee w is set to cover the premium risk necessary to attract a risk-averse operator willing to take certain operational risks as required by the granting of incentives.

And last, we assume that the government maximizes social welfare under the incentive constraints (4) and (5) while taking into account the total profits as well as the costs of investing in efforts, covering the risk premium. The problem of social welfare maximization of G is thus written:

$$\sum_k \left[\max_{\psi} p_0 \big(q_0 + \psi_j\big) - \frac{\psi_j^2}{2} - \frac{\pi\sigma^2\Phi^2 {p_0}^2}{2} \right], \quad subject \quad to \quad (5)$$

However, we can express the effort and marginal pay-off as follows in the second-order equilibrium (SBE).

$$\sum_k \psi^{SB}_{j/tr} = \Phi^{SB} \sum_k p_0 = k \frac{p_0}{1 + \pi\sigma^2} \tag{6}$$

As indicated above, $\Phi^{SB} \in \{0, 1\}$. This implies that the risk-averse company only gets a portion of the total profit due to insurance reasons and under-supplied

4. The justification for this fixed payment assumption is developed in Iossa and Martimort (2009), see p.8

effort below the first-best solution. Then, the fixed payment w^{SB} is set such that the company breaks even in the expectation. It should be recalled once again that granting incentives commits the company to taking more risk. Indeed, this risk is socially costly so that the effort under the first-best condition is more than its second-best level. The social welfare under the traditional public sector investment can be expressed as:

$$SW_{tr}^{SB} = \left(p_0 q_0 + \frac{p_0^2}{2(1+\pi\sigma^2)}\right)k \tag{7}$$

2.2.2. *Under the Public-Private Partnership (PPP) contracting.* — In PPP contracts, government G transfer investment investments projects from public sector to the company C in private sector. It consists of a long-term contractual arrangements where C participate in, or supports G in the delivery of public infrastructure. In such collaboration, private company C can finance, design, build, maintain and operate public infrastructure. So, under the PPP scenario, C is in charge of the infrastructure's building and operational aspects, and can therefore decide either to maximize θ_i or ψ_j

$$(\theta_i, \psi_j^k) = \sum_k \left[\text{argmax}_{\tilde{\theta},\tilde{\psi}}\, w + \Phi p_0\big(q_0 + q\tilde{\theta}_i + \tilde{\psi}_j\big) - \frac{\tilde{\theta}_i^{\,2}}{2} - \frac{\tilde{\psi}_j^{\,2}}{2} - \frac{\pi\sigma^2\Phi^2 {p_0}^2}{2}\right] \tag{8}$$

Accounting for the additional non-negativity constraint $\theta_i \geq 0$, the incentive constraints can be expressed as below:

$$\psi_j = k\Phi p_0 \quad \textit{and} \quad \theta_i = k\Phi p_0 q = \psi_j q \tag{9}$$

Let us point out that the level of effort in the quality of the services provided is the same under both the traditional public sector provision and the PPP contracting. This remark is not similar for the infrastructure quality θ_i given the positive external effects that are internalized in PPP contracts.

The private company C benefits from somewhat internalizing the cost of building high quality infrastructure since its revenues depend on it, and additionally the incentives granted by G are all the greater the more risk [(5)] is transferred to C as is the case with public-private partnerships, since quality is difficult to contract. The government's problem is to maximize its payoff by taking into account how the Company C opts to invest in the quality of the infrastructure and effort. The G's

5. The allocation of risks between the two parties (G and C) has been discussed in this section. Cooperation allows for the transfer of risk to either the public or private sector as is necessary, and thus allows for better management of risks associated with PPP contracts. Thus, when the government transfers more risk to the private company, it is expected that the fee payment will be set at a level that covers the risk, at least the premium risk, given that C is risk averse, $\pi > 0$.

problem is expressed as follow:

$$\sum_k \left[\max_{\theta,\psi} p_0\left(q_0 + q\theta_i + \psi_j\right) - \frac{\theta_i^2}{2} - \frac{\psi_j^2}{2} - \frac{\pi\sigma^2\Phi^2{p_0}^2}{2} \right] \quad subject \quad to \quad (9)$$

at equilibrium, the following levels of effort can be derived:

$$\psi_{j|pp}^{SB} = \frac{p_0(1+q^2)}{(1+q^2+\pi\sigma^2)}k \quad and \quad \theta_{i|pp}^{SB} = \frac{p_0 q(1+q^2)}{(1+q^2+\pi\sigma^2)}k$$

when public and private actors contract in co-investment, the social welfare is

$$SW_{pp}^{SB} = p_0 q_0 k + \frac{p_0^2(1+q^2)}{2(1+q^2+\pi\sigma^2)}k$$

As a result, PPP payoffs far outweigh the payoffs from pure public investment

$$SW_{pp}^{SB} > SW_{tr}^{SB}$$

The welfare payoff under investment through public-private partnership (PPP) raises with the magnitude of the external effect q so that:

$$\frac{\partial}{\partial q}(SW_{pp}^{SB} - SW_{tr}^{SB}) > 0$$

Applying PPP is associated with a lot of benefits: increasing the quality of public goods or infrastructure, decreasing of coasts of their providing, or more efficient allocation of resources. In particular, if the investment is made on the basis of a partnership between government and the partner, there is a quality-enhancing effort and increasing in cost-reducing effort in the provision of infrastructure. The PPP contract also provides a framework for efficient risk management, such that greater powered incentives and more operational risk being transferred to the private sponsors.

2.3. Comparative payoffs for households. — Since financing on the basis of public-private partnerships has a greater impact on the economy than financing through pure public investment, this additional impact is felt in the utility of citizens. Each household derive utility u from private consumption c_t and public goods and services w_t, so that household's utility per time t is given by

$$u_t = c_t + w_t \quad (10)$$

Each country having a population size n, then

$$w_t = \frac{1}{n} SW^{SB}$$

is the public consumption benefiting household. Consequently, household maximizes it welfare by combining consumption c and gain of public projects:

$$U = \int_0^\infty u(c)e^{-\rho t}dt + w_t$$

where ρ denotes the time preference. The utility function can be usefully written in its isoelastic form as follows:

$$u(c) = \frac{c^{1-\delta} - 1}{1-\delta}, \quad \delta \neq 1$$

More precisely, the specific functional forms for utility function under the traditional public sector provision funding through pure public investment,

$$U(c_t, w_t) = \int_0^{\infty} e^{-\rho t}\left(\frac{c^{1-\delta}-1}{1-\delta}\right)dt + \frac{1}{n}k\left(p_0 q_0 + \frac{p_0^2}{2(1+\pi\sigma^2)}\right) \quad subject\ to \quad Z_t^{e\,\phi_1} K_t^{\theta} L_t^{1-\theta}$$

is compared to the the specific functional forms for utility function under the contracting public-private partnership (PPP) investment

$$U(c_t, w_t) = \int_0^{\infty} e^{-\rho t}\left(\frac{c^{1-\delta}-1}{1-\delta}\right)dt + \frac{1}{n}k\left(p_0 q_0 + \frac{p_0^2(1+q^2)}{2(1+q^2+\pi\sigma^2)}\right) \ subject\ to\ Z_t^{e\,\phi_2} K_t^{\theta} L_t^{1-\theta}$$

***Proposition**: Public-private partnerships (PPP) investment is more productive and efficient than pure public investment, as we showed PPP contracts do not impact the infrastructure quality and service provision in the same way. Public-private partnerships provide a better management and risk-sharing framework between government and private partners and allow for the transfer of certain risks to the private sector against payment of incentives, thereby improving the quality of infrastructure and services provided.*

3. Some preliminary testing

3.1. Empirical prediction. — In this section we performs an empirical test of our prediction model. The purpose of this test is simply to provide empirical evidence to support our modelling intuition. To this end, we conduct an empirical investigation comparing the impact of public investment to PPP investment on economic growth in 14 Sub-Saharan African Countries. For this aim, we employed the linear Pooled Mean Group (PMG) estimator for dynamic heterogeneous panels developed by Pesaran et al. (1999). Since our data covers a small number of countries as compared to the number of period $N = 14$ and $T = 28$, the PMG estimator is therefore likely to provide more consistent results than the classical dynamic model from panel data of Arellano and Bond (1991), because a longer period is a synonym of increasing the number of instruments and throws back the null hypothesis of instrument exogeneity through the Sargan validity test. Accordingly, the GMM only grasps the short-term dynamics of the data. Thus, our study applied a panel ARDL approach to account for the short- and long-run effects prevailing between variables. The ARDL$(p, q_1, ..., q_k)$ dynamic panel is specified in the form:

$$y_{it} = \mu_i + \sum_{j=1}^{p} \delta_{ij} y_{i,t-j} + \sum_{j=0}^{q} \gamma_{i,j}^{'} X_{i,t-j} + \epsilon_{it} \tag{11}$$

where the subscripts i and t represent respectively country and time period. The dependant variable y_{it} is the real GDP per capita growth; X_{it} is a k x 1 vector of our explanatory variables with $\gamma_{ij}^{'}$ the coefficient vectors having also k x 1 dimension; δ_{ij} are the scalars or the lag dependent variable coefficients; μ_i is country-specific effect; and ϵ_{it} represents the time-varying regression residual.

The specific model for PMG estimator in which we redefine into the error-correction equation is given below:

$$\Delta y_{it} = \phi_i(Ec_{it}) + \sum_{j=1}^{p-1} \delta_{ij}^{*} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \gamma_{i,j}^{'*} \Delta X_{i,t-j} + \vartheta_{it} \tag{12}$$

where ϑ_{it} denotes the errors independently distributed for the country i and the time t; $\phi_i = -(1 - \sum_{j=1}^{p} \delta_{ij})$; $Ec_{it} = y_{i,t-1} - \theta_i^{'} X_{it}$ with $\theta_i = \sum_{j=0}^{q} \gamma_{it} / (1 - \sum_k \delta_{ik})$; $\delta_{ij}^{*} = -\sum_{m=j+1}^{p} \delta_{im}$ with $j = 1, 2, ..., p-1$; and $\gamma_{ij}^{*} = -\sum_{m=j+1}^{q} \gamma_{im}$ with $j = 1, 2, ..., q-1$;

The parameter ϕ_i is the error-correcting of adjustment speed term which defines the long-term convergence or divergence of the model. In the model, the convergent or divergent nature depends on the sign of the value of error correction term. This parameter is expected to be significantly negative under the prior hypothesis that the variables show a return to a long-run equilibrium. But, in case it is equal to zero i.e $\phi_i = 0$, that means there would be no evidence for a long-run relationship.

Three candidates' approaches are suggested in the literature on dynamic heterogeneous panel estimation for estimating of equation (12). First, we have the dynamic fixed effects (DFE) estimation approach in which the time-series data for each country (i) are pooled and only the intercepts are allowed to differ across countries. Second, we have the Mean Group (MG) estimator that fits the model separately for each country (i), computes a simple arithmetic average of the coefficients, and allows the intercepts, slope coefficients, and error variances to differ across countries. And finally, we have the PMG estimator that combines both pooling and averaging that allows the intercept, short-run coefficients, and error variances to differ across the country (as would the MG estimator) but constrains the long-run coefficients to be equal across countries (as would the DFE estimator). The specification used a Maximum Likelihood (ML) method to estimate the parameters since the equation (12) is non linear in parameters (see Pesaran et al., 1999). The test of difference giving the efficiency gain among these three models is carried out with the familiar Hausman test. We use alternatively each of these three estimators only for the baseline model.

3.2. Data and choice of variables. — The data set consist of annual observations over the period $1990 - 2017$ and covers 14 Sub-Saharan African countries [(6)]. Our analysis considers for both, time and cross-country variation in the data. The

6. The 14 countries covered by this analysis are: Benin, Burkina Faso, Cameroon, Congo Republic, Cote d'Ivoire, Gabon, Gambia, Ghana, Guinea, Mali, Nigeria, Senegal, Sierra Leone and Togo.

choice of these countries is based on the availability and accuracy of data, especially data on investments in public-private partnerships that are our primary concern.

In our Investment-growth model, the dependent variable is economic growth measured by the growth rate of real GDP per capita. Notice that governments make investments to pursue a variety of objectives, including increasing per capita income. The reason we focus on growth is that since growth is one of the government's goals, it is then useful to assess the contributions of both pure public and PPP investment to this goal.

Actually, as we are interested in the comparative effects of pure public and PPP investments as driver of economic growth, we used two variables of interest for capturing the investment-growth impact: pure public investment and public-private partnerships (PPP) investment. Thus, we expect not only that these two investment measures have positive effects as shown in a part of the existing literature, but above all that, an increase in the PPP investment will produce a greater effect than that of an increase in the pure public investment. The investment flows data are from the IMF Investment and Capital Stock Dataset [(7)] (2019).

The set of controls variables includes the initial GDP per capita to account for the conditional convergence hypothesis assuming that economic growth converges across countries and over time, and several underlying factors that can affect the change in the growth rate of GDP per capita. Key among these are the physical capital measuring by the investment in gross capital formation, the government expenditure in percent of GDP to control for the effect of government spending and taxation, the growth rate of population as proxy for the change in labour force, the trade openness to appraise the effect of international shocks on domestic economic growth, the ratio of domestic credit to GDP accounting for the important role played by the private sector in expanding production capacity, and the broad money stock that is used to consider the of effect currency in circulation and demand deposits. We use the value of one year's lag in the GDP per capita variable to measure its initial level in order to pick out the convergence tendency of Solow (1956), an insight that countries with lower initial production per capita (poorer countries) grow faster than

7. Most of the time, studies on Public-Private Partnerships use data from the Private Participation in Infrastructure (PPI) Project Database. The PPI database has data on over 6,400 infrastructure projects in 137 low- and middle-income countries and covers projects in energy, transport, water and sewerage, telecommunications, and Municipal Solid Waste (MSW) sectors. Projects include management or lease contracts, concessions, greenfield projects, and divestitures. However, the use of PPP investment data derived from this database could be problematic in case of our analysis. The logic behind this claim is that the total investment commitments agreed at the financial closure of a PPP project. Romp and De Haan (2005) consider that the use of such data should be considered as being in the upper bound of the size of PPPs. As a matter of fact, it makes more sense to use a measure of PPP investments that varies with actual PPP investments over the life cycle of a project. Certain authors, among whom Romp and De Haan (2005) and Kappeler and Nemoz (2010) have tackled this measurement problem and proposed to spread the amounts of investment commitment equally over certain years. It is for this interest that we have chosen to use the IMF Investment and Capital Stock Dataset which constructed its public-private partnerships (PPP) flows for 170 countries by spreading the total transaction amounts over 5 years to convert to yearly PPP investment flows expressed in constant 2011 international dollars.

those with higher production per capita (richer countries) and converge to similar levels of income. We therefore expected the sign of this variable to be negative to confirm this principle. According to the economic growth literature, certain of our control variables are expected to have positive effects such as physical capital, growth rate of population, trade openness, the ratio of domestic credit to GDP and while negative effects are expected for others as government expenditure as a share of % of GDP and broad money stock (positive/negative sign can be expected). The definition of data used in this analysis and its measurement, derived from different sources are presented in Table 6 in appendix.

A descriptive analysis (Tables 4 and 5 in appendix) of the investment data shows that the average share of pure public investment in GDP (4.46%) remains relatively higher than that of PPP investment (0.49%) in our sample. The maximum PPP investment was reached in The Gambia in 2014, accounting for 14.8% of GDP. But in terms of pure public investment, the maximum represents 26.3% of GDP in 2013 in Congo Republic.

A view at the country level indicates that Togo and The Gambia have the highest average level of PPP investment at 1.29% and 1.62% of GDP respectively. In Togo, such investments have been drained by major infrastructure projects, particularly those of railways, electricity and above all thermal power stations, container terminals and the port of Lome. In The Gambia, it concerns the natural gas transmission, water and electricity management and ACE (African Coast to Europe) submarine infrastructure projects. Among the countries in our sample, the Congo Republic has the highest level of pure public investment as a percent of GDP of 26.3% in 2013 with a mean of 8.8% ahead of Burkina Faso which spent in average 6.47% of its GDP on pure public investment over the period $94 - 2017$.

4. Results

First, we perform the unit root test in order to verify and take into account for non stationarity in the variables due to the wide time period in our study. To achieve that, we apply a second-generation panel unit root test, based on Pesaran (2007) unit root test, for variables in level and in first differences, the results of which are reported in the Table 1. We can remark through these results that some variables are stationary I(0) while others non-stationary in level, but that all the variables have been found to be stationary in the first differences I(1). Given that the order of integration of our series does not exceed I(1) the application of the ARDL model in such context would be largely satisfying.

TABLE 1. Panel Unit root test by Pesaran (2007)

CIPS stats	Variables in levels				Variables in fisrt differences			
	Zt-bar[a]	p-value	Zt-bar [b]	p-value	Zt-bar[a]	p-value	Zt-bar[b]	p-value
GDP per Capita growth	-4.587	0.000	-2.701	0.003	-13.36	0.000	-11.51	0.000
Initial GDP per Capita	4.930	1.000	-0.541	0.294	-4.375	0.000	-1.724	0.042
Pure public investment	-3.287	0.001	-3.270	0.001	-9.334	0.000	-8.215	0.000
PPP investment	0.574	0.717	1.376	0.916	-3.651	0.000	-1.360	0.087
Private capital	-2.582	0.005	-2.409	0.008	-8.331	0.000	-6.304	0.000
Government expenditure	-1.061	0.144	-1.017	0.155	-7.073	0.000	-4.971	0.000
Population growth	-10.00	0.000	-13.30	0.000	-12.23	0.000	-13.29	0.000
Trade openness	0.187	0.574	1.099	0.864	-7.560	0.000	-6.230	0.000
Money stock	-3.624	0.000	-1.839	0.033	-6.617	0.000	-5.278	0.000
Domestic credit	-4.497	0.000	-1.965	0.025	-8.705	0.000	-7.492	0.000
Central government debt	-2.030	0.021	-0.895	0.186	-8.186	0.000	-6.736	0.000

Note : (a) constant included (b) constant and trend are included. Lags equal to 1.

The results of the benchmark models using the three different candidate estimators, including PMG, MG and DFE are presented in Table 3 in appendix. The test of difference in these estimators is performed with the familiar Hausman test. The results provide the dynamic relationships i.e. short-run and the long-run relationships among variables. Whatever the model, the Hausman statistic (Table 3 in appendix) confirms the null hypothesis of the constraint of uniformity of the coefficients in the long run, indicating that the PMG is more efficient and consistent than the other candidates (MG and DFE) and that the simultaneous equation bias is minimal for these data (Pesaran et al., 1999).

In the output shown in the Table 2, the estimated Short-run coefficient of pure public investment is positive and statistically non-significant. Also, the Short-run coefficient of PPP investment is statistically non-significant, but exerts negative effect. Often under the PMG estimator, only the long term parameters are of interest. The error correction parameter is found to be significantly negative, confirming the prior hypothesis that the variables show a return to a long-run equilibrium, in both the growth-pure public investment and growth-PPP investment models. The higher marginal productivity of PPP investment is precisely what we want to test, and so the most interesting results from the point of view of these estimates are the two respective coefficients of pure public investment in model (1) and PPP investment in model (2). In other terms, $\phi_2 > \phi_1$.

Considering the models (columns 1 and 2) in Table 2, we find that the coefficient of pure public investment $\phi_1 = 0.174$ is positive and significantly different from zero at the 1% level. And more interestingly of course, the marginal impact of PPP investment also turned out to be positive with a coefficient $\phi_2 = 0.547$ that is also statistically significantly and different from zero at 1%. On the basis of these estimates, there is little doubt that the long-term growth effects of PPP investment outweigh the long-term growth effects of pure public investment as expected. We can therefore confirm the tested hypothesis previously announced, according to which, investing through public-private partnerships would produce greater economic and social benefits than conventional public investment, so that $\phi_2 > \phi_1$. All things being

equal, PPP investment would produce 3.14 times more economic growth impacts than pure public investment in the long term.

In order to further explore the effects of PPP investment on productivity in debt times, we re-estimated model (2), introducing an interaction term of PPP investment with a debt conditional variable being 1 when the debt level is above 70% of GDP and 0 otherwise, in line with the convergence criteria in practice in the sample countries. The results are also presented in the Table 2 (column 3*a*) and the interaction variable is named *debt conditions*. Since the coefficient of *debt conditions* variable is significantly different from zero at 1%, it suggests that there would be a certain difference in the impact of PPP investment on the countries' economic growth linked to their level of indebtedness. The coefficient has a negative sign. In concrete terms, this result means that PPP investment produces a lower impact in countries with a high level of debt (the level of debt in our analysis is set in reference to the community debt threshold set by convergence criteria) compared to those with a low level of debt. But in fact, this gives us no idea of the magnitude of the effect of PPP investment on growth in highly indebted countries. To find this out, we should first consider another coefficient such as that of PPP investment. In the case of the latter, we can see that this coefficient has a positive slope, with an amplitude of 0.438 and close to being significantly different from zero at the 10% level. This coefficient is interpreted as the impact of PPP investment in countries with low debt levels, i.e. below the threshold of 70% of nominal GDP. Hence, for countries with a high level of debt (more than 70% of GDP), the impact of PPP investment on economic growth is given by $0.438 + (-0.958) = -0.52$. The interpretation is that PPP investment rather decelerates the growth process in countries with high levels of debt. A possible explanation for this identified negative conditional effect on public debt relates to the fact that PPPs do not always avoid long-term debt distress. It should be noted that long-term contracts defer payment obligations and spread them over long periods, and therefore the fiscal consequences of PPPs are often overlooked in the short term. However, the full fiscal implications of PPPs only become clear once the payment obligations of PPPs contracts affect the government budget. Thus, countries with a high level of debt at the outset, face an unsustainable debt situation afterwards in meeting PPP obligations. Yet it is clear that a high level of public debt is likely to crowd out long-term economic growth. For example, excessive debt increases the interest rate which slows down growth by increasing the demand for loanable funds, or it causes high inflation that modifies consumption behaviour over time in relation to so-called rational consumer expectations. In addition, there is also the channel of taxation, as the payment of debt servicing requires an increase in taxes, leading to a fall in disposable income (and therefore savings), and thus crowding out private investment, which is the essential link in the chain of growth.

In line with this idea of testing the magnitude of the impact that PPP investment would have on countries' economic growth according to different level of debt, we simulate once again a deepening of the debt level by 10% of GDP beyond the threshold, which can indicate a period of severe fiscal constraint. Thus, countries with severe budgetary constraints are defined as those with a public debt of more than 80% of GDP, i.e. 10% or more outside the community level. These results are

reported in column 3*b*. The findings seem to be similar to the previous one. One thing that is different, however, is that the slope is steeper at the 80% debt level (from column 3*a* to 3*b*). This indicates that, for countries whose debt is increasing but remains below or equal to 80% of GDP, investments contracted in the form of PPPs continue to accelerate the country's productivity, even to a greater extent, and consequently above 80%, there is a downward trend in the growth diminishing effect of PPP investment (in column 3*b*, the impact of PPP investment for higher debt countries is given by the magnitude $0.639 + (-0.657) = -0.018$). From this point of view, reaching the community debt threshold is not a fact that could possibly harm the returns from PPP investments. However, if debt exceeds 90% of GDP, no growth enhancing effect of PPP investment can be predicted by our results, as can be seen in column (3*c*), where the coefficient of PPP investment is found to be positive but not significant.

In summary, the results in Table 2 indicate the following: firstly, both pure public investment and public-private partnership (PPP) investment positively drive economic growth in countries, and of the two, PPP investment appears to have the greater effect. Secondly, that the stimulus effect of PPP investment remains and seems to be more powerful even beyond the community debt threshold. And finally, that PPP investment is unlikely to produce any positive growth effects when the debt level reaches a certain level of 90% of GDP in the country.

After having looked at the coefficients of the different investment variables, we can now describe the relative contributions of the different factors controlling the growth of production. Most of the control variables have the expected sign and are overall significant in long-run, whatever the specification. The initial GDP per capita is a key determinant of long-run economic growth. The negative sign of the associated coefficient confirms the conditional convergence hypothesis (Solow, 1956) saying that countries with a low level of per capita income grow faster than those with a high level of per capita income. The accumulation of the physical capital stock, population growth, trade openness, and domestic credit also boost long-term economic growth. In contrast, the stock of money and government expenditures induce a diminishing effect on long-run growth. The negative sign of the money stock is not necessarily expected. That said, the long-term impact of an increase in the money supply is always difficult to predict. The increase in the stock of money leads to artificially increase the prices of assets. That is a misallocation of capital which leads to speculative investments, resulting in volatile asset prices followed by a contraction in economic activity. An important note is that the significance of each of these coefficients improved in the specification including PPP investment and had relatively higher impacts (see Figure 1 in appendix), all significant at the 1% level.

TABLE 2. Results of empirical prediction using PMG estimator

	Public	PPP	debt> 70	debt> 80	debt> 90
VARIABLES	(1)	(2)	3a	3b	3c
Long-Run effects					
Investment variables	0.174***	0.547***	0.438*	0.639***	0.183
	(0.008)	(0.003)	(0.089)	(0.004)	(0.314)
Debt conditions			-0.958***	-0.657**	-0.607*
			(0.009)	(0.029)	(0.074)
Per capita GDP, year's lag	-0.004***	-0.007***	-0.007***	-0.006***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Private capital	0.215***	0.234***	0.389***	0.240***	0.334***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Government expenditure	-0.140**	-0.215***	-0.344***	-0.232***	-0.295***
	(0.011)	(0.000)	(0.003)	(0.000)	(0.002)
Population, annual growth	0.136	1.014***	1.449***	1.082***	1.194***
	(0.609)	(0.000)	(0.002)	(0.000)	(0.002)
Trade openness	0.023**	0.028***	-0.034**	0.031**	-0.013
	(0.020)	(0.006)	(0.040)	(0.011)	(0.339)
Domestic credit	0.088**	0.129***	-0.071	0.091**	-0.013
	(0.038)	(0.001)	(0.167)	(0.026)	(0.757)
Money stock	-0.047*	-0.071***	0.028	-0.052*	0.010
	(0.091)	(0.005)	(0.484)	(0.074)	(0.777)
Short-Run effects					
Error Correction	-1.248***	-1.152***	-0.617**	-1.172***	-0.806***
	(0.001)	(0.000)	(0.017)	(0.000)	(0.004)
Δ.Investment variables	0.078	-0.032	1.401	0.254	0.916
	(0.664)	(0.990)	(0.618)	(0.923)	(0.737)
Δ.Debt conditions			-2.315**	7.211	3.700
			(0.020)	(0.171)	(0.433)
Δ.Per capita GDP, year's lag	0.041	0.031	-0.032	0.032	-0.007
	(0.247)	(0.315)	(0.271)	(0.281)	(0.825)
Δ.Private capital	-0.113	-0.105	-0.064	-0.120	-0.094
	(0.251)	(0.331)	(0.582)	(0.259)	(0.382)
Δ.Government expenditure	-0.122	0.165	0.144	0.168	0.136
	(0.534)	(0.368)	(0.464)	(0.391)	(0.475)
Δ.Population, annual growth	13.530	9.859	5.269	8.914	7.482
	(0.153)	(0.290)	(0.597)	(0.352)	(0.430)
Δ.Trade openness	0.015	0.002	-0.002	-0.017	0.002
	(0.704)	(0.946)	(0.947)	(0.607)	(0.941)
Δ.Domestic credit	0.362	0.375	0.510	0.380	0.512
	(0.330)	(0.362)	(0.134)	(0.366)	(0.169)
Δ.Money stock	-0.148	-0.202	-0.204	-0.188	-0.249
	(0.339)	(0.244)	(0.292)	(0.281)	(0.157)
Constant	0.230	1.317	2.328***	0.396	1.677**
	(0.774)	(0.224)	(0.004)	(0.677)	(0.029)
Observations	357	357	355	355	355
Number of id.	14	14	14	14	14
Log Likelihood	-757,35	-760,13	-746,96	-751,45	-753,70

Note: Pvalues in parentheses.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Concluding remarks

There are pervasive arguments in the economic literature that Public-Private Partnerships (PPP) investments yield more efficient economic and social benefits than conventional public investments, but there has been no empirical investigation of this premise in the case of many economies, especially those suffering from budgetary constraints. Obviously, the lack of convincing empirical proof, the superiority of PPP arrangements over the classic public investment in stimulating overall growth in the economy is very difficult to assert. That is why this study carried out a comparative analysis of the spillover effects of public-private partnerships (PPPs) and traditional public investments in 14 Sub-Saharan African countries. To achieve this goal, we first drew on game theory to show that cooperation between the government and the private operator guarantees a better allocation and management of risks associated with the provision of public infrastructure and services, and therefore improves the gains for each stakeholder. Second, we drew on Iossa and Martimort (2009) model to design a conceptual framework showing that PPP investments would produce greater benefits than pure public investments by providing incentives and transferring a number of risks to the private company, and the government itself taking on those risks for which it has the skills. And lastly, we have explored whether a higher level of debt matters for the growth stimulating effect of PPP investments.

Our paper leads to the following conclusions: the principal finding is that both PPP investment and pure public investment are key drivers and differently affect long-term rate of economic growth. In fact, PPP investment and public investment do not affect marginal productivity in the same way. Moreover, and perhaps more interesting for the debate on financing economies in countries with budgetary constraints, PPP investment plays an important and more powerful role than public investment in stimulating the growth process. Therefore, one can argue that the intuition according to which PPP investment would have a greater impact than traditional public investment is supported by empirical proof. As a follow-up, we also observe that a level of debt plays a distinctive role in the growth potential of PPP investments. And as long as this level remains below a certain threshold, there is a growth accelerating impact. In more precise terms, the growth enhancing impact of PPP investment is consolidated as the level of debt increases to a point where any favorable impact could not be expected.

From the overall mix of these results, it is possible to draw some policy implications. One lesson is that PPPs are a credible alternative source of financing to traditional public investment. Therefore, PPPs are a way to overcome fiscal constraints, and a tool for carrying out public investments when governments lack the resources to finance infrastructure projects. Indeed, governments are required to create conditions that can attract private partners to public-private partnerships (PPP) investments. The aim is for the government to ensure cohesive political institutions, stable political environment, macroeconomic stability, a sound fiscal and legal base, and a strong litigation system, all of which are essential to attract PPP investment and make it successful. The hoped-for benefits of these policies of attracting private partners into PPP contracts are intended to produce growth-multiplying effects in

the long term and improve social welfare of populations. However, for countries with high public debt, it is advisable to match increases in public investment with commensurate increases in public savings by mobilizing additional revenues, for example by raising taxes or switching spending priorities.

Another lesson concerns the consolidation of the macroeconomic and discipline framework established by the convergence criteria. Some have already begun to query the real impact of compliance with the convergence criteria on the population' s well-being. With regard to the criterion that sets the ceiling of debt at 70% of GDP, our study opens the way for thinking about a possible re-examination of these convergence criteria that could create a fiscal space, especially in the current context of fiscal constraints, at least in the countries in our study. Above all, it is clear that PPP investments have a greater growth accelerating effect than traditional public investment, as they enhance the quality and efficiency of services, and are certainly an alternative source of financing for economic and social infrastructure.

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Appendix

TABLE 3. Benchmark models using PMG, MG, and DFE estimators

	Pure Public investment			PPP investment		
VARIABLES	PMG	MG	DFE	PMG	MG	DFE
Long-Run effects						
Investment variables	0.174***	-0.028	0.031	0.547***	5.013	0.004
	(0.008)	(0.964)	(0.766)	(0.003)	(0.238)	(0.986)
Per capita GDP, year's lag	-0.004***	-0.082	-0.001	-0.007***	-0.041	-0.000
	(0.000)	(0.222)	(0.155)	(0.000)	(0.196)	(0.109)
Private capital	0.215***	-0.235	-0.020	0.234***	0.240	-0.017
	(0.000)	(0.789)	(0.823)	(0.000)	(0.367)	(0.814)
Government expenditure	-0.140**	-0.049	-0.191*	-0.215***	-1.481	-0.203*
	(0.011)	(0.968)	(0.095)	(0.000)	(0.241)	(0.094)
Population, annual growth	0.136	109.620	2.018***	1.014***	28.726	2.054***
	(0.609)	(0.266)	(0.000)	(0.000)	(0.136)	(0.000)
Trade openness	0.023**	0.171	0.051**	0.028***	-0.065	0.050**
	(0.020)	(0.313)	(0.021)	(0.006)	(0.799)	(0.021)
Domestic credit	0.088**	0.699	-0.054	0.129***	1.227	-0.063
	(0.038)	(0.180)	(0.609)	(0.001)	(0.157)	(0.549)
Money stock	-0.047*	0.128	0.106	-0.071***	-0.690	0.116
	(0.091)	(0.737)	(0.244)	(0.005)	(0.247)	(0.203)
Short-Run effects						
Error Correction	-1.248***	-0.617	-0.987***	-1.152***	-1.115	-0.992***
	(0.001)	(0.642)	(0.000)	(0.000)	(0.311)	(0.000)
Δ.Investment variables	0.078	0.139	0.072	-0.032	3.004	-0.271
	(0.664)	(0.696)	(0.555)	(0.990)	(0.522)	(0.505)
Δ.Per capita GDP, year's lag	0.041	-0.164	0.002	0.031	-0.019	0.002
	(0.247)	(0.406)	(0.570)	(0.315)	(0.878)	(0.519)
Δ.Private capital	-0.113	-0.067	0.018	-0.105	-0.100	0.020
	(0.251)	(0.575)	(0.845)	(0.331)	(0.507)	(0.810)
Δ.Government expenditure	-0.122	0.240	0.016	0.165	0.512	0.028
	(0.534)	(0.247)	(0.903)	(0.368)	(0.209)	(0.828)
Δ.Population, annual growth	13.530	-19.461	2.566*	9.859	-23.344	2.608*
	(0.153)	(0.395)	(0.078)	(0.290)	(0.334)	(0.086)
Δ.Trade openness	0.015	-0.023	-0.018	0.002	-0.085**	-0.019
	(0.704)	(0.492)	(0.749)	(0.946)	(0.043)	(0.750)
Δ.Domestic credit	0.362	-0.110	0.062	0.375	0.918	0.071
	(0.330)	(0.600)	(0.772)	(0.362)	(0.249)	(0.726)
Δ.Money stock	-0.148	0.058	-0.274**	-0.202	-0.291	-0.271**
	(0.339)	(0.764)	(0.029)	(0.244)	(0.138)	(0.021)
Constant	0.230	-9.077	-5.763*	1.317	3.838	-5.737**
	(0.774)	(0.823)	(0.057)	(0.224)	(0.923)	(0.043)
Observations	357	357	357	357	357	357
Number of id.	14	14	14	14	14	14
Hausman statistic	1.30	-	3.33	5.23	-	10.78
Pvalue	(0.9884)	-	(0.8534)	(0.7329)	-	(0.2143)

FIGURE 1. Plots showing coefficients and spikes for confidence intervals

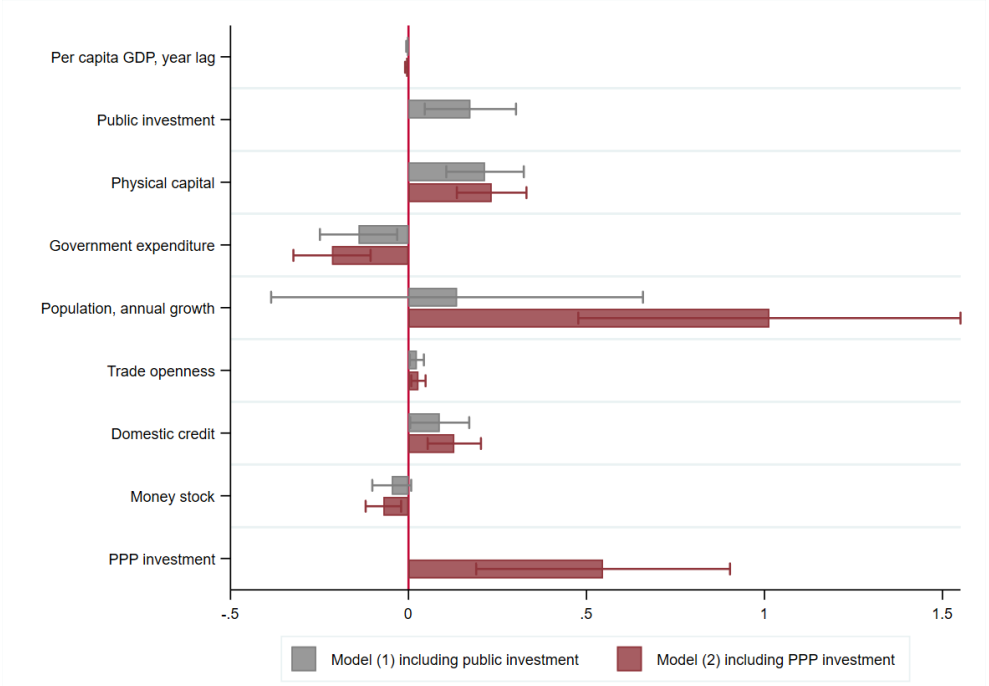

TABLE 4. Descriptive statistics of variables

Variables	Nb. Obs	Mean	Std.Dev	Min	Max
Growth in GDP per capita	392	0.95	4.26	-22.31	21.03
Per capita GDP, year's lag	378	1723.68	2432.38	272.99	11949.28
Pure public investment	392	4.46	3.19	0.16	26.34
PPP investment	392	0.49	1.17	0.00	10.13
Private capital	392	21.00	9.53	-2.42	77.89
Trade openness	392	64.82	24.82	20.72	156.86
Money stock	387	21.73	7.69	8.68	56.41
Population, annual growth	392	2.71	0.54	-0.44	4.63
Government expenditure	392	12.37	4.28	0.91	27.74
Domestic credit	387	12.24	7.10	1.60	41.16
Central government debt	391	63.41	42.52	7.28	270.18

TABLE 5. PPPs investment ratio to Pure public investment in 14 SSA countries, 90 – 2017

Country	Pure public investment (% of GDP)	PPP investment (% of GDP)	Ratio of PPP investment to Public investment (%)
Benin	4,73	0,46	10,98
Burkina Faso	6,48	0,18	2,90
Cameroon	3,32	0,15	7,27
Congo, Rep.	8,82	0,45	8,85
Cote d'Ivoire	3,84	0,56	18,15
Gabon	3,97	0,45	13,71
Gambia, The	5,62	1,62	38,27
Ghana	3,62	0,54	15,64
Guinea	3,21	0,23	5,13
Mali	3,49	0,10	2,56
Nigeria	2,75	0,12	5,08
Senegal	4,63	0,58	10,75
Sierra Leone	3,19	0,11	2,25
Togo	4,79	1,30	34,66

TABLE 6. Definitions and sources of variables

Variable	**Unit of measurement**	**Definition**	**Sources**
GDP per capita growth	Growth rate of real GDP per capita in %	Annual percentage growth rate of GDP per capita	World Development Indicators, Updated: 02/17/2021
Initial real GDP per capita	One year lag of real GDP per capita	GDP per capita is gross domestic product divided by midyear population.	
Pure public investment	GFCF (public) in % of GPD	General government investment (gross fixed capital formation), in billions of constant 2011 international dollars.	IMF Investment and Capital Stock Dataset, 2019
PPP investment	PPP investment in % of GDP	Public-private Partnerships (PPP) investment, in billions of constant 2011 international dollars.	
Physical capital	Gross Capital Formation in % of GDP	Gross capital formation (formerly gross domestic investment) in % of GDP	
Government expenditure	Government consumption in % of GDP	General government final consumption expenditure (formerly general government consumption) in % of GDP	
Population	Population, growth rate	Annual population growth rate , expressed as a percentage	
Trade openness	Trade (exports + imports) divided by GDP	Trade is the sum of exports and imports of goods and services measured as a share of GDP.	World Development Indicators, Updated: 02/17/2021
Domestic credit	Ratio of domestic credit to GDP	Financial resources provided to the private sector, expresses as a % of GDP	
Money Stock	Money supply M2/GDP	Broad money is the sum of currency outside banks includes notes and coins but also saving accounts and deposits in a savings account.	
Public debt	Ratio debt (central government) to GDP	Central government debt expressed as % of GDP	IMF Global Debt Database (GDD), December 2019