Institutions and public investment as a fiscal stimulus

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April 20, 2015

Abstract

This paper examines the role of institutions in the effects of public investment as a fiscal stimulus. Empirical evidence suggests that when institutions protect the general public from government expropriation better, public investment has significantly larger output-promoting effects, particularly in the medium run (about a 5 years horizon). To interpret this finding, we build a dynamic general equilibrium model, where government officials expropriate rents from private agents for their personal consumption. Theory indicates that, to the extent that public capital complements private capital, stronger property rights of private agents yield a larger medium-run output effect of public investment. Complementarity matters, because, in the situation where well-protected property rights ensure the initially-abundant provision of private capital, the additional formation of public capital has strong output-promoting effects, only when it complements existing private capital.

Keywords: Public investment, Fiscal stimulus, Institutions, Property rights, Substitutability between public and private capital

JEL: E62, H54, O43

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1 Introduction

The widespread use of fiscal expansion to tackle the 2007-09 financial crisis and the subsequent shift to fiscal austerity have hugely revived the debate on the determinants of fiscal multipliers, both from theoretical and empirical perspectives. A large number of theoretical works indicate various key mechanisms through which the multiplier is affected, including the type of spending and its financing source, whether the initial shock is anticipated or not, and interactions with monetary policy conducts.\(^1\) Meanwhile, empirical works also have contributed to the debate, by estimating the roles of several potential determinants of the multiplier, such as exchange rate schemes, the degree of openness to trade, and the state of public finances, both in the short run and medium run.\(^2\)

However, the literature on fiscal multipliers tends to overlook the potential role of institutions, generally defined as the rules and organizations of a society which shape the incentives of different economic agents. In contrast, in the literature on long-run economic growth/development, institutions are often given central attention, including early seminal works such as Hall and Jones (1999) and Acemoglu et al. (2001). For instance, Acemoglu and Johnson (2005) show that the worsening of institutions which protect the general public against expropriation by the government and elites has adverse effects on long-run growth, by discouraging general public from accumulating capital.\(^3\) Intuitively, however, this type of institutions may also affect the output responses to fiscal policy over a shorter time horizon. For example, while public investment, and the subsequent accumulation of public capital, has potentially critical effects on the optimal use of private capital by profit-maximizing firms, the degree to which property rights of private investors are protected may affect their willingness to invest, and thus private capital formation, even in the medium run.

\(^1\)Examples include Uhlig (2010), Drautzburg and Uhlig (2011), Leeper et al. (2010), Cogan et al. (2010), and Leeper et al. (2011).

\(^2\)Some of the recent works are Corsetti et al. (2012), Auerbach and Gorodnichenko (2012), Born et al. (2013), Ilzetzki et al. (2013), Riera-Crichton et al. (2015).

\(^3\)Denoting this type of institutions as “property rights institutions”, they emphasized its particular relevance in the development context, rather than the other type of institutions, denoted “contracting institutions”, which facilitate private contracts between citizens.
This paper explores this possibility of institutions as a potential determinant of short- and medium-run output effects of fiscal policy, particularly public investment spending. For this purpose, we first examine the empirical relevance of institutions in the effects of public investment. Specifically, based on Corsetti et al. (2012), we first extract public investment “shocks”, by estimating a type of fiscal rule for public investment, country by country, and regarding the residual as shocks. When formulating the fiscal rule, our key assumption is that public investment spending decisions are largely made in the past, rather than contemporaneously, reflecting the commonly-observed implementation delay in this type of spending. In the second step, we conduct fixed-effects panel regressions, to estimate the short- and medium-run effects of these shocks on output, conditional on the quality of institutions. Our measures of institutional quality, particularly in terms of the degree of property rights protection, are “executive constraints” and “democracy/autocracy” from Polity IV. The former proxies the degree to which government officials are constrained, while the latter, more broadly, also reflects the extent to which citizens’ political participation is guaranteed. The second-step analyses, based on 48 countries with the average of about 28 observations per country, suggest that under better property rights protection, a rise in public investment spending increases output more significantly, particularly in the medium run.

Next, to shed light on how institutions may affect the output effects of public investment, we build a parsimonious dynamic general equilibrium model. In particular, to mimic imperfect property rights protection of general public, the model assumes that government officials expropriate rents from private agents for their personal consumption, discouraging private capital accumulation. Further, to explore the potentially critical role of the interaction between public and private capital, we use a constant elasticity of substitution (CES) production function with these types of capital, enabling us to consider different degrees of substitutability/complementarity between them. We show that, as long as public and private capital are complementary to each other, stronger property rights protection of private

\[ \text{Baier and Glomm (2001) theoretically illustrate the critical relevance of public-private capital interactions in the fiscal policy-growth nexus.} \]
agents yields the larger output effect of public investment in the medium run. Intuitively, while better-protected property rights indicate the initially-abundant provision of private capital, the additional formation of public capital is productive, when it complements the existing private capital. However, if the public capital formation is substitute (i.e., similar to private capital), it simply blends into the abundantly-provided private capital, with little productivity gain. For example, if a government builds a new road or bridge in the abundant presence of privately-owned tracks, this addition of public capital has a significant output-promoting effect, whereas if it provides a track of a different color, it hardly promotes output. Thus, our theoretical analysis suggests one possible explanation to the above empirical finding, provided that public capital is generally complementary to private capital.

As mentioned, this paper links two distinct strands of the economic literature, one on fiscal multipliers and another on institutions. Regarding the former, given the focus on public investment as a fiscal stimulus, this work is closely related to Leeper et al. (2010). Bearing the post-crisis US public investment policies in mind, they clarify the roles of implementation delays for building public capital and expected adjustments to deficit-financed spending in the size of public investment multipliers. Turning to the latter (equally vast) literature on institutions, a number of empirical works highlight the role of institutions in the public investment-development nexus. For instance, Keefer and Knack (2007) find that the level of public investment spending increases in the worsening of institutional quality, suggesting that this type of spending may be unproductive in countries where institutions prompt government officials to seek for private rents. Further, Cavallo and Daude (2011) show that, while public investment contemporaneously crowds out private investment in developing countries, this effect is mitigated in countries with better institutions.

Other works considering the effect of public investment include Drautzburg and Uhlig (2011). Note, however, that the majority of works on fiscal multipliers rather focus on “unproductive” government spending, which does not directly affect firms’ production.

They explain this contemporaneous effect of public investment on private investment, by referring to the possibility that the announcement of public investment projects is made to the (potentially forward-looking) private sector well before the actual implementation and spending.
The remainder of the paper is structured as follows. Section 2 empirically investigates the role of institutions in the output effects of public investment. Then, Section 3 conducts theoretical analyses, shedding light on the empirical results. Lastly, Section 4 presents concluding remarks.

2 Empirical analysis

Is there any evidence suggesting that institutions may actually matter as a determinant of output effects of public investment, in the short- and medium-run? We investigate this question, using a variant of the two-step approach taken by Corsetti et al. (2012), who examine various economic environments as possible determinants of public consumption spending multipliers.\(^7\) In the first step, we estimate a simple fiscal rule for public investment, country by country, and interpret the residuals as a public investment shock. Then, in the second step, we analyze the effects of this shock on output, conditional on the quality of institutions, using fixed effects panel regressions.

2.1 Identifying public investment spending shocks

To formulate the first-stage regressions, our basic assumption is that public investment spending decisions are largely determined in the past, rather than contemporaneously. This assumption is based on the reality that public investment decision often follows a long process of project appraisal, selection, and implementation, while the implementation stage itself can sometimes last over a few years, even after the project selection is finalized.\(^8\) Specifically, we

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\(^7\) Specifically, they consider the exchange rate regimes, the state of public finances, and the occurrence of a financial crisis, as conditioning factors of the multipliers.

\(^8\) Dabla-Norris et al. (2012) discuss the details of different phases of public investment (appraisal, selection, implementation, and evaluation), while assessing the quality of each phase, country by country. Leeper et al. (2010) document the implementation delay of the public investment project in the US after the recent financial crisis of 2007-09.
assume that the following fiscal rule for public investment:

\[ \text{pubinv}_{i,t} = \phi_i + \eta_i \text{trend}_t + \sum_{j=1}^{m} \beta_{i,j} \text{pubinv}_{i,t-j} + \sum_{j=1}^{m} \lambda_{i,j} \text{debt}_{i,t-j} + \sum_{j=1}^{m} \theta_{i,j} y_{i,t-j} + \mu_i E_{i,t-1}(y_{i,t}) + \epsilon_{i,t}, \]  

(1)

where in the left hand side (LHS), \( \text{pubinv}_{i,t} \) is log of public investment per capita in country \( i \) in year \( t \). (All the data sources are described in Appendix A.) Turning to the right hand side (RHS), \( \text{trend}_t \) is a linear trend, accounting for the often-observed downward trend in this type of spending across a wide range of countries. The RHS also includes the lagged dependent variables, \( \text{pubinv}_{i,t-j} \), acknowledging that investment spending may persist, possibly due to the prolonged implementation of public investment. Next, we include public debt (relative to GDP) at the end of year \( t-j \), \( \text{debt}_{i,t-j} \), which reflects the states of public finances, and is expected to have a bearing on public investment. Also, \( y_{i,t-j} \), the lags of log of real GDP per capita, a proxy of past economic conditions, may affect the level of public investment in year \( t \). Lastly, the expectation of real GDP per capita in year \( t \), based on the information available in the previous year, \( E_{i,t-1}(y_{i,t}) \), is considered, as a proxy for the government’s pre-budget expectation of the economic situation next year. Note that the absence of contemporaneous interdependence between public investment and its determinants in Eq.1 is consistent not only with the long-lasting investment procedure, but also with the general lack of automatic components in public investment linked to output.\(^9\)

Turning to the actual implementation, we estimate the first difference of Eq. 1 from the lagged equation:

\[ \Delta \text{pubinv}_{i,t} = \eta_i + \sum_{j=1}^{m} \beta_{i,j} \Delta \text{pubinv}_{i,t-j} + \sum_{j=1}^{m} \lambda_{i,j} \text{def}_{i,t-j} + \sum_{j=1}^{m} \theta_{i,j} g_{i,t-j} + \mu_i E_{i,t-1}(g_{i,t}) + \nu_{i,t}, \]  

(2)

where \( \Delta \text{pubinv}_{i,t} \) is a change in log of public investment per capita between year \( t-1 \) and \( t \) in country \( i \), multiplied by the public investment share of GDP in period \( t-1 \) (to ease the comparison with the change in output in the second stage regressions); \( \text{def}_{i,t-j} \) is the

\(^9\)In public consumption spending, components such as unemployment benefits are linked to output.
budget deficit (relative to GDP) in year \( t - j \); \( g_{i,t-j} \) is the growth rate of real GDP per capita between year \( t - (j + 1) \) and \( t - j \); \( E_{i,t-1} (g_{i,t}) \) is the expected growth rate between year \( t - 1 \) and \( t \), based on the information available in year \( t - 1 \). The advantage of considering the first difference of Eq. 1 is that we can work with budget deficits, whose availability tends to be greater than for the public debt, particularly for developing countries. Additionally, estimating Eq. 1 in first-differences, we avoid potential problems of spurious regressions when public investment is not stationary.

We estimate Eq. 2 for each country separately, as long as it provides at least 20 observations, and regard the residuals as public investment spending shocks. Specifically, we take the following implementation procedure. For each country, whenever possible, we estimate Eq. 2 for different number of lags, i.e., two and three \((m = 2 \text{ and } 3)\), and with and without the forecast of growth rate of GDP, \( E_{i,t-1}(g_{i,t}) \).\(^{10}\) Then, we regard the residuals as shocks, only when explanatory variables are jointly significant (at 10 percent level). We consider different number of lags, because explanatory variables are not necessarily significant for both of the lag numbers. Besides, we examine the case with and without the forecast variable, because this variable, particularly scarce for developing countries, is sometimes not available (for the required 20 years). In case explanatory variables are significant for multiple cases, we pick the shocks obtained from the equation with 2 lags and with the forecast variable included. Overall, we obtain (at least) 20 public investment shocks for 48 countries for the second step regressions, with the average of 28.1 observations per country.\(^{11}\) For brevity, the first regression results are not presented (they are available upon request).

\(^{10}\)We examine the cases when the number of lag are two and three, but not one, to ensure that the delayed implementation process in public investment is taken into account.

\(^{11}\)To note, if we do not drop the countries for which explanatory variables are jointly insignificant, 70 countries are available, with at least 20 observations per country. However, we dropped the 22 countries, to focus on the cases where the given fiscal rules are valid.
2.2 Role of institutions in the output effects of public investment

In the second step, we examine the role of institutions in the output effects of public investment shocks, both in the short- and medium-run. Specifically, we use fixed-effects panel regressions, where public investment shocks are interacted with institutional proxies:

\[
\Delta y_{i,t+k} = \delta_i^k + \zeta_t^k + \lambda^k \Delta \text{exopubinv}_{i,t} + \rho^k \Delta \text{exopubinv}_{i,t} \ast \text{inst}_{i,t} + \sigma^k \text{inst}_{i,t} + \nu_{i,t}^k,
\]  

(3)

where \(\Delta y_{i,t+k}\) represents the change in log of output per capita between year \(t+k\) and \(t-1\), \(y_{i,t+k} - y_{i,t-1}\). In the RHS, \(\Delta \text{exopubinv}_{i,t}\) is the residual obtained in the first stage, public investment shocks from year \(t-1\) to \(t\), interacted with the proxy for institutional quality in year \(t\), \(\text{inst}_{i,t}\). One of the proxies we examine is “executive constraints” ("constraints", for short) from Polity IV, which measures the degree of institutionalized constraints on the decision making powers of chief executives.\(^{12}\) Assuming that the degrees of constraints on executives and political officeholders are likely to be correlated, we regard this variable as a proxy for the constraints on a government, which, in turn, is related to the degree to which general public is protected from government’s expropriating behavior. The second proxy is “democracy/autocracy” (“democracy”, for short), also from Polity IV, reflecting not only the previous measure of “constraints”, but also other democratic elements such as the degree to which citizens’ political participation is guaranteed.\(^{13}\) Our reasoning of using this broad measure is that freedom of citizens to pursue alternative political preferences clearly constrains politicians’ irresponsible behavior. Lastly, we also include unobserved country-fixed effects, \(\delta_i^k\), as well as time dummies, \(\zeta_t^k\), capturing international shocks.

**Unconditional effects** Before highlighting the role of institutions in the output effects of public investment, we examine their unconditional effects. Figure 1 reports the output responses to investment shocks over time together with 90% confidence intervals, covering

\(^{12}\)The variable name in Polity IV is “XCONST”.

\(^{13}\)The official name of this measure in Polity IV is “POLITY2”.

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all the 48 countries. (The corresponding regression results are in Table 1 in Appendix B.) Output effects measure the size of multiplier, i.e., a rise in output in dollars in response to one dollar rise in spending. Notice that the output effect of public investment is significantly positive throughout, including the contemporaneous effects ($k = 0$), as well as delayed effects ($k > 0$). In terms of the quantitative effects, the contemporaneous multiplier is less than unity, whereas it appears to increase towards the medium run, peaking around after 5 years ($k = 5$).

**Role of institutions**  Next, we examine how the quality of institutions affect the output responses to public investment shocks. First, notice from Eq. 3 that the marginal effect of public investment shocks between year $t−1$ and $t$ on output between $t−1$ and $t+k$ is given as:

\[
\frac{\partial (\Delta y_{i,t+k})}{\partial (\Delta exopubinv_{i,t})} = \lambda^k + \rho^k inst_{i,t}. \tag{4}
\]
Figure 2: Output effect of public investment across time: role of institutions

Figure 2, using “democracy” as a proxy for institutions, inst_{i,t} (in ascending order of quality between −10 and 10), reports the output responses to investment shocks over time, for the cases with low- and high-quality institutions. The low institutional quality is defined as inst_{i,t} = −1.3, the mean of its country average values (= 5.0) minus its standard deviation (= 6.3), while the high quality simply is inst = 10. (The baseline regression results are in Table 2 in Appendix B.) Observe that the contemporaneous effects (k = 0), statistically significant in both cases, are similar in their magnitude, whereas the effects under high-quality institutions become much higher towards the medium run. For instance, in 5 years after the shock, the multiplier under high (low)-quality institutions is above (below) 1.5 (1). This observation corresponds to the fact that the interaction terms are significantly positive for k = 3, 4, and 5 (see Table 2).

Lastly, to highlight the role of institutions in the output effects in the short (k = 0) and medium run (k = 5), Figure 3 describes how those effects differ across the institutional quality. Consistent with Figure 2, the short-run effects are significant across the levels of
institutions, although qualitatively, the effects do not differ much. Turning to the medium run, however, while under low-level institutions, the effects can be insignificant, they are rapidly increasing in the institutional quality. Further, we report that all the above results essentially hold, even when we use “constraints” as a proxy.\footnote{All the results are available from the author upon request.}

3 Theoretical Analysis

To give a possible interpretation to the above empirical finding on the role of institutions in the output effects of public investment, we construct a simple dynamic general equilibrium model. It is a closed economy model with households, firms, and a government, where a representative firm produces homogeneous goods, using a CES aggregate of private and public capital, as well as labor. The model is entirely real, with goods consumed by households, and also used for investment both by households and the government. A government collects lump-sum taxes to finance public investment. To motivate institutions which may not pro-
tect private agents’ property rights, we assume that a part of the profits made by firms, and also by households (as investors), are expropriated and then wasted by government officials. Using this parsimonious setup, we analyze how institutional quality, proxied by the degree of property rights protection, may play a role in public investment multipliers.

3.1 Framework

Households A representative household has the following utility function

\[ U_t = \sum_{t=0}^{\infty} \beta^t \left[ \log C_t - \frac{\mu}{2} L_t^2 \right], \tag{5} \]

where the parameter \( \beta \) denotes the time preference, \( C_t \) is private consumption, and \( L_t \) is labor supply to firms. A rise in \( L_t \) reduces the flow utility, since it implies less time available for leisure. In turn, his/her budget constraint is given as:

\[ C_t + B_{t+1} + K_{t+1} + T_t + \frac{\lambda_1}{2} \left( \frac{I_t}{K_t} - \delta_1 \right)^2 K_t = w_t L_t + [r^K_t - \tau^K_t(r^K_t - \delta_1)] K_t \]
\[ + \Pi_t + (1 + r_t) B_t + (1 - \delta_1) K_t. \tag{6} \]

The right hand side (RHS) represents the resources available in period \( t \), where the first component, \( w_t L_t \) is labor income, with \( w_t \) denoting wage. Next, \( [r^K_t - \tau^K_t(r^K_t - \delta_1)] K_t \) is net income from renting private capital, \( K_t \), to firms, where \( r^K_t \) is the rental rate. Importantly, the proportion \( \tau^K \) of income (bar depreciation, \( \delta_1 K_t \)) is expropriated by government officials and then wasted, in the sense that it benefits neither households’ utility nor firms’ productivity. Because the higher value of \( \tau^K \), corresponding to larger expropriation, discourages private capital formation (as clarified below), we regard this parameter as a proxy for the degree of property rights protection in the economy.\(^{15}\)

The rest of the RHS of Eq. 6 comprises \( \Pi_t \), firms’ profit gain received by households as shareholders; \( (1 + r_t) B_t \), gross return from holding previous-period bonds, where \( r_t \) and

\(^{15}\)This way of modeling property rights protection is suggested, for instance, by Barro (2004).
$B_t$ are interest rates and bond holding; and $(1 - \delta_1)K_t$, undepreciated capital. Meanwhile, the left hand side (LHS) indicates that the revenue is spent on consumption, $C_t$; the new acquisition of bond, $B_{t+1}$ and private capital, $K_{t+1}$; lump-sum tax payment, $T_t$; and the capital adjustment costs, $\frac{\lambda_1}{2} \left( \frac{I_t}{K_t} - \delta_1 \right)^2 K_t$, where $I_t$ is private investment and $\lambda_1 > 0$. Last, note that this budget constraint entails the law of motion for the private capital stock:

$$K_{t+1} = I_t + (1 - \delta_1)K_t. \tag{7}$$

Solving the above representative household’s utility optimization problem yields:

$$C_{t+1} = \beta (1 + r_{t+1})C_t, \tag{8}$$

$$L_t = \frac{1}{\mu} \frac{1}{C_t} w_t, \tag{9}$$

$$1 + r_{t+1} = \frac{1 + (1 - \tau^k)(r_{t+1}^k - \delta_1) + \frac{\lambda_1}{2} \left( \frac{I_{t+1}}{K_{t+1}} - \delta_1 \right)^2 + \lambda_1 \left( \frac{I_{t+1}}{K_{t+1}} - \delta_1 \right)}{1 + \lambda_1 \left( \frac{I_t}{K_t} - \delta_1 \right)}. \tag{10}$$

Eqs. 8, 9, and 10 are the consumption Euler equation, the labor supply function, and the arbitrage relation between holding bonds and investing into physical capital, respectively. Notice that the RHS of Eq. 10 clarifies that the return from capital investment becomes smaller, as the degree of government expropriation becomes worse, i.e., $\tau^k$ becomes larger.

**Firms** A representative firm produces a homogeneous good, using private and public capital, as well as labor. The production follows the following technology:

$$Y_t = A_t \left[ \eta X_t^{1-\nu} + (1 - \eta)K_t^{1-\nu} \right] \frac{\alpha}{1-\alpha} L_t^{1-\alpha}, \tag{11}$$

where $0 < \eta < 1$ and $\nu \geq 0$ and $A_t$ is a productivity parameter, $X_t$ is public capital provided by a national government, which a firm takes as given, $K_t$ is private capital, and $L_t$ is labor. To enrich the interaction between public and private capital, we consider a constant elasticity
of substitution (CES) aggregate of these types of capital, where the degree of substitutability is represented by \(1 - \nu\). Larger values of \(\nu\) correspond to greater complementarity, with the limit of \(\nu\) being infinity in the Leontief case, whereas at the other end of \(\nu = 0\), public and private capital are perfect substitutes. Note that, when \(\nu\) approaches unity, the function converges to Cobb-Douglas.

As indicated, firms rent private capital accumulated by households, while employing them as workers. To further motivate the varying degree of property rights protection in the economy, we assume that a proportion, \(\tau_f\), of firms’ profits are also expropriated. In particular, \(\tau_f\) of firms’ earnings, \(Y_t - w_tL_t\), are taken and again wasted.\(^{16}\) Correspondingly, firms maximize the following profit function

\[
\Pi_t = (1 - \tau_f)(Y_t - w_tL_t) - r_t^kK_t. \tag{12}
\]

Solving this maximization problem gives

\[
w_t = (1 - \alpha) \left( \frac{Y_t}{L_t} \right), \tag{13}
\]

and

\[
r_t^k = (1 - \tau_f)\alpha \frac{(1 - \eta)K_t^{1-\nu}}{\eta X_t^{1-\nu} + (1 - \eta)K_t^{1-\nu}} \frac{Y_t}{K_t}. \tag{14}
\]

Notice that the latter indicates that the rental rate of capital is decreasing in the expropriation rate of firms’ earnings, \(\tau_f\), further discouraging households’ capital formation.

**Government** The government budget constraint is defined as:

\[
H_t + \frac{\lambda_2}{2} \left( \frac{H_t}{X_t} - \delta_2 \right)^2 X_t = T_t. \tag{15}
\]

\(^{16}\)We could instead assume that the proportion of firms’ gross earning, \(Y_t\) is expropriated. Yet, in this case, the wedge would be created between wage and marginal product of labor (cf. Eq. 13), as well as between rental rate and marginal product of private capital (cf. Eq. 14). However, since the wedge in the labor demand relation does not directly affect private capital formation, we assume that only the part of net earning bar wage is subject to government expropriation.
The RHS represents revenue from lump-sum taxes. In the LHS, the first term, $H_t$, is public investment, and the second, $\frac{\lambda_2}{2}(\frac{H_t}{X_t} - \delta_2)^2 X_t$, represents public capital adjustment costs, with $\lambda_2 > 0$. Relatedly, the law of motion for public capital is given as

$$X_{t+1} = H_t + (1 - \delta_2)X_t,$$

where $\delta_2$ denotes the depreciation rate of public capital. Focusing on the macroeconomic effects of public investment spending, we abstract from modeling public consumption, comprising items such as public wage payments and social security payments in reality.

**Equilibrium conditions** The goods market equilibrium condition is given as

$$Y_t = C_t + I_t + H_t + \frac{\lambda_1}{2} \left( \frac{I_t}{K_t} - \delta_1 \right)^2 K_t + \frac{\lambda_2}{2} \left( \frac{H_t}{X_t} - \delta_2 \right)^2 X_t + S_t,$$

where

$$S_t = \tau_f(Y_t - w_tL_t) + \tau_k(r_t^K - \delta_1)K_t.$$

Notice that the profits expropriated from private firms and households generate a wedge in Eq. 17, without benefiting households’ utility and firms’ productivity. To complete, regarding the private capital market, the demand is determined by firms’ capital demand function, Eq. 14, while the supply is predetermined by households’ investment decision in the previous period. Last, the labor market equilibrium is given at the intersection of Eqs. 13 and 9, the corresponding demand and supply relations, respectively.

### 3.2 Analysis

In what follows, we examine the short- and medium-run output effects of an unexpected change in public investment spending, conditional on the degree of property rights protection. We assume that prior to a change in public investment, the economy is in a steady state,
where the productivity is constant, i.e., $A_t = 1$ (for simplicity) and all the other variables are also constant. To proceed, we log-linearize the model about the steady state and then conduct numerical analyses.\footnote{To solve the dynamics of the model, we use the QZ decomposition proposed by \textit{Klein (2000)}.} (See Appendix C for the linearized system of equations.) Note that while the difficulty of obtaining closed-form solutions inevitably prompts us to proceed numerically, our prime objective is to formulate the key mechanisms through which property rights protection may affect the size of output effects of public investment in the short- and medium-run, rather than attempting to claim the quantitative realism of the results, including the size of multipliers.

\textbf{Parameter values} We first discuss parameter values used below. While many are rather conventional, it is worth discussing a few key parameters, including $\nu$, which determines the degree of substitutability/complementarity between between private and public capital, $1 - \nu$ (see Eq. 11). As indicated by Baier and Glomm (2001) in their analyses of the fiscal policy-growth nexus, the reported value of this parameter in the literature appears diverse.\footnote{Specifically, they point out that Nadiri and Mamuneas (1994) find a high degree of substitution, while Berndt and Hansson (1991) find its low degree. Based on this diversity, they consider the range of $\nu$ between 0.25 and 1.85.} For instance, Eden and Kraay (2014), estimating the effects of public investment on private investment and output for a sample of 39 low-income countries, report that the substitutability between public and private capital calibrated with the CES production function tends to be very low, around $\nu = 2.43$ for their reference case, and can be even lower, such as $\nu = 5$, when variations in their estimations are taken into account. On the other hand, Gupta et al. (2014), estimating the CES production function directly for a large number of low- and medium income countries, show that the substitutability could be rather high, $\nu = 0.16$, not statistically different from the Cobb-Douglas case of $\nu = 1$.\footnote{The strength of Eden and Kraay (2014) is that based on Kraay (2012), they extract the exogenous component of public investment using a unique instrument, namely, fluctuations in a predetermined component of disbursements on loans from official creditors to low-income country governments. Meanwhile, Gupta et al. (2014) have an advantage in that they explicitly incorporate the efficiency of public capital, following Dabla-Norris et al. (2012), which Eden and Kraay (2014) abstract from.} Acknowledging this apparently

\footnote{The strength of Eden and Kraay (2014) is that based on Kraay (2012), they extract the exogenous component of public investment using a unique instrument, namely, fluctuations in a predetermined component of disbursements on loans from official creditors to low-income country governments. Meanwhile, Gupta et al. (2014) have an advantage in that they explicitly incorporate the efficiency of public capital, following Dabla-Norris et al. (2012), which Eden and Kraay (2014) abstract from.}
non-conclusive nature of the degree of the substitutability, we examine values of both $\nu = 2.5$ and 0.5, with the former (latter) representing complementary (substitutable) case.

Likewise, there is no consensus regarding the value of $\eta$, another technology parameter in firms’ production function. Following Baier and Glomm (2001), we set this value as 0.3, implying the elasticity of output with respect to public capital is 0.105, for the Cobb-Douglas case of $\nu = 1$. This is similar to the value considered by other theoretical analyses such as Leeper et al. (2010) and Ganelli and Tervala (2010). Further, given that the public investment decision is treated as exogenous in the model, we set the steady state share of government investment to output, $\gamma$, as 0.05 (5%), similar to our sample average in the above empirical analysis. Lastly, regarding the degree of a government’s expropriation of private agents’ profits, i.e., $\tau_k$ and $\tau_f$, we again consider different values. Specifically, assuming $\tau_k = \tau_f = \tau$ for simplicity, we experiment with the values of 0.01 and 0.5, where the former corresponds to the virtually perfect property rights protection, while the latter indicates severe expropriation of private agents’ profits. All the other parameter values are summarized in Appendix D.

Impulse responses and interpretations  We now examine how output responds to an unanticipated rise in public investment both in the short- and medium run. In the impulse responses below, one period represents a quarter. To illustrate, we consider a rise in the spending by 10 percent from its initial steady state level (corresponding to the rise of 0.5% of output), which then follows AR(1) process with the persistence coefficient of 0.8. Specifically, Figure 4 examines the complementary ($\nu = 2.5$) and substitutable ($\nu = 0.5$) cases. For both cases, high property rights protection, $\tau = 0.01$, and low protection, $\tau = 0.5$ are considered, with the former represented by solid line, and the latter by dashed line. The figure shows that while output effects are generally larger when public and private capital are complementary, the degree of property rights protection plays a different role depending on whether they

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20 Both consider the values of 0.05 and 0.1. (However, they do not consider the CES production function with public and private capital.)
are complementary or substitutable. Specifically, when they are complements, the better protection yields the generally larger response of output (except for the impact), whereas when substitutable, the worse protection corresponds to the larger effects.

Figure 4: Output responses: solid (dotted) lines for high (low)-quality institutions

![Graph showing output responses](image)

To consider these different output responses to public investment, Figure 5 examines the evolution of each input, i.e., private and public capital and labor, individually. First, the sub-figures in the third row clarify that, since the shock process to public investment is identical by assumption, the evolution of public capital is the same regardless of the degrees of substitutability and property rights. Second, as the first row shows, when the two types of capital are complements (substitutes), private capital is accumulated (decumulated) over time, because complementary (substitutable) public investment tends to crowd in (out) private investment.\(^{21}\) However, regardless of the substitutability level, poorly-protected property rights tend to reduce capital accumulation, since private investors, anticipating the future

\(^{21}\)The immediate fall in private capital, even in the complementary case, corresponds to households' consumption smoothing behavior in the face of the tax increase to finance public investment.
expropriation of profits, refrain from investment. Third, labor generally jumps (and leisure plunges) at the moment public investment rises, because a rise in the tax (to finance public investment) decreases households’ disposable income. However, again, regardless of the substitutability, labor tends to rise more under the low property protection case, because the larger profit expropriation reduces households’ life-time disposable income more.

Then, what explains the different roles of property rights in the output effects of public investment across the levels of substitutability between public and private capital? In particular, why does the better protection yield the larger medium-run output effect only when they are complements? To understand this, it is useful to highlight the marginal product of public capital in the initial steady state, $\alpha \Gamma_1 Y/X$, where $\Gamma_1 = \frac{\eta}{\eta + (1 - \eta)(K/X)^{1-\nu}}$. Critically, while better property rights protection affects the marginal product by raising the steady-state provision of private capital relative to public capital, $K/X$, how this affects
the marginal product depends on the size of $\nu$.\footnote{Note that the inverse of public capital share in output, $Y/X$, is common by construction. With the calibrated public investment share of 0.05, $Y/X = 2$.} Specifically, when $\nu > 1$ (i.e., complementary case), higher $K/X$ corresponds to higher marginal product, whereas when $\nu < 1$ (i.e., substitutable case), it lowers marginal product. That is, when public and private capital are complements (e.g., roads/bridges and tracks, respectively), better property rights, corresponding to the initially-abundant private capital, imply that a given rise in public investment has a larger output-promoting effect, than the case with initially-scarce private capital provision under poorer protection. Meanwhile, however, when they are substitutes (e.g., tracks and tracks, of different colors), the initially ample provision of private capital under high property rights protection means that an extra unit of public capital does not increase output as much as the case with initially-scarce private capital.

Figure 6: Cumulative multipliers: solid (dotted) lines for high (low)-quality institutions

Lastly, to complement the above analyses, we consider the cumulative output effects of public investment as in Mountford and Uhlig (2009) and Leeper et al. (2010). The cumulative
multiplier at a given point in time \( k \) is defined as

\[
\sum_{i=1}^{k} r^{-i+1} \Delta Y_i \\
\sum_{i=1}^{k} r^{-i+1} \Delta H_i
\]

where \( r \) is the steady state gross real interest rate (i.e., the inverse of discount factor) and \( \Delta Y_i \) and \( \Delta H_i \) are deviations of output and public investment in levels from the respective steady state values. Figure 6, again for the complementary and substitutable cases with different degrees of property rights protection (solid and dotted lines represent near-perfect and imperfect protection, respectively), shows that the cumulative multiplier becomes larger over time, while they tend to be generally larger under the complementary case.\(^{23}\) As pointed out by Leeper et al. (2010) based on their simulation results, this increasing pattern of public investment multiplier over time is quite different from the pattern of the public consumption multiplier, with which its size is often highest at the impact. More importantly, however, consistent with Figure 4, the multiplier under better property rights protection is larger only when public and private capital are complements, while the opposite is observed when they are substitutes.

4 Concluding Remarks

This paper examined the role of institutions in the output effects of public investment as a fiscal stimulus. Our empirical analysis suggested that institutions may matter particularly in the medium run (about a 5 years horizon). Specifically, only when institutions protect private agents from expropriation by a government, the medium-run output effects of public investment is significantly positive. Meanwhile, theory highlighted the importance of the substitutability/complementarity between public and private capital, regarding the

\(^{23}\)As noted above, we are not claiming the quantitative realism regarding the size of cumulative multipliers obtained here. For instance, while the medium-run multipliers go well beyond two particularly in the complementary case, different factors can lower these multipliers in reality, including the use of distortionary taxes, instead of lump-sum taxes, to finance public investment.
role of institutions in the medium-run output effects of public investment. The degree of substitutability matters, because, while high property rights protection implies the initially-abundant provision of private capital, the additional formation of public capital has a significant output-promoting effect only when it complements existing private capital. Thus, one theoretical indication is that the empirical finding on the role of institutions in the medium-run output effects of public investment may be driven by the types of investment particularly complementary to private capital, such as investment into roads/bridges/airports.
Appendix

A Data sources

Real GDP per capita and nominal GDP are taken from the World Economic Outlook (WEO) database of the International Monetary Fund (IMF). The growth rate of GDP is obtained as the log difference of real GDP per capita over 1 or 5 years. The WEO is also the main source for public investment, private investment, budget deficit/surplus, and real GDP growth forecasts/estimates.

Given the relative scarcity of public finance and private investment (and consumption) data in the WEO, especially for earlier years, other databases were used in a complementary manner. That is, when an alternative database provided more years of observations of a specific variable for a given country, that database was used instead of the WEO for that country and variable pair. The alternative databases used were the World Development Indicators (WDI) of the World Bank, the OECD Economic Outlook database, and the European Commission’s AMECO database.

The same procedure was adopted for the expected growth rate of GDP. The May forecast of the WEO in year t was used as the main source of the expected growth rate of real GDP for year t+1. If the WEO May forecast was missing, but the October forecast (also in year t) was available, the latter was used instead. In the absence of WEO forecasts, the December OECD Economic Outlook forecasts were used. Finally, if no forecast data was available, year t+1 estimates were used in the following order of preference: 1) WEO May estimate; 2) WEO October estimate; and 3) OECD December estimate.

Turning to the institutional variables, the government accountability proxies of executive constraints and democracy/autocracy are from Polity IV (Marshall et al. (2013)).
B Supplementary regression results

Table 1: Public investment and output: unconditional effects

<table>
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<tr>
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<th>(1)</th>
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<th>(4)</th>
<th>(5)</th>
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<tr>
<td>$\Delta y_{i,t+0}$</td>
<td>$0.757^{***}$</td>
<td>$0.963^{***}$</td>
<td>$0.804^{***}$</td>
<td>$0.858^{***}$</td>
<td>$0.921^{***}$</td>
<td>$1.094^{***}$</td>
<td>$0.791^{**}$</td>
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<td>$0.937^{***}$</td>
<td>$0.735^{***}$</td>
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<td>$0.767^{***}$</td>
<td>$0.892^{***}$</td>
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<td>$0.0746^{**}$</td>
<td>$0.0475$</td>
</tr>
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</table>

Notes: Fixed effects estimations. Constant and time dummies are not shown for brevity. Robust t-statistics are in parentheses. 
*** p < 0.01, ** p < 0.05, * p < 0.1.

Table 2: Public investment and output: role of institutions

<table>
<thead>
<tr>
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<td>$0.791^{**}$</td>
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<td>$0.718^{***}$</td>
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</tr>
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<td>$0.892^{***}$</td>
<td>$1.094^{***}$</td>
</tr>
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<td>$\Delta y_{i,t+3}$</td>
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<td>$0.0260$</td>
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<td>$0.0683^{**}$</td>
<td>$0.0746^{**}$</td>
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</tr>
<tr>
<td>$\Delta y_{i,t+4}$</td>
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<td>$0.0683^{**}$</td>
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<td>$0.0475$</td>
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<tr>
<td>$\Delta y_{i,t+6}$</td>
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<td>$0.0786^{**}$</td>
<td>$0.0683^{**}$</td>
<td>$0.0746^{**}$</td>
<td>$0.0475$</td>
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</tbody>
</table>

Notes: Fixed effects estimations. Constant and time dummies are not shown for brevity. Robust t-statistics are in parentheses. 
*** p < 0.01, ** p < 0.05, * p < 0.1.

C Linearized system

In the equations below, any variable with hat notation is defined as the log deviation from its steady-state value. Eq. 20 indicates (representative) firms’ production technology, while Eqs. 21 and 22 are their demand functions for labor and capital. Eq. 23 is the consumption Euler equation, with the asset-holding arbitrage relation, Eq. 10 incorporated, whereas Eq.
24 is labor supply relation. Next, Eqs. 25 and 26 are the laws of motion for private and public capital. Lastly, while Eq. 27 is the goods market equilibrium condition, Eq. 28 represents the waste through government expropriation.

\[
\hat{Y}_t = \hat{A}_t + (1 - \alpha)\hat{L}_t + \alpha \Gamma_1 \hat{X}_t + \alpha(1 - \Gamma_1)\hat{K}_t, \quad (20)
\]

\[
\hat{w}_t = \hat{Y}_t - \hat{L}_t, \quad (21)
\]

\[
\hat{r}^k_t = \hat{Y}_t - \hat{K}_t + (1 - \nu)\Gamma_1(\hat{K}_t - \hat{X}_t), \quad (22)
\]

\[
\hat{C}_{t+1} = \beta \left[ (1 - \tau^k) r^k_{t+1} + \lambda_1 \delta_1 (\hat{I}_{t+1} - \hat{K}_{t+1}) \right] - \lambda_1 \delta_1 (\hat{I}_t - \hat{K}_t) + \hat{C}_t, \quad (23)
\]

\[
\hat{L}_t = \hat{w}_t - \hat{C}_t, \quad (24)
\]

\[
\hat{K}_{t+1} = \delta_1 \hat{I}_t + (1 - \delta_1)\hat{K}_t, \quad (25)
\]

\[
\hat{X}_{t+1} = \delta_2 \hat{H}_t + (1 - \delta_2)\hat{X}_t, \quad (26)
\]

\[
\hat{Y}_t = \Gamma_2 \hat{C}_t + \Gamma_3 \hat{I}_t + \Gamma_4 \hat{H}_t + \Gamma_5 \hat{S}_t, \quad (27)
\]

\[
\hat{S}_t = \Gamma_6 \hat{Y}_t + \Gamma_7 (\hat{w}_t + \hat{L}_t) + \Gamma_8 (\hat{r}^k_t + \hat{K}_t) + \Gamma_9 \hat{K}_t, \quad (28)
\]

where \( r^k = \frac{1}{1 - \tau^k} \frac{1 - \beta}{\beta} + \delta_1 \); \( \Gamma_1 = \frac{\eta_1^{X_s}}{\eta_1^{X_s} + (1 - \eta_1^{K})^{1 - \nu}} \); \( \Gamma_2 = \frac{C}{Y} ; \Gamma_3 = \frac{L}{Y} ; \Gamma_4 = \frac{H}{Y} ; \Gamma_5 = \frac{S}{Y} ; \Gamma_6 = \tau_f \frac{Y}{S} ; \Gamma_7 = -\tau_f \frac{wL}{S} ; \Gamma_8 = \tau_k \frac{r^k K}{S} ; \Gamma_9 = -\tau_k \delta_1 \frac{K}{S} .

\[\text{D Parameter values}\]

Table 3 describes the parameter values considered in the simulation exercise above.
Table 3: Parameter values for numerical analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
<th>Description</th>
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<td>$\beta$</td>
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<td>Discount factor</td>
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<tr>
<td>$\mu$</td>
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<td>Weight on leisure in utility</td>
</tr>
<tr>
<td>$\alpha$</td>
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<td>Share of an aggregate of public and private capital in production</td>
</tr>
<tr>
<td>$\eta$</td>
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<td>Weight on public capital inputs</td>
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<tr>
<td>$\nu$</td>
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<td>Substitutability between private and public capital</td>
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<tr>
<td>$\tau_f \ (=\tau^k)$</td>
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<td>Property rights protection</td>
</tr>
<tr>
<td>$\gamma$</td>
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<td>Public investment/GDP in the steady state</td>
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<td>$\delta_1 \ (=\delta_2)$</td>
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</tr>
<tr>
<td>$\lambda_1 \ (=\lambda_2)$</td>
<td>5</td>
<td>Capital adjustment cost: private (private) capital</td>
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Acknowledgements

We thank Roberto Bonfatti, Campbell Leith, Neil Rankin, and Francisco Veiga for their comments. Any remaining errors are my own responsibility.
References


