How Big are Public Investment Multipliers?*

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Abstract

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1 Introduction

Ever since the Global Financial Crisis and as a consequence of the need to foster economic growth and the still high levels of global liquidity, there has been a major push for an "infraestructure"/public investment agenda around the world. In this paper we show both theoretically and empirically that such an agenda should not be of global/universal nature as the size of the public multiplier and its synergies with the private sector crutially depends upon the already existing stock of public capital. In countries with low levels of public capital, and based on simple first principle arguments, the marginal product of an additional unit of public investment is large and, therefore (coupled with synergies with private investment) delivers large public investment multipliers. On the contrary, when starting with high levels of public stock of capital, such an impact is small.

The paper proceeds as follows. Section 2 shows a very simple neoclassical type of model delivering the abovementioned theoretical results. Sections 3, 4, and 5 provide empirical evidence for a European sample of coutries, U.S. states, and Argentinean provinces using alternative identification strategies including Blanchard Perotti time identification, forecast errors, and instrumental variables approaches, respectively.

2 Government Consumption and Investment Multipliers in a Neoclassical Growth Model

In order to provide an analytical framework to explore the aggregate consequences to government consumption and investment shocks, in this section we describe a general equilibrium model used to compute fiscal multipliers. We follow closely the seminal work by Baxter and King (1993), who study the equilibrium effects of fiscal policy changes in the neoclassical growth model. Using alternative calibrations of the model, we analyze how the fiscal multipliers vary with the type of fiscal spending shock and the level of public capital of the economy. The first part of this section presents the ingredients of the model and the equilibrium conditions. The second part explains the calibration of the parameters used to compute the quantitative model simulations. Finally, the third part shows the responses of the alternative version of the model to temporary changes in government spending.

2.1 A Neoclassical Growth Model with Productive Public Capital

The economy is populated by a representative household with preferences over consumption and leisure. Formally, the intertemporal utility of the representative household is

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\log(C_t) + \psi \log(1 - L_t) \right) \right], \tag{1}$$

where $\mathbb{E}_0$ is the conditional expectations operator, C_t denotes consumption, L_t stands for the time devoted to work, and $\beta < 1$ corresponds to the discount factor. In the expression above, we have normalized the available time for households to 1, so that the amount of time devoted to leisure is given by $1 - L_t$. The household budget constraint in period t is given by:

$$C_t + I_t = R_t^K K_t + W_t L_t - T_t, \tag{2}$$

where W_t represents the real wage, R_t^K stands for the real rental rate of capital, K_t is the private capital stock, I_t is gross private investment, and T_t is net lump sum taxes. The stock of capital evolves according to the following law of motion:

$$K_{t+1} = (1 - \delta) K_t + \Phi \left(\frac{I_t}{K_t} \right) K_t \tag{3}$$

where δ is the depreciation rate and function $\Phi(\cdot)$ controls the adjustment costs for capital.

We consider a Cobb-Douglas production function technology:

$$Y_t = A \left(K_t \right)^{\alpha_K} \left(L_t \right)^{\alpha_L} \left(K_t^G \right)^{\alpha_G}. \tag{4}$$

In the technology above, K_t^G is the stock of public capital. Following Baxter and King (1993), we assume that the production technology has constant return to scale over private factors (K_t and L_t) , meaning that $\alpha_K + \alpha_L = 1$. Firms operating this technology rent private capital and labor from households to produce output. Consequently, the real wage and real rental rate of capital are equal to the marginal productivity of private capital and labor respectively:

$$W_t = \alpha_L \frac{Y_t}{L_t} \tag{5}$$

$$R_t^K = \alpha_K \frac{Y_t}{K_t} \tag{6}$$

Public capital evolves according to:

$$K_{t+1}^G = (1-\delta)K_t^G + I_t^G \tag{7}$$

where I_t^G denotes government investment. The government budget constraint is:

$$T_t = G_t + I_t^G \tag{8}$$

Government spending has two components: government consumption (G_t) and investment(I_t^G). We abstract from government debt since we assume that spending is financed via lump-sum taxation. Finally, we assume that both components of government spending follow AR(1) processes in logs:

$$\log(G_t) = (1-\rho_g)\log(\overline{G}) + \rho_g \log(G_{t-1}) + \varepsilon_{G,t} \tag{9}$$

$$\log(I_t^G) = (1-\rho_g)\log(\overline{I}^G) + \rho_g \log(I_{t-1}^G) + \varepsilon_{I^G,t} \tag{10}$$

where $\overline{G}$ and $\overline{I}^G$ are, respectively, the steady state levels for the government consumption and investment. $\varepsilon_{G,t}$ and $\varepsilon_{I^G,t}$ are iid shocks with zero mean to the government consumption and investment spending, and ρ_g controls the persistence of these shocks in different component of the fiscal spending.

A competitive equilibrium can be defined in a standard way as a sequence of allocations and prices such that satisfy the representative household and the firm optimality conditions, markets clear and the government budget constraint holds. The set of equilibrium conditions is given by

$$\psi \frac{C_t}{1-L_t} = \alpha_L \frac{Y_t}{L_t} \tag{11}$$

$$\frac{1}{C_t \Phi'(\frac{I_t}{K_t})} = \beta \mathbb{E}_t \left[\frac{1}{C_{t+1}} \left(\alpha_K \frac{Y_{t+1}}{K_{t+1}} + \frac{1}{\Phi'(\frac{I_{t+1}}{K_{t+1}})} \left(1 - \delta + \Phi(\frac{I_{t+1}}{K_{t+1}}) - \Phi'(\frac{I_{t+1}}{K_{t+1}}) \frac{I_{t+1}}{K_{t+1}} \right) \right) \right] \tag{12}$$

$$K_{t+1} = (1-\delta)K_t + \Phi\left(\frac{I_t}{K_t}\right) K_t \tag{13}$$

$$Y_t = C_t + I_t + I_t^G + G_t \tag{14}$$

$$Y_t = A\left(K_t\right)^{\alpha_K} \left(L_t\right)^{\alpha_L} \left(K_t^G\right)^{\alpha_G} \tag{15}$$

$$K_{t+1}^G = (1-\delta)K_t^G + I_t^G \tag{16}$$

Given the evolution of exogenous fiscal variables in (9) and (10) and the initial values

for private and public capital (K_0 and K_0^G), conditions (11)–(16) determine the equilibrium dynamics for C_t, L_t, Y_t, K_{t+1}, I_t, and K_{t+1}^G. In order to solve and compute numerical simulations with the model we present the calibration of the parameters in the next subsection.

2.2 Calibration

The baseline parameter values are given in table 1. Our calibration is mainly based on the parameters proposed by Baxter and King (1993), considering that the time frequency is quarterly. We use a value for the discount factor that implies a real interest rate of 4 percent in annual terms ($\beta = 0.99$). The depreciation rate is set at 10 percent in annual basis ($\delta = 0.10/4$). We assume that the capital and labor share in production are $\alpha_K = 0.30$ and $\alpha_L = 0.70$. We impose that $\alpha_G = 0.07$, which is close to the benchmark value set in Baxter and King (1993). The capital adjustment cost is modeled as:

$$\Phi(x) = (x - \phi_2(x - \delta)^2/2).$$

Using an elasticity of price of capital relative to the investment-capital ratio of 0.25, we set $\phi_2 = 0.25/(\delta) = 10.0$. See Table 1 for details.

INSERT TABLE 1 HERE

The steady state ratio of government consumption to GDP is set to 15 percent. We estimate the persistence of government consumption and investment and find that $\rho_g = 0.30$. The parameter for leisure utility, ψ, has a value that implies a labor supply at the steady state of $L = 0.2$. See Table 2 for details.

INSERT TABLE 2 HERE

Finally, for the steady state ratio of government investment to GDP, we assume three alternative values that imply different public capital-output ratios. Table 2 presents the distribution of the public capital to output ratio in a sample of European countries. These statistics are computed with the values at the initial of the sample and corresponds to the public capital-output ratio in annual terms. We calibrate the model to three different levels of public capital: the median (0.7), the 5th percentile (0.15), and the 95th percentile (1.25).

2.3 Government Consumption and Investment Multipliers

In this subsection, we use the model to compute the government consumption and investment multipliers. First, we compute the effects of a transitory increase in government consumption and investment for a model economy calibrated to the median value of the public capital-output ratio. Then, we repeat the same computation for the case of an economy with high public capital-output ratio. Finally, we obtain of the effects of the same fiscal shocks for an economy with a low public capital-output ratio. The model-based cumulative fiscal multipliers are computed in the same way as in the empirical estimation.[1]

Figure 1 shows the cumulative multipliers in the economy with the median value of the public capital-output ratio. We first consider a temporary increase in government consumption equivalent to one percent of GDP that decays according to the calibrated persistence of 0.3 (black line). Since this increase in government consumption is financed through lump-sum taxes, households experiences a reduction in their income and private consumption (panel B of figure 1). The fall in household's income also reduces leisure, resulting in an increase in labor supply. Private investment declines, reflecting the crowding out effects of the transitory increases in lump-sum taxes. Hence, GDP rises reflecting the dominant effect of higher labor supply, resulting in a cumulative fiscal multiplier close to 0.5. We then notice differences in the effects of a temporary increase in government investment (blue line in figure 1). In fact, GDP increases by more with a rise in government investment. In contrast to the government consumption changes, government investment directly improves the productive capacity of the economy, by shifting the marginal product of private capital and labor. In consequence, the fall in private consumption and investment is attenuated. These results are consistent with the empirical estimates for European countries that find public investment multipliers higher than government consumption multipliers.

INSERT FIGURE 1 HERE

Figure 2 presents the cumulative multipliers of government investment in economies with high and low public capital-output ratios. In this case, we observe a much larger multiplier on GDP with the economy has a low steady state public capital than when that level is high. These quantitative differences between fiscal multipliers in economies with high and low public capital resemble closely the empirical estimates for European countries. In an economy with a

[1] Cumulative fiscal multiplier in variable x_t in period t is measured as $\sum_{j=1}^{t} x_j / g_1$, where x_j is the response of variable x in period j in logarithmic terms to an initial fiscal shock of g_1. g_1 is expressed as percentage of GDP.

high level of public capital, we find that cumulative multiplier on GDP is less than one during the first two years. In contrast, in an economy with a low level of public capital, the cumulative multiplier on GDP is increasing and reaching a value around 2 after 8 quarters. Hence, the model simulation show that the private benefits of more public investment are magnified when the economy starts from a low level of public capital, generating a crowding-in effect in private consumption and investment over the medium-term. This reflects the fact that the return to private capital and household's income improve in economies with low public capital after some quarters following a transitory rise in government investment.

INSERT FIGURE 2 HERE

3 Empirical evidence for European countries

3.1 Countries

Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Iceland, Norway, Switzerland.

3.2 Sample

Quarterly Unbalanced Panel. 1987q1-2014q4

3.3 Identification of spending shocks - Blanchard-Perotti

In our basic linear specification, each response of percent changes in real gross domestic product to contemporaneous onset of percent changes in government expenditure at horizon h is obtained from the following equation:

$$\Delta \ln Y_{i,t+h} = \alpha_{i,h} + \beta_h \Delta \ln G_{i,t} + \psi_h(L)\Delta X_{i,t-1} + T + T^2 + \mu_{i,t,h} \tag{17}$$

where $\Delta \ln Y_{i,t+h} \equiv \ln Y_{i,t+h}$-$\ln Y_{i,t-1}$, represent the accumulated measure of real GDP at time $t+h$ and $\Delta \ln G_{i,t} \equiv \ln G_{i,t}$-$\ln G_{i,t-1}$ represents the contemporaneous change in the chosen component of the Government Expenditure growth at time t. $\Delta X_{i,t-1}$ represents a vector of lagged controls. We control for the dynamics of the system including a set of lags of the dependent and independent variables. Finally, we include a full set of country dummies and a quadratic time trend. Every equation for each h is estimated using a standard LSDV

approach. We use robust Driscoll and Kraay (1998) standard errors for our coefficients to correct for potential heteroskedasticity, autocorrelation in the lags and error correlation across panels.

Each component of the estimated vector β_h represents the step in the impulse response function at a forward time h and reads as the effect in the accumulated output growth of one percent increase in the accumulated government expenditure growth.

The typical multiplier discussed in the literature refers to the increase in real domestic currency units in output after a one-unit increase in real domestic currency government expenditure. To obtain this multiplier from our regressions we multiply expression 17 by the ratio G_h/Y_h.[2]

In order to account for the potential non-linearties along the stock of public capital in each country, we upgrade our Linear Projections methodology with the following specification:

$$\Delta \ln Y_{i,t+h} = \alpha_{i,h} + \beta_{1,h}\Delta \ln G_{i,t} + \beta_{2,h}\left(\Delta \ln G_{i,t} \cdot Stock_{i,0}\right) + \psi_h(L)\Delta X_{i,t-1} + T + T^2 + \mu_{i,t,h}, \tag{18}$$

where the variable $Stock_{i,0}$ represents the different measures of initial stock of public capital in each country deflated by GDP. The initial stock of capital as percent of GDP is measured as the average of the three years before our sample begins.

In this case the estimations of $\beta_{1,h} + \beta_{2,h} \cdot Stock_{i,0}$ serve directly as the steps in the impulse response functions for expansions and recessions respectively. We apply the same transformation as before to obtain the associated multiplier.

3.4 Empirical results

- Figure 3:
  Multiplier of total primary spending on output<1

- Figure 4:
  Effect of Figure 3 comes mainly via private consumption, not private investment (or exports or imports).

- Figure 5:
  Panel A: Multiplier of current primary spending on output<1
  Panel B. Multiplier of government investment on output>1 !

- Figure 6:
  The effect of Panel A in Figure 5 (i..e, Multiplier of current primary spending on

[2] We use the sample averages for G_h/Y_h.

output<1) mostly comes via small effect of private consumption, not private investment

- Figure 7:
  The effect of Panel B in Figure 5 (i..e, Multiplier of government investment on output>1) comes via both private consumption and private investment

- Figure 8:
  Like in the model, the multiplier of government investment on output does critically depend on the stock of public capital to GDP (i.e., Multiplier of Panel A<Multiplier of Panel B). Multiplier of Panel A≈0 and Multiplier of Panel B≈2 after two years (like in the model)

- Figure 9:
  The effect of Panel A in Figure 8 (i..e, Multiplier of government investment on output≈0) comes with no major reaction of any aggregate component of the demand.

- Figure 10:
  The effect of Panel B in Figure 8 (i..e, Multiplier of government investment on output≈2 after two years) comes from private consumption and, specially, from strong sinergies comeing from private investment

INSERT FIGURES 3 *to* 10 *HERE*

3.5 World map

Figure 11. Out of sample excersice; always with grain of salt. Currently working (as we speak) on a true global data. Worth noting that the range of the stock of public capital of the European countries cover about 90 percent of range of stock of public capital for the world.

INSERT FIGURE 11 *HERE*

For example, U.S. multiplier in the year 1960 was 0.37, in the year 1970 was 0.41, in the year 1980 was 0.55, in the year 1990 was 0.65, in the year 2000 was 0.75, in the year 2014 was 0.65. In recent times, close to one, but lower than one. As we will see, these averages hide important heterogeneity within U.S., across U.S. states (see Section 4).

For example, Argentina multiplier in the year 1960 was 1.6, in the year 1970 was 1.6, in the year 1980 was 1.5, in the year 1990 was 1.3, in the year 2000 was 1.5, in the year 2014

was 1.3. In recent times, close to one, but larger than one. As we will see, these averages hide important heterogeneity within Argentina, across Argentinean provinces (see Section 5).

4 Empirical evidence for United States states

4.1 U.S. states

All but Hawaii.

4.2 Sample

Yearly Unbalanced Panel. 1987-2016

4.3 Identification of spending shocks - Forecast errors

In our basic linear specification, each response of percent changes in real gross domestic product to contemporaneous onset of percent changes in government expenditure at horizon h is obtained from the following equation:

$$\Delta \ln Y_{i,t+h} = \alpha_{i,h} + \beta_h \Delta \ln G_{i,t}^{shock} + \psi_h(L)\Delta X_{i,t-1} + T + T^2 + \mu_{i,t,h}, \tag{19}$$

where $G_{i,t}^{shock} \equiv (G_{i,t}^{actual} - G_{i,t}^{anticipated})/Y_{i,t}$ represents the difference between the contemporaneous consolidated expenditure component in time t and the anticipated expenditure at time t calculated at time $t-1$. $\Delta X_{i,t-1}$ represents a vector of lagged controls. We control for the dynamics of the system including a lag of the dependent variable as well as a lag of the total consolidated government expenditure. Finally, we include a full set of state dummies and a quadratic time trend. Every equation for each h is estimated using a standard LSDV approach. We use robust Driscoll and Kraay (1998) standard errors for our coefficients to correct for potential heteroskedasticity, autocorrelation in the lags and error correlation across panels.

Each component of the estimated vector β_h represents the step in the impulse response function at a forward time h and reads as the effect in the accumulated output growth of one percent increase in the accumulated government expenditure growth. Since our expenditure shock is deflated by GDP, β_h also represents the typical multiplier discussed in the literature, i.e. an increase in real domestic currency units in output after a one-unit increase in real domestic currency government expenditure.

In order to account for the potential non-linearties along the stock of public capital in each country, we upgrade our Linear Projections methodology with the following specification:

$$\Delta \ln Y_{i,t+h} = \alpha_{i,h} + \beta_{1,h} \Delta \ln G^{shock}_{i,t} + \beta_{2,h} \left(\Delta \ln G^{shock}_{i,t} \cdot Stock_{i,0} \right) + \psi_h(L) \Delta X_{i,t-1} + T + T^2 + \mu_{i,t,h}, \tag{20}$$

where the variable $Stock_{i,0}$ represents the different measures of initial stock of public capital in each state deflated by GDP. The initial stock of capital is measured as the value in 1987, first year in our sample. In this case the estimations of $\beta_{1,h} + \beta_{2,h} \cdot Stock_{i,0}$ serve directly as the steps in the impulse response functions for expansions and recessions respectively. These steps can also be interpreted as the classical "multiplier."

4.4 Empirical results

Figure 12

INSERT FIGURE 12 HERE

4.5 U.S. map

Figure 13. Currently working (as we speak) on doing an updating the capital stock measure for U.S. states from 1993 to 2018.

5 Empirical evidence for Argentinean provinces

5.1 Argentinean provinces

All but City of Buenos Aires

5.2 Sample

Yearly Balanced Panel. 1964-2014

5.3 Identification of spending shocks - Instrumental variables

We estimate the multiplier for Argentinean provinces through a basic regression between real gross subnational product ($y_{i,t}$) and real total public spending of each province ($g^T_{i,t}$).[3] Specifically:

$$y_{i,t} = \alpha_i + \beta\, g^T_{i,t} + \lambda\, y_{i,t-1} + \phi_1\, T_t + \phi_2\, T_t^2 + \mu_{i,t}. \tag{21}$$

[3] Total public spending does not include interest payments, so it refers to total primary public spending.

Both variables are expressed in logarithms and per capita terms. The subscripts i, t indexes provinces and years respectively, α_i is the fixed effect by province and T_t controls for possible temporal trends.[4] Since the regression is specified in levels we also control by the lagged dependent variable $y_{i,t-1}$.[5] The parameter β is the multiplier of public total spending and following the traditional practice is multiplied by the average ratio of $\frac{Y}{G}$ to express it in monetary terms.

5.3.1 Instrumenting total primary government spending

Naturally, the obtained multiplier from equation 21 could be biased if we do not control by endogeneity concerns that typically affect the relationship between economic activity and fiscal variables. In this section we tackle this issue with an instrumental variable strategy by using an original and novel instrument in fiscal multiplier literature. Our instrument is the unbalanced representation in National Congress of subnational governments in Argentina. We explain this strategy below.

Argentina is a federal republic with a representative democracy as a form of government. In its territory coexist 24 subnational governments (23 provinces and the autonomous city of Buenos Aires) with a great heterogeneity in terms of population density and economic development. While each subnational government has the constitutional right to execute its own fiscal policy, Argentinean fiscal federalism presents an outstanding feature: a vertical fiscal imbalance (public spending is strongly decentralized at the subnational level, while revenues are concentrated at the federal level) "offset" with a system of transfers from the government. Federal transfers explain on average 60% of subnational public spending, are typically unconditioned and two-thirds are automatically determined by the federal tax-sharing system while one-thirds are discretionary determined.[6] The representatives of each province in the National

[4] We include linear and quadratic trends as in Owyang, Ramey, and Zubairy (2013) and Riera-Crichton, Vegh and Vuletin (2015).

[5] Arellano and Bond (1991) show that the estimation of dynamic panel data models lead, by construction, to inconsistent standard estimators as the unobserved panel-level effects are correlated with the lagged dependent variables. To overcome this limitation Arellano and Bond (1991) and Blundell and Bond (1998) propose the use of alternative consistent GMM estimators based on the use of internal instruments. These estimators do not come free of limitations as the initial conditions and moment requirements are not necessarily satisfied in all cases. Relying on Monte Carlo simulations these authors also show that this bias rapidly decreases as the number of observations per group (provinces in our case) increases; in particular when reaching about 20 observations of the dependent variable. In this paper, we have approximately 50 observations per province. For this reason we do not use the GMM estimator.

[6] The tax-sharing system is based on an agreement called "coparticipaciÃ³n" and establishes which taxes are shared between the federal government and the provinces, how these taxes will be distributed between them ("Primary distribution") and how the funds allocated to the provinces are shared between them ("Secondary distribution "). Since 1988 the coefficients of the primary distribution and those corresponding to the secondary distribution remain unchanged. The latter are determined using formulas that weigh several indicators as population and distributive considerations to favor less developed provinces.

Congress, composed of Chambers of Senators and Chamber of Deputies, are responsible for legislating over tax-sharing system and also have the possibility of influencing over the discretionary transfers distribution (i.e. negotiating their support for laws and reforms promoted by the national government in exchange for benefits for their provinces). Historically, since the first National Constitution of 1853, Argentina has shown an unbalanced representation of its provinces in its National Congress.[7] In particular, the low-population provinces have found themselves systematically overrepresented not only in the Senate (where all the provinces have the same number of representatives, regardless of their population) but also in the Chamber of Deputies. Porto and Sanguinetti (2001) established that this observed imbalance in per capita representation between different provinces is an important factor explaining the allocation of transfers. They showed that overrepresented provinces have received (on average) more resources from the federal government than more populated and less represented provinces. Thus, concluded that changes in the Chambers of the National Congress can cause changes in the allocation of the transfers. Considering this along with the significant share of transfers in subnational public spending, it can be argued that the latter is affected by changes in the composition of the National Congress. This relevance condition is presented, firstly, in Figure 14 through the correlation between total primary subnational spending and federal transfers. Secondly, the correlation between representation of each province at the National Congress with total primary subnational spending is shown in Figure 15.[8] For all cases, these correlations are positive and with statistical significance, supporting the relevance of the instruments to implement the proposed strategy. Finally, regarding to the exogeneity condition our strategy feeds on Vegh and Vuletin (2015) that on the basis of historical documentation shows that all changes in the number of senators and deputies throughout the Argentinean history were driven by governance considerations and not in response to contemporary macroeconomic changes.[9]

[7] See VÃ¨gh and Vuletin (2015) for a detailed discussion about departs from proportionality in the representation of Argentinean provinces in National Congress since 1853.

[8] Like other works in this literature (Porto and Sanguinetti, 2001 and VÃ¨gh and Vuletin, 2015), the autonomous city of Buenos Aires is excluded from the analysis mainly for having a special treatment in terms of the Argentine tax transfer system. Additionally, we use VÃ¨gh and Vuletin (2015) definition of provincial representation which restricts the instrument to those episodes in which changes in Chambers occurred and altered the representation of the provinces. For those episodes, the difference between the number of representatives (deputies or senators) assigned to the provinces in each reform and the number of representatives that would have resulted from a proportional allocation (to the population) is defined as absolute distortion. In addition, the relationship between absolute distortion and population is defined as an effective distortion. We included this metric instead of the typical one of representatives per capita (for every year) to guarantee that changes in representation is driven by changes in Chambers composition and not by population.We also use only the representation on Chamber of Deputies given its best explanatory power. Anyway results remain robuts to the inclusion of effective distortion in Chamber of Senators. See VÃ¨gh and Vuletin (2015) for a detailed discussion.

[9] See Vegh and Vuletin (2015) for a detailed description of this imbalance in the representation of each

Since the focus of this paper is on public investment, equation (21) should consider the share of public consumption and public investment. We define $g^T_{i,t} = g^C_{i,t} + g^K_{i,t}$ where $g^C_{i,t}$ is public consumption spending of province i at period t and $g^K_{i,t}$ is public investment spending. We also define $\theta_{i,t}$ as the share of the public consumption in province i at period t. Thus, equation 21 can be reexpressed as follows:

$$y_{i,t} = \alpha_i \; + \; \beta_c \; \theta_{i,t} \; g^T_{i,t} \; + \; \beta_k \; (1 - \theta_{i,t}) \; g^T_{i,t} \; + \; \lambda \; y_{i,t-1} \; + \; \phi_1 \; T_t + \; \phi_2 \; T_t^2 + \; \mu_{i,t}, \qquad (22)$$

where $\theta_{i,t} \; g^T_{i,t} \; = \; g^C_{i,t}$ and $(1 - \theta_{i,t}) \; g^T_{i,t} \; = \; g^K_{i,t}$. Thus, equation (22) is the relevant to estimate the multiplier by type of spending.

5.3.2 Instrumenting government spending composition

Here we still used (as for the multiplier of the total spending) the representation of each province in the National Congress to instrument changes in public spending $g^C_{i,t}$ and $g^K_{i,t}$. This instrumentation would be operating through the level effect of spending as one more representative of each province triggers greater transfers and consequently greater public spending. However, it is also relevant to consider the composition effect because the higher spending could be carried out in a certain type of spending (consumption or investment). So the parameter θ becomes central and here we instrumented it through one determinant of public spending composition able to be considered exogenous: the population dependency, defined as the population share under 15 years old and older than 65 years old over the population between 15 and 65 years old.[10] Our prior is the greater the population dependency, the greater share of spending allocated to public consumption.[11]

Using the population dependency index for each Argentinean province, we test its relevance to explaining public spending composition.[12] Panel A in Figure 16 shows the correlation

province in the National Congress as well as its changes throughout the history of Argentina.

[10] See Izquierdo, Puig, Vegh and Vuletin (2018) for a recent discussion about determinants of public spending composition.

[11] Many studies suggest a direct relationship between population dependence and public spending, especially in social purposes. Thus, young population and the adult population increase the spending in health and social security (Visco, 2001). A particular case is given with spending on education because various studies pose a competition between adults and youth for resources, and in this case a higher percentage of young population pressure for higher educational spending, and vice versa (Poterba 1997 and 1998). Also Izquierdo and Kawamura (2015) presents an interesting approach by holding that the adult-older sector of the population, for reasons of life expectancy, biases their preferences towards public consumption spending. Thus, for greater public investment that demands maturing time and whose benefits will be appropriate for future generations, intergenerational altruism becomes a key factor in the composition of public spending, especially when future generations have no right to vote.

[12] Population dependency index is published by the National Institute of Statistics and Censuses (INDEC)

between the share of public consumption spending and population dependency, indicating a positive association. Panel B in Figure 16 does with the share of public investment, indicating a negative correlation and suggesting that population dependency biases the composition towards public consumption. Figure 17 shows that the same relationship is also true when using a global sample. The discussion about exogeneity condition begins with Figure 18 which presents the correlation between those two rates is presented, which does not differ from zero. Beyond the graphical analysis, it may be relevant to discuss two more conceptual issues associated with population dependency exogeneity. On the one hand, the fact that the definition of population dependency is strictly based on populations breaks by age (i.e. share of population less than 15 years old) allows to think that population is not likely to correlate with economic activity. Different would be the case where instead of using the population between 15 - 65 years as a denominator, labor force is used. This variable would be more prone to present variability associated with the economic cycle. On the other hand, it may be wise to think that the population under 15 years is determined, among other things, by fertility decisions that can be taken based on labor market issues. Or that population elderly population is related with life expectancy issues, linked to a greater development caused by a higher level of economic growth. Whatever the case, it is reasonable to assume that the mechanisms that define age structure of the population could play in the very long run, with low probability of being determined by the contemporaneous economic activity of the moment, and that in case that would be by second or third order channels.[13] Thus, we estimate equation 22 instrumenting the level and the composition of public spending with the representation of each province in the National Congress and population dependency of each province, respectively. We also include the interaction term.

5.3.3 Measuring stock of public capital

The last question we tried to tackle in this paper is whether public investment multipliers are heterogeneous or not given the level of the initial stock of public capital. In empirical terms the main limitation to test this hypothesis in a country like Argentina lies in the measurement of the initial stock of the public capital by province. In the attempt to get over this restriction in this paper we made a great effort to approximate it with the kilometers of asphalted roads by province.[14] With this variable we estimate a model between it and the subnational gross

[13] *MAYBE THIS AS A FOOTNOTE*

[14] Data about asphalted roads by province are not easy to obtain in Argentina for years before 2001. From 2001 to 2014 data provided by the National Observatory of Transport Data - Technological Center for Transport, Traffic and Road Safety (UTN) is used. From 1964 to 2001, information comes from INDEC statistical data, as well as information from the National Economic Censuses also carried out by INDEC and data from the National Road Administration.

product of each province. The linear prediction is taken as the optimal level of roads given the economy. The ratio between observed and optimal roads is our proxy of initial stock of public capital. Intuitively provinces with lower than one ratio will have a lower-than-optimal capital stock. Thus, the hypothesis of a greater public investment multiplier in those provinces is tested. For this purpose, equation 23 is estimated, considering the interaction between the initial stock of public capital and public investment spending.[15] The multiplier is derived from the expression $(\beta_k + \beta_{Kint} * Stock_{i,t0})$.[16]

$$y_{i,t} = \alpha_i \ + \ \beta_c \ g^C_{i,t} \ + \ \beta_k \ g^K_{i,t} \ + \ \beta_{kint} \ g^K_{i,t} * Stock_{i,t0} + \\ + \rho \ Stock_{i,t0} + \ \lambda \ y_{i,t-1} \ + \ \phi_1 \ T_t + \phi_2 \ T_t^2 + \ \mu_{i,t} \quad (23)$$

5.4 Empirical results

Figure 19

5.5 Argentina map

Figure 20

6 Final thoughts

To be completed.

7 Appendices

7.1 Data definitions and sources

7.1.1 Europe

Total Primary Government Expenditure. Eurostat, Quarterly non-financial accounts for general government.

Total Primary Government Consumption Expenditure. Eurostat, Quarterly non-financial accounts for general government.

Total Government Gross Fixed Capital Formation. Eurostat, Quarterly non-financial accounts for general government.

[15] Note that the estimation includes the initial stock of capital at the beginning of the sample ($Stock_{i,t0}$) to avoid endogeneity concerns between the subnational gross product and the stock of public capital.

[16] Given the presence of interaction terms, estimated coefficients are calculated using Delta method.

Real Gross Domestic Product. Eurostat. National Accounts

Total Stock of Capital. World Penn Tables

General Government Capital Stock. IMF, Fiscal Affairs Department.

Private Capital Stock. IMF, Fiscal Affairs Department.

7.1.2 United States

Total State Expenditures (Estimated and Actual) – Capital Inclusive. National Association of Budget Officers, State Expenditure Report

Total Capital Expenditures (Estimated and Actual) – Capital Inclusive. National Association of Budget Officers, State Expenditure Report

Real Gross Domestic Product. Bureau of Economic Activity. Regional Accounts

Total, Private and Public Stock of Capital. Aklilu A. Zegeye (2000), "U.S. Public Infrastructure and Its Contribution to Private Sector Productivity" BLS Working Paper Working Paper 329 June 2000

7.1.3 Argentina

The total subnational public expenditure, as well as its components (consumption and investment), and total transfers from federal government to the provinces come from Porto (2004) for the period 1964-2000. Then, for the period 2001-2014, information from the Ministry of Economy and Public Finance of the Republic was used.

The subnational Geographical Gross Product comes from Porto (2004) for the period 1964-2000. For the period 2001-2014, data proceed from the Center for Production Studies (CEP), which reports to the Ministry of Industry of Argentine. The years not registered by the CEP for this period were completed with data from the Provincial Statistics Offices of each province and information from the Secretariat of Economic Policy and Development Planning, dependent on the Ministry of Economy and Public Finance of the Argentine Republic.

The provincial population comes from Porto (2004) for the period 1964-2000 and from the National Institute of Statistics and Census (INDEC) for the period 2001-2014.

The data referring to Congress composition in Argentina was obtained from the Electoral Atlas, published by Andy Tow.

Figure 1. Government consumption and investment multipliers.
Evaluated at the median public capital to GDP ratio.

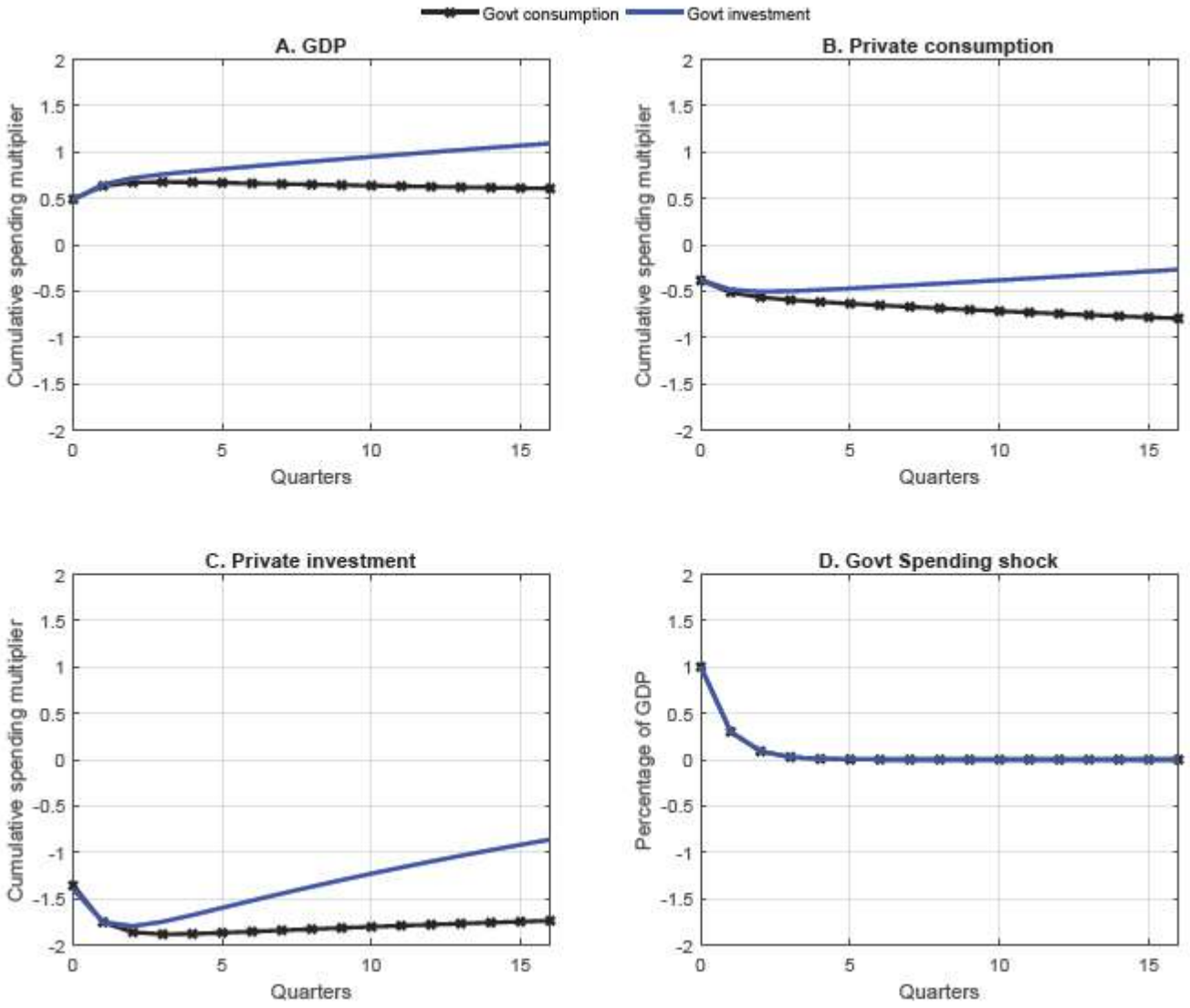


Figure 2. Government investment multipliers for alternative levels of public capital to GDP ratio: High vs. low public capital to GDP ratio

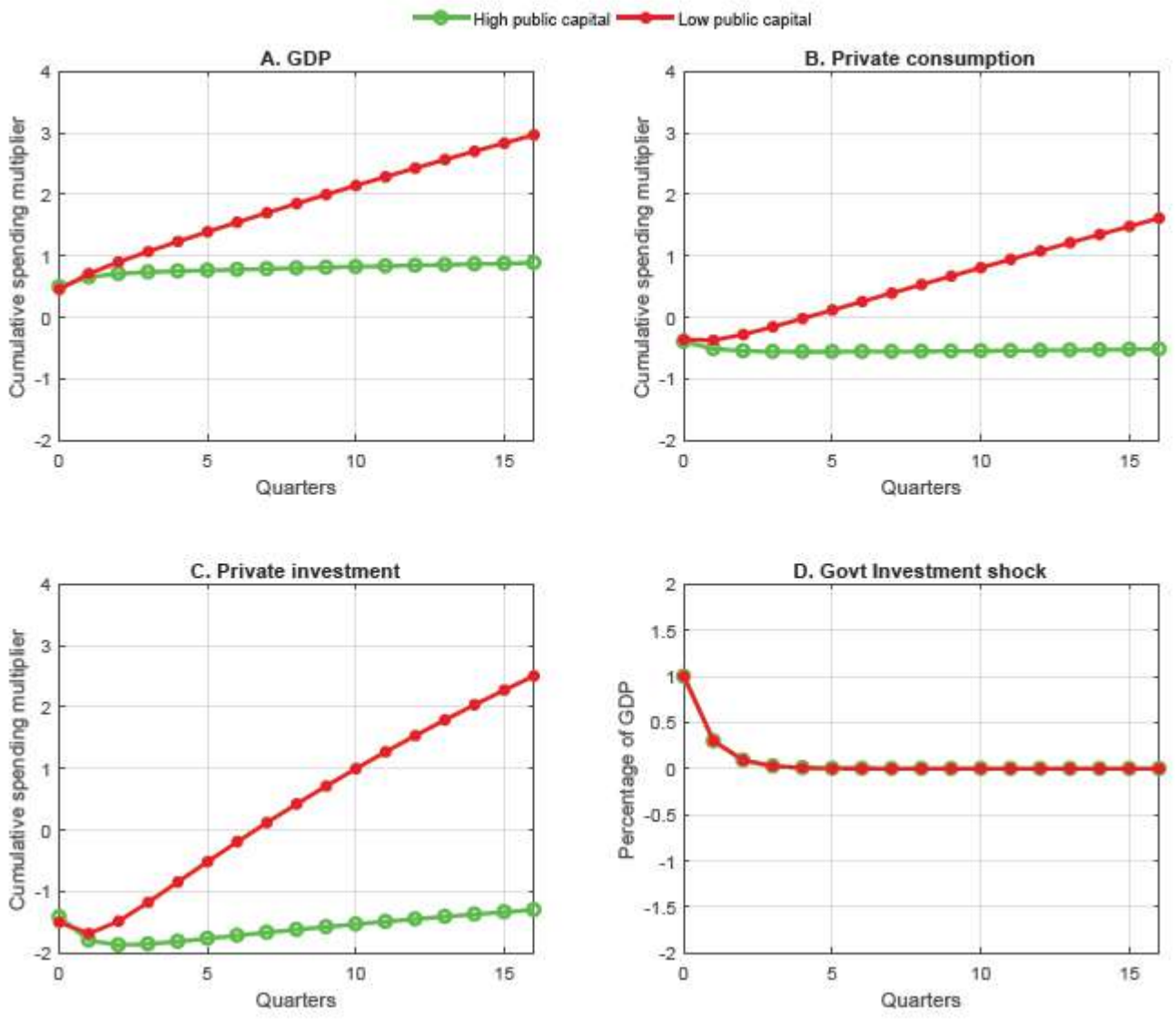
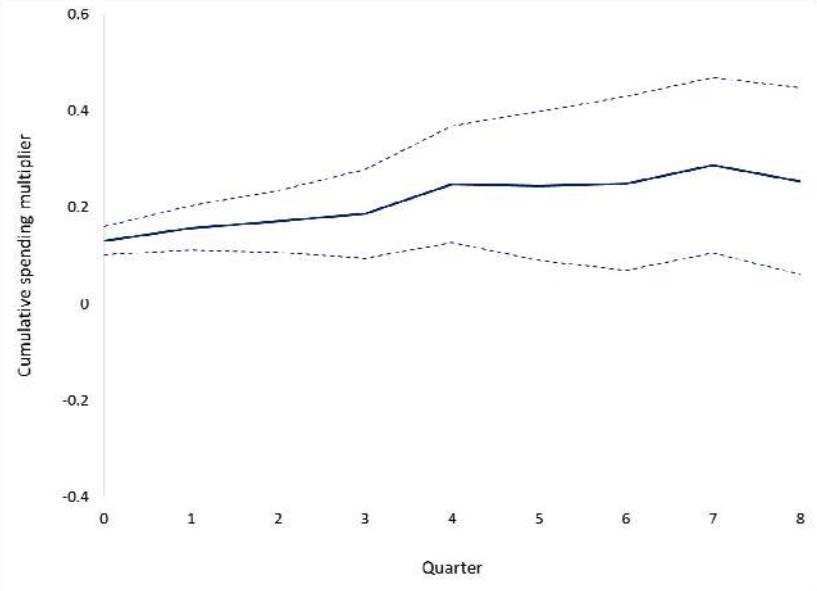


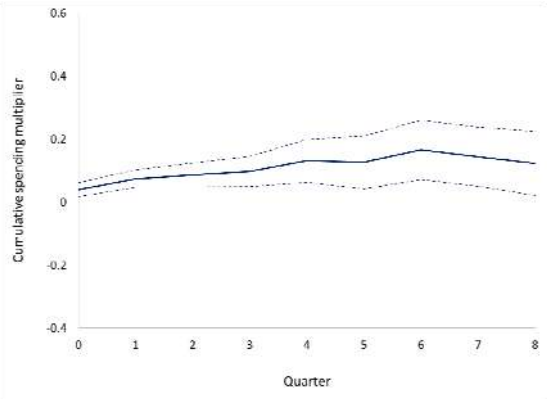
Figure 3. Multiplier of total primary spending on output



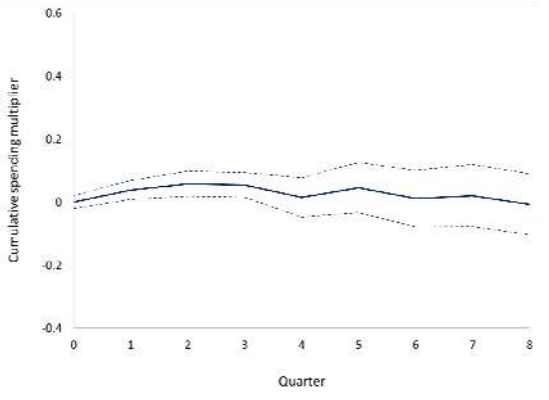
Note: Evidence for Europe

Figure 4. Multiplier of total primary spending on aggregate components of demand

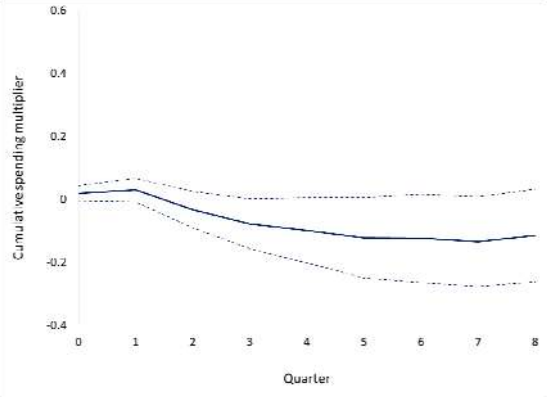
Panel A. Effect on private consumption



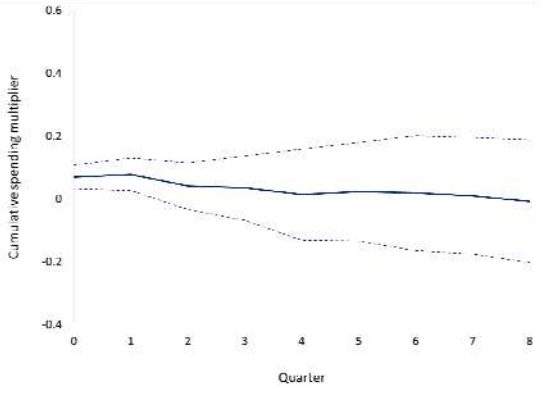
Panel B. Effect on private investment



Panel C. Effect on exports



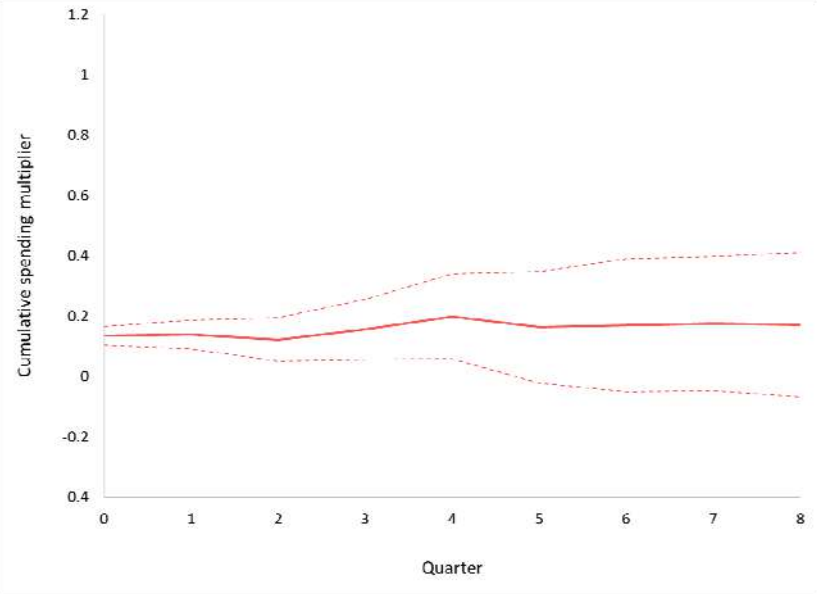
Panel D. Effect on imports



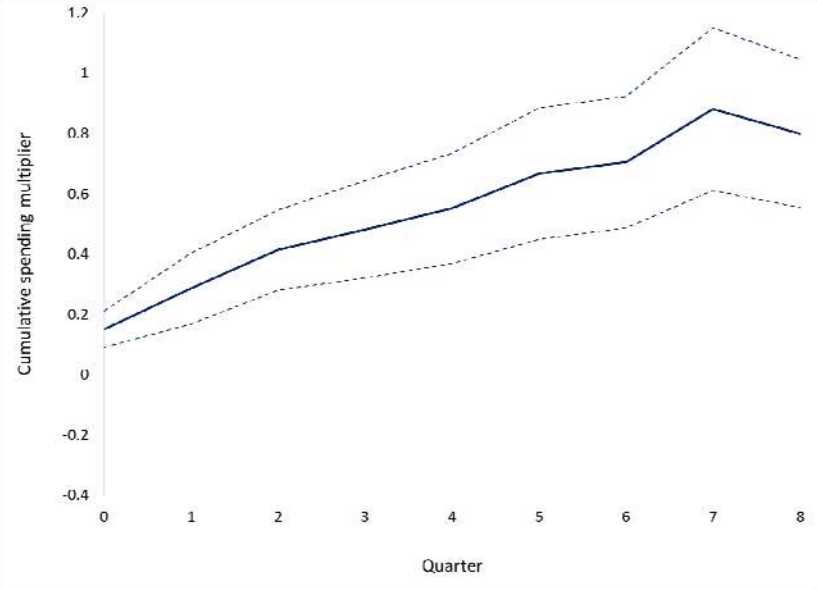
Note: Evidence for Europe

Figure 5. Multiplier of total primary spending components on output

Panel A. Multiplier of current primary spending on output



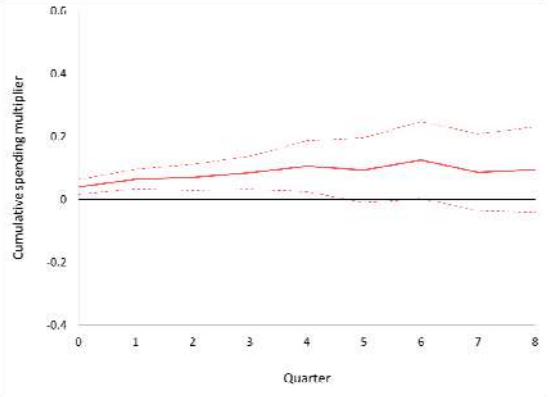
Panel B. Multiplier of government investment on output



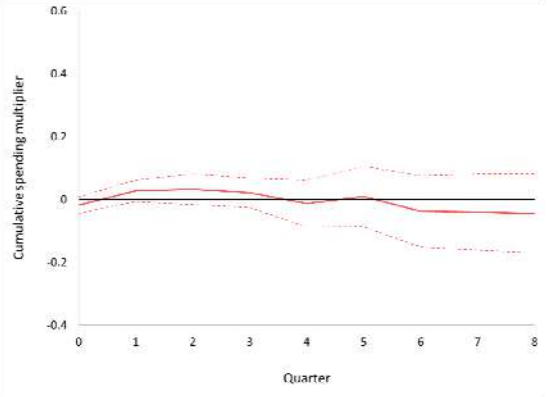
Note: Evidence for Europe

Figure 6. Multiplier of current primary spending on aggregate components of demand

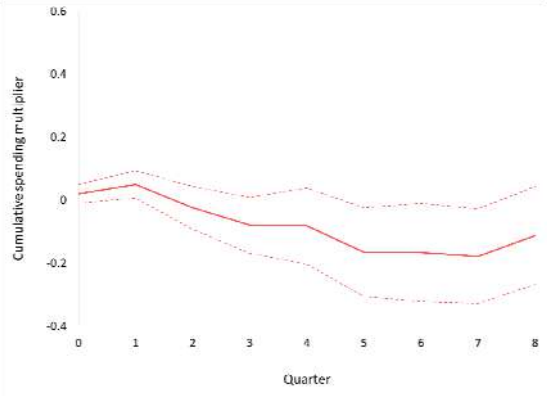
Panel A. Effect on private consumption



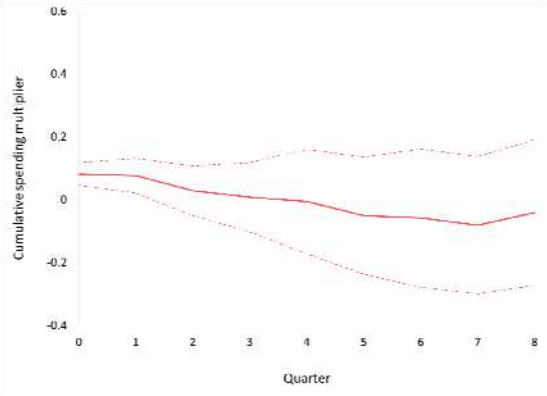
Panel B. Effect on private investment



Panel C. Effect on exports

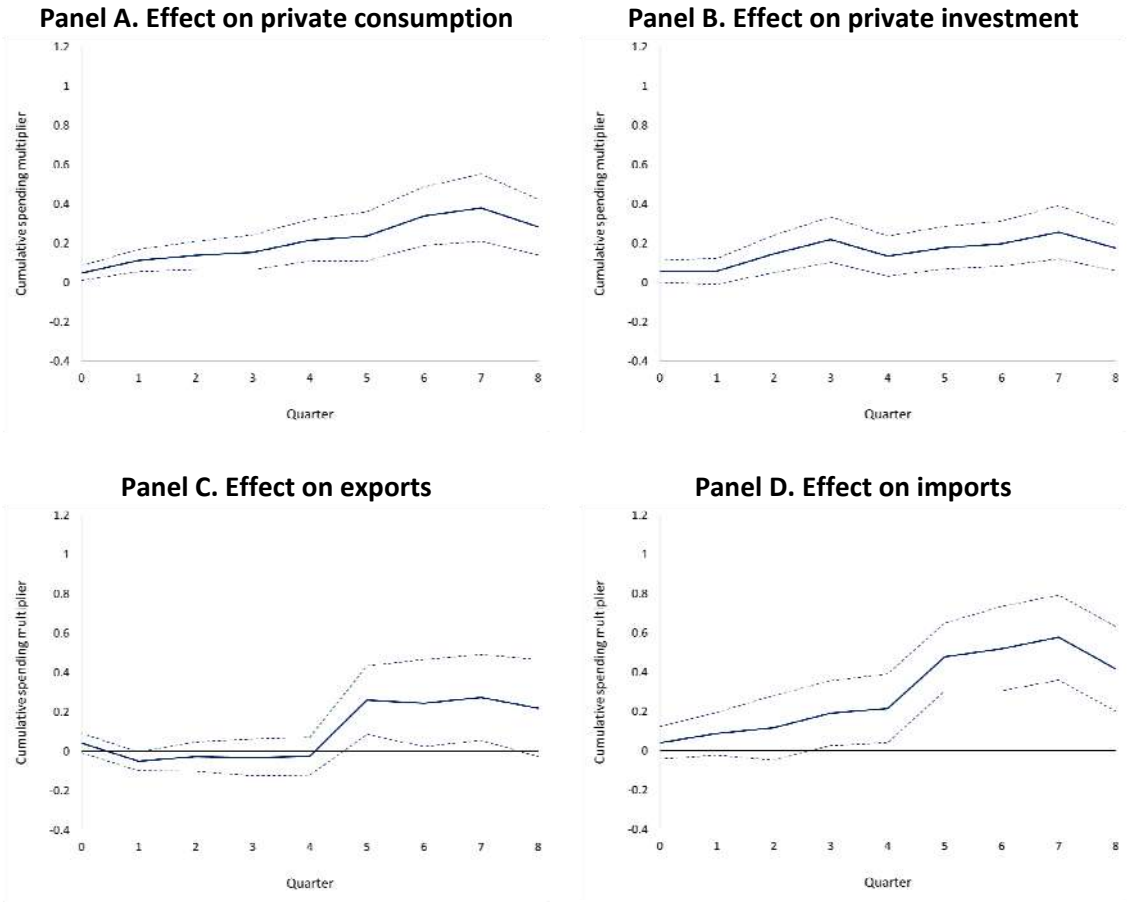


Panel D. Effect on imports



Note: Evidence for Europe

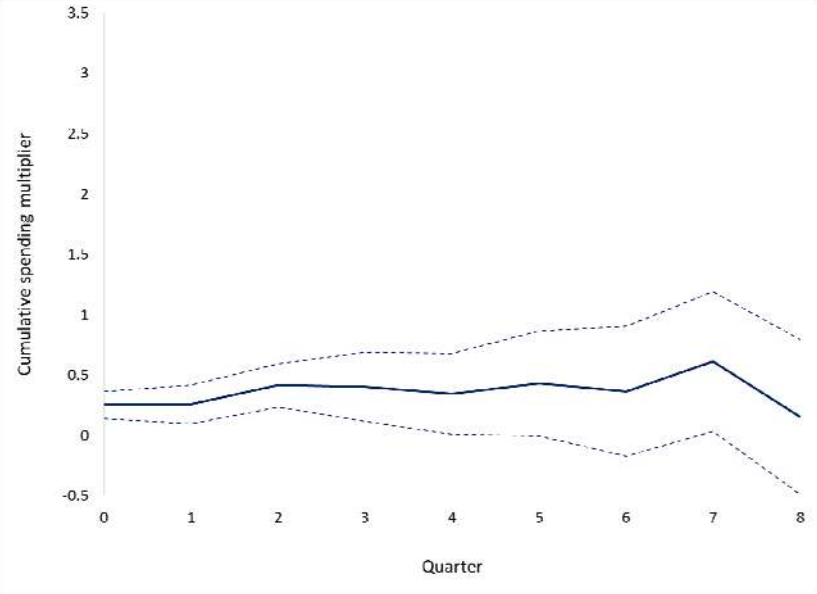
Figure 7. Multiplier of government investment on aggregate components of demand



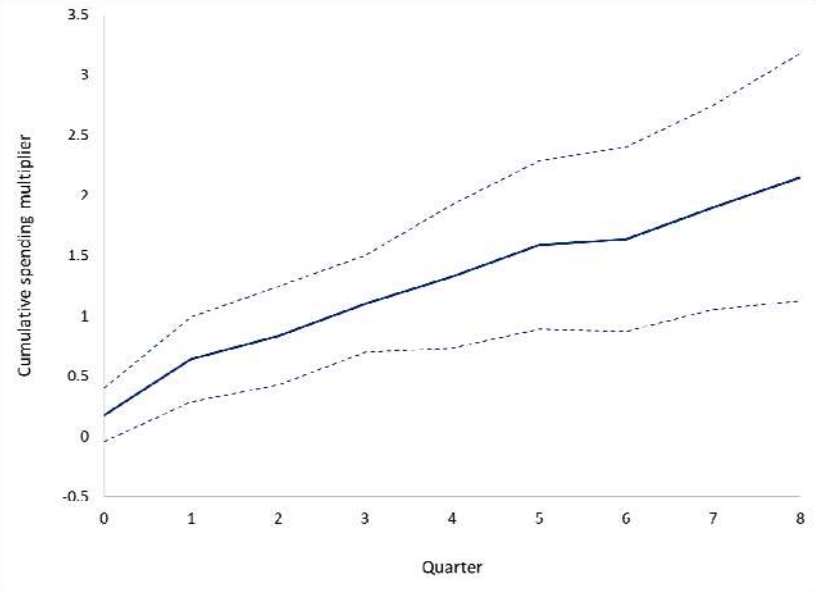
Note: Evidence for Europe

Figure 8. Multiplier of government investment on output

Panel A. Conditional on high initial stock of public capital over GDP



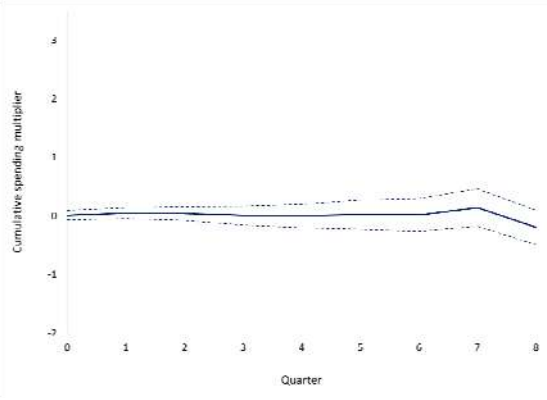
Panel B. Conditional on low initial stock of public capital over GDP



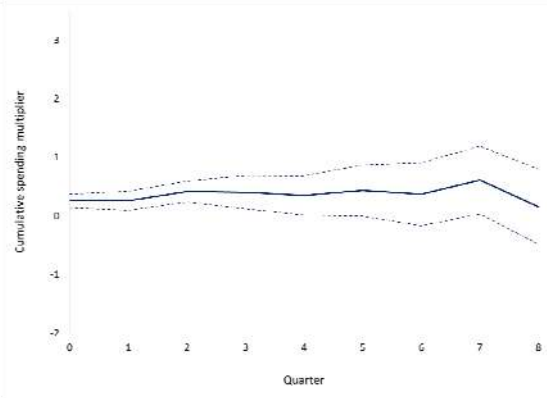
Note: Evidence for Europe

Figure 9. Multiplier of government investment on aggregate components of demand, conditional on high initial stock of public capital over GDP

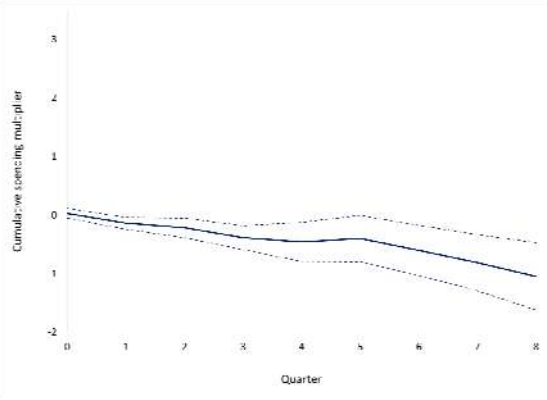
Panel A. Effect on private consumption



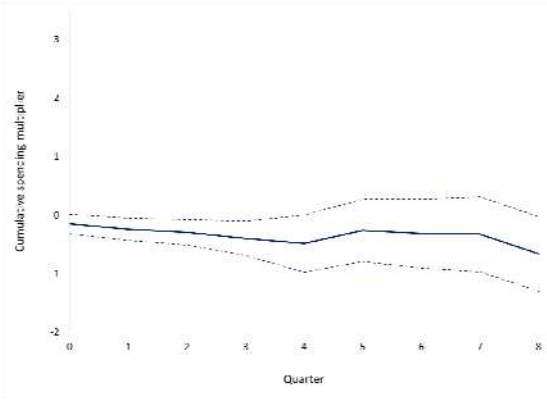
Panel B. Effect on private investment



Panel C. Effect on exports



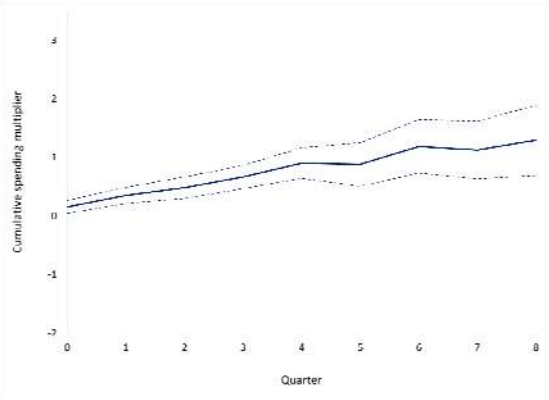
Panel D. Effect on imports



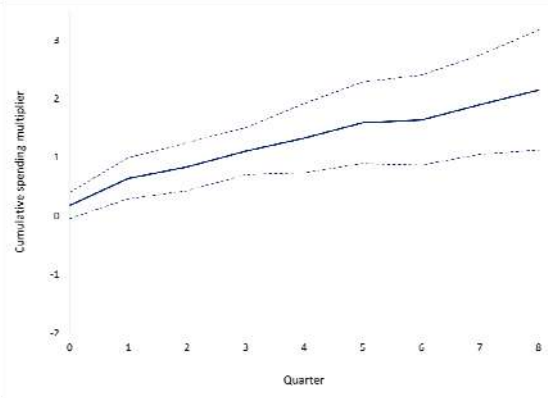
Note: Evidence for Europe

Figure 10. Multiplier of government investment on aggregate components of demand, conditional on low initial stock of public capital over GDP

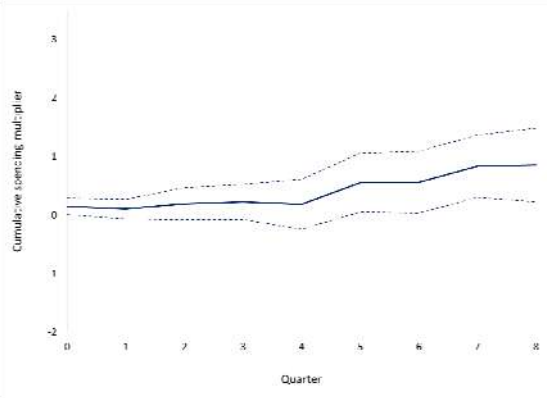
Panel A. Effect on private consumption



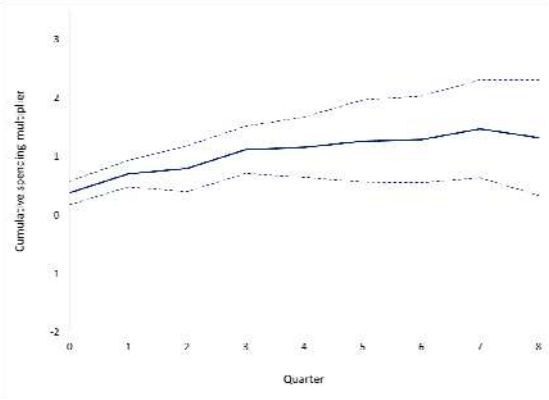
Panel B. Effect on private investment



Panel C. Effect on exports



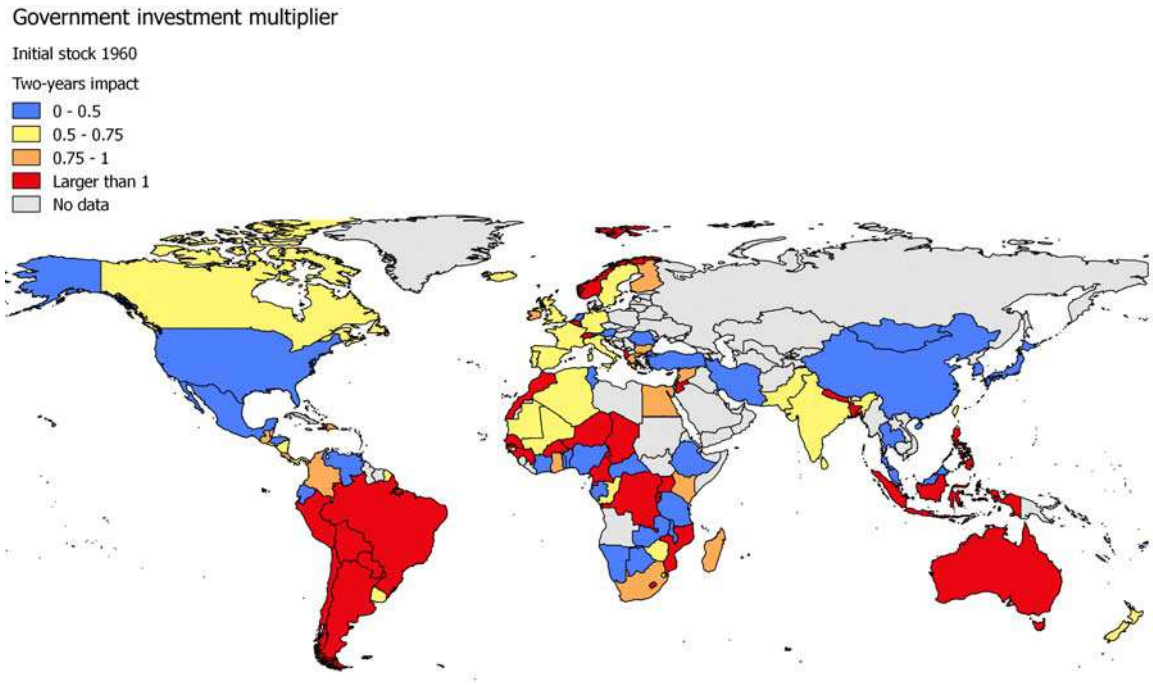
Panel D. Effect on imports



Note: Evidence for Europe

Figure 11. Investment multiplier around the world after two years of the spending shock

Panel A. For the year 1960



Panel B. For the year 2010

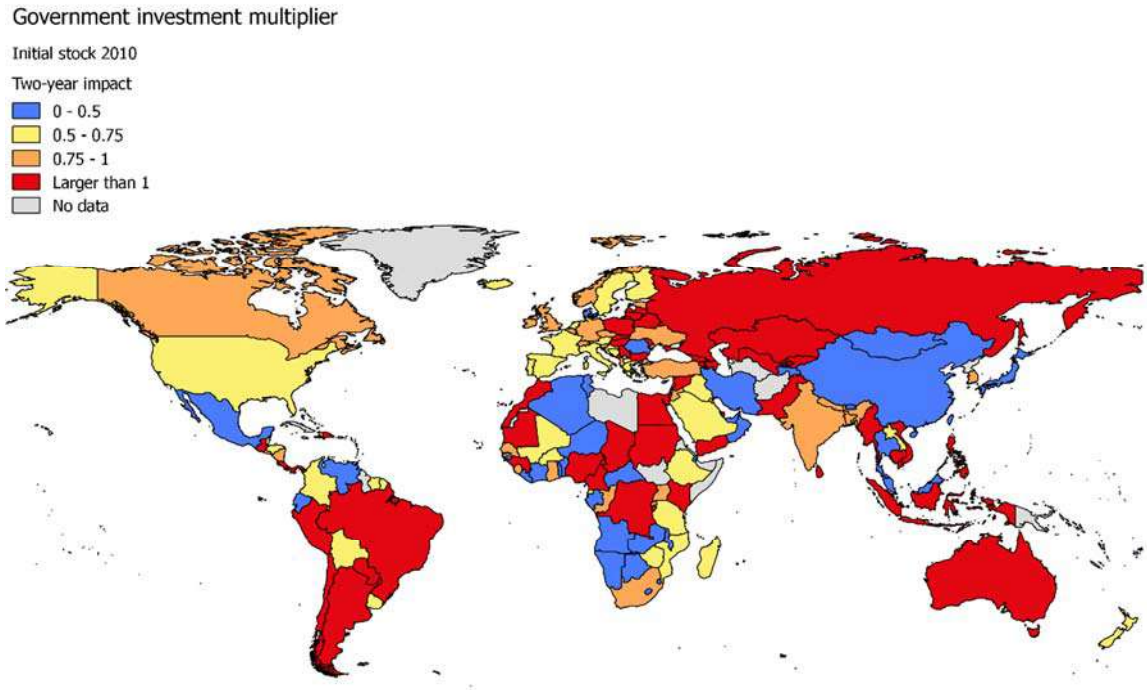
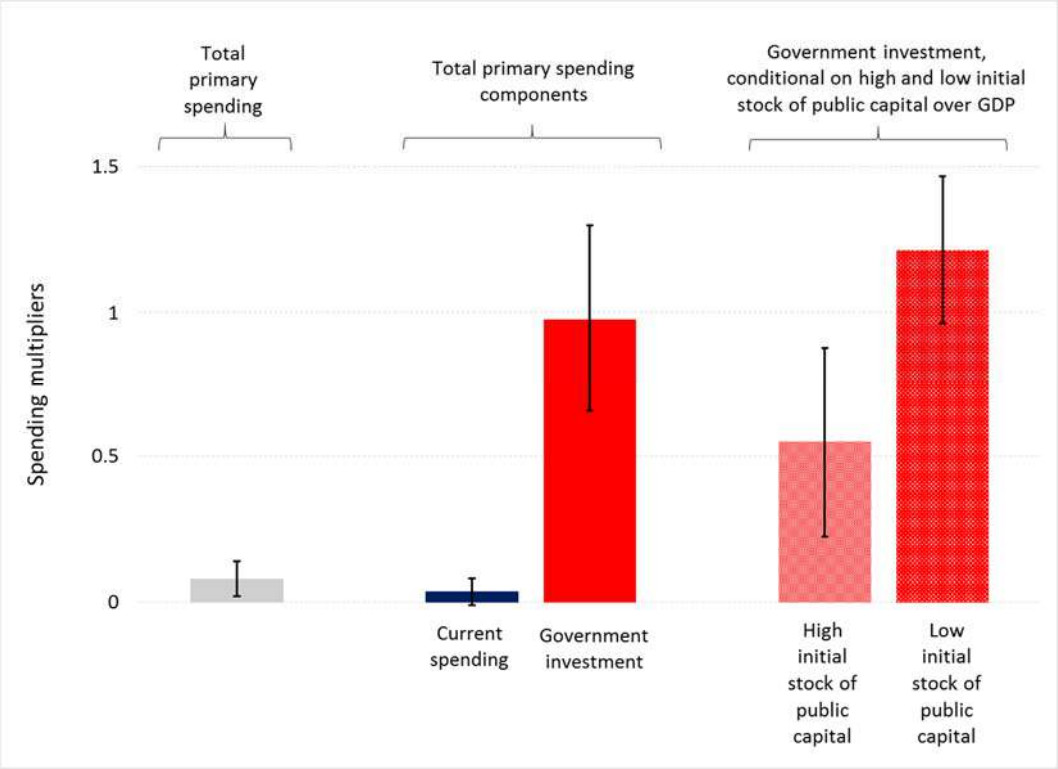


Figure 12. Multiplier of total primary spending (and its components) on output



Note: Evidence for United States states

Figure 13. Investment multiplier for U.S. states after one year of the spending shock for the year 1992

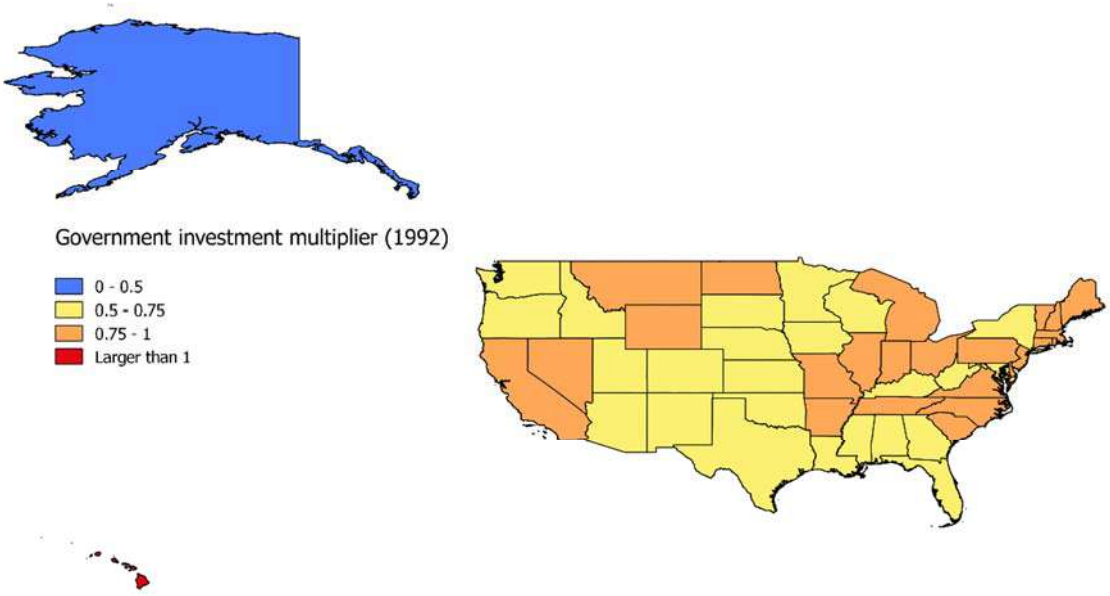


Figure 14. Relationship between spending and transfers per capita

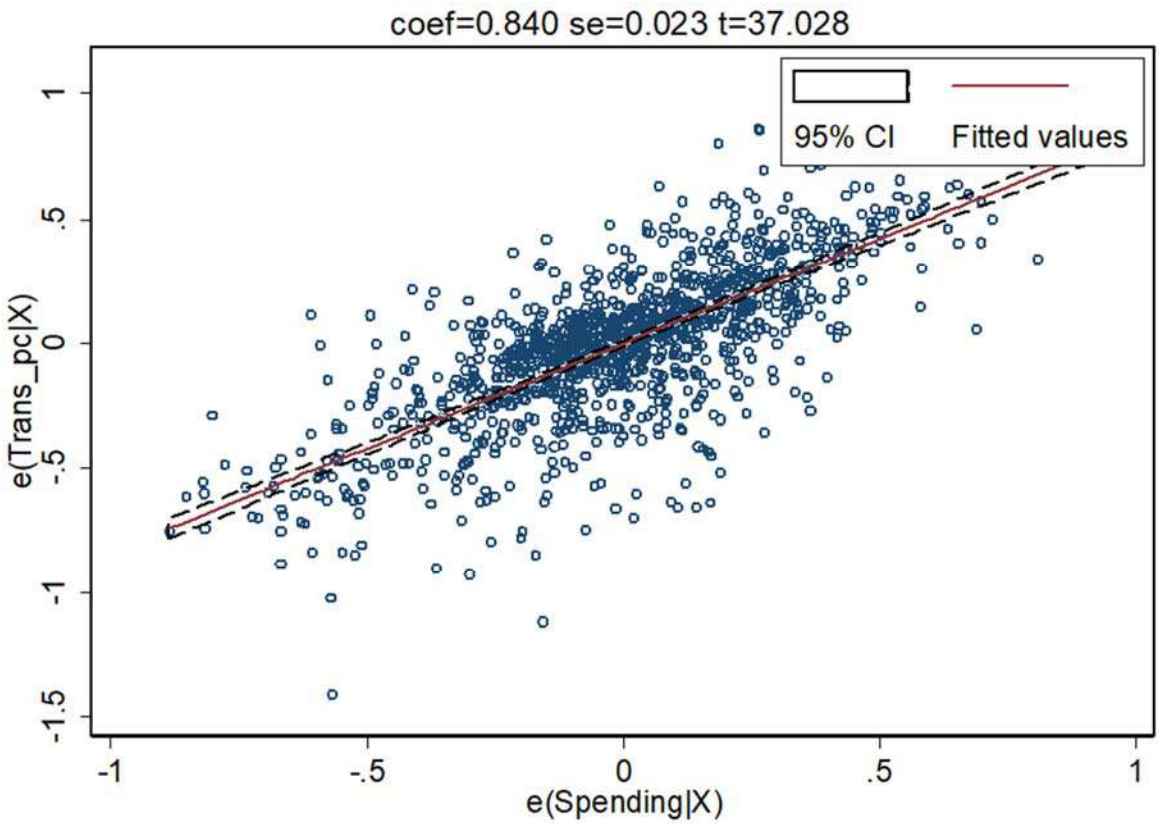


Figure 15. Relationship between spending per capita and effective distortion in Congress

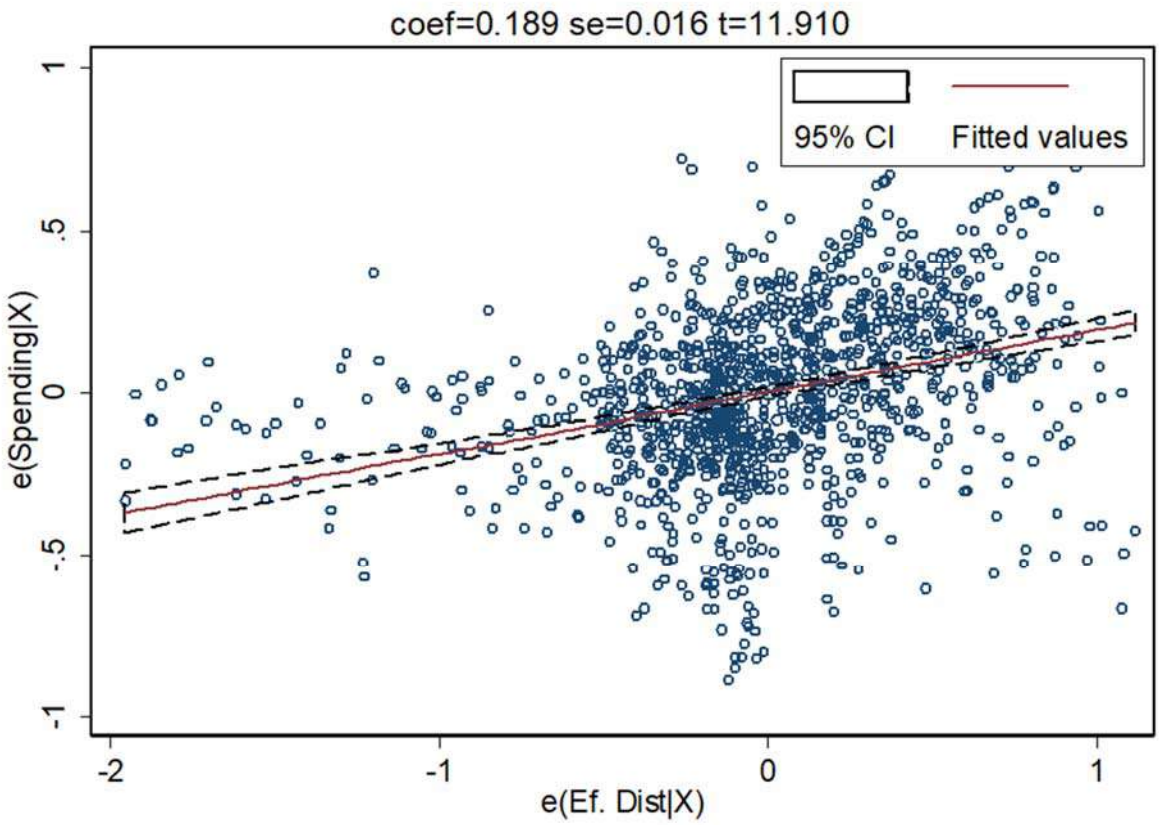
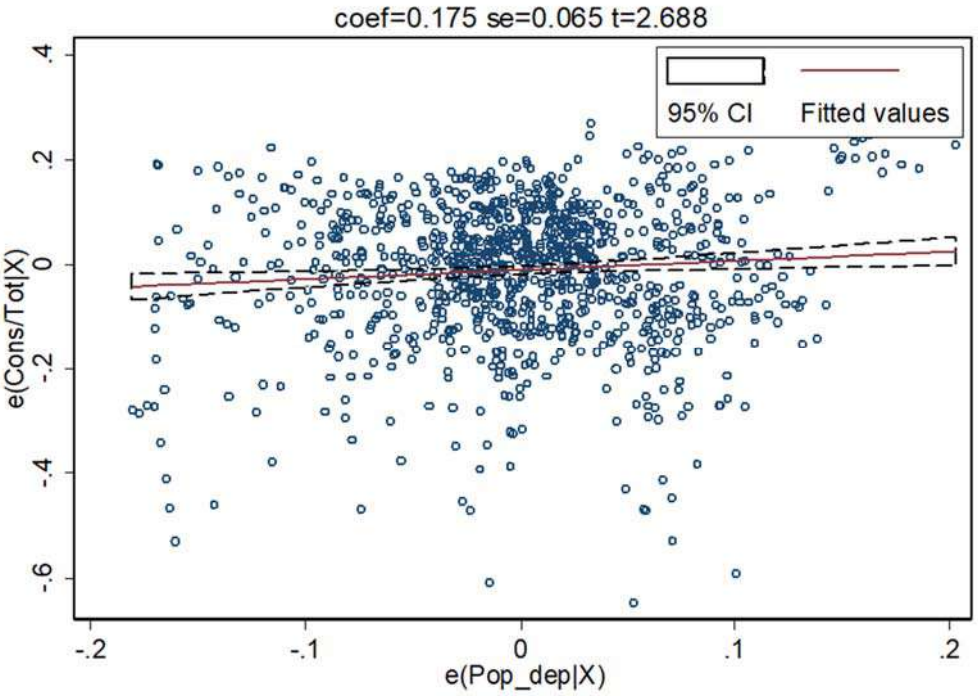


Figure 16. Relationship between population dependency ratio and spending composition for Argentinean Provinces

Panel A. Relationship between population dependency ratio and current primary spending



Panel B. Relationship between population dependency ratio and public investment

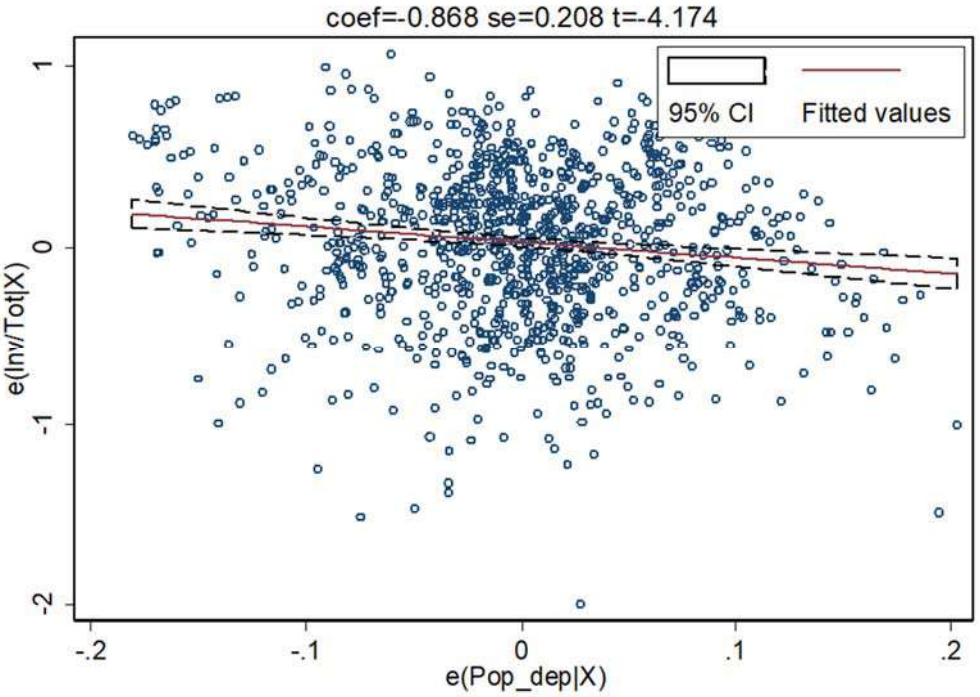
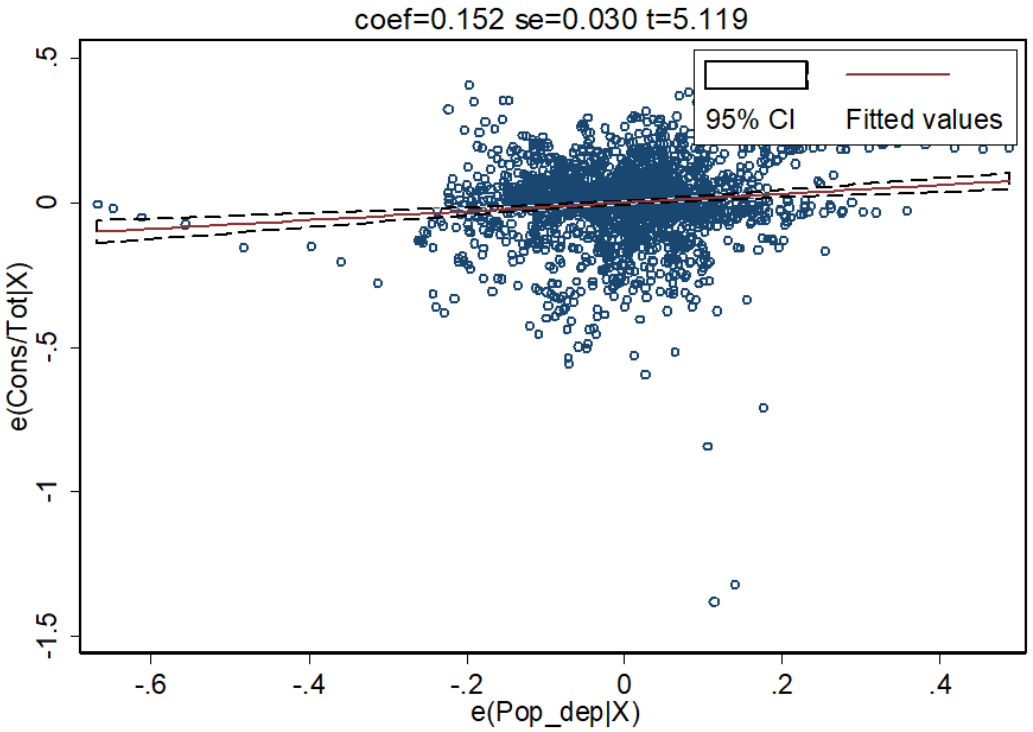


Figure 17. Relationship between population dependency ratio and spending composition for the world

Panel A. Relationship between population dependency ratio and current primary spending



Panel B. Relationship between population dependency ratio and public investment

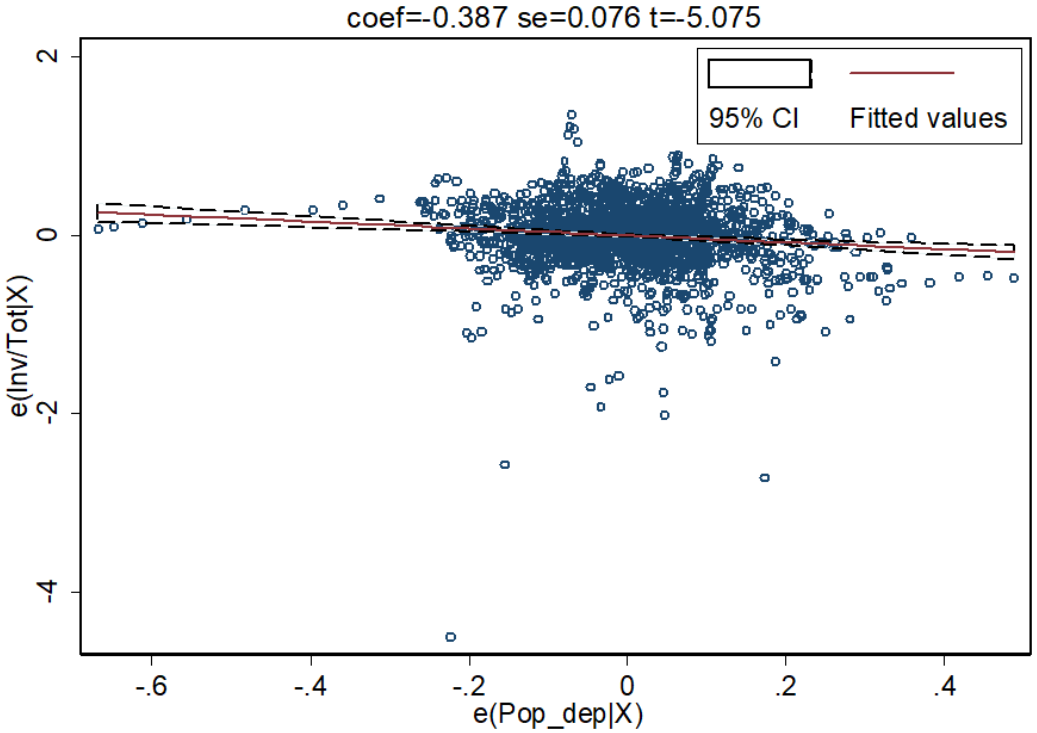


Figure 18. Relationship between population dependency ratio and GDP

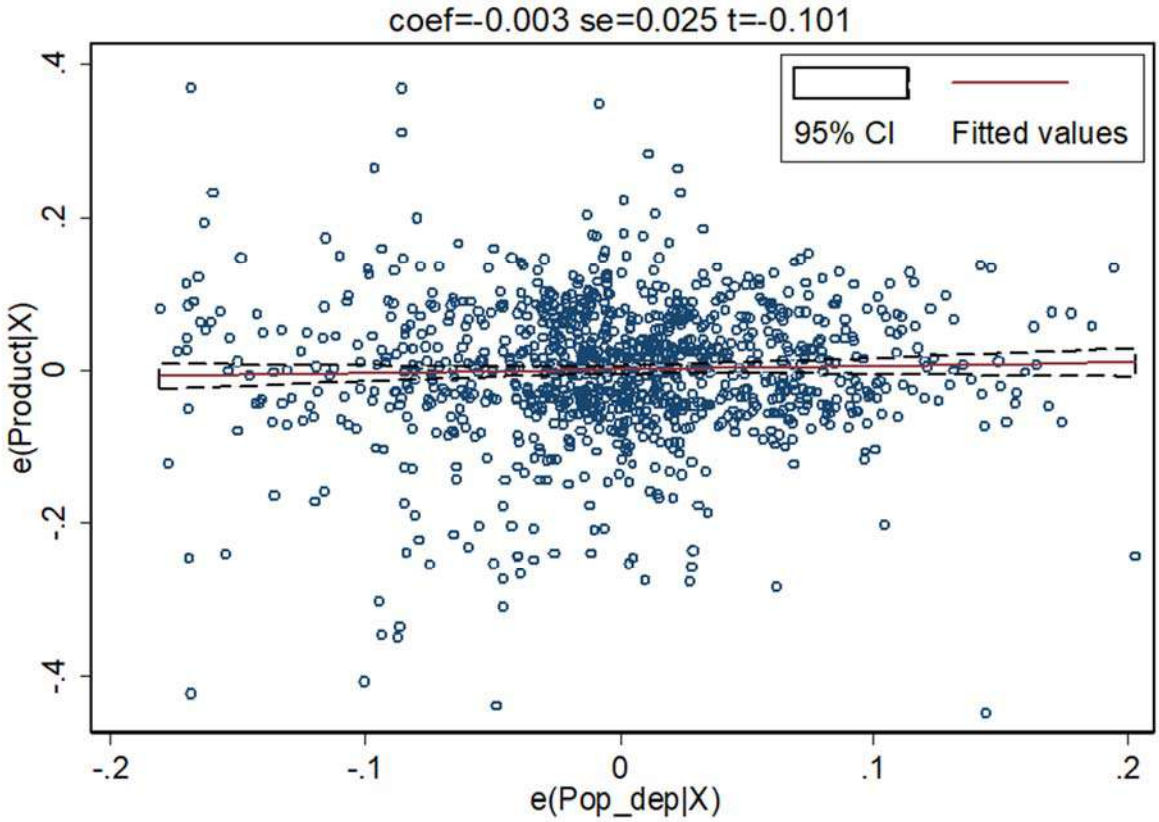
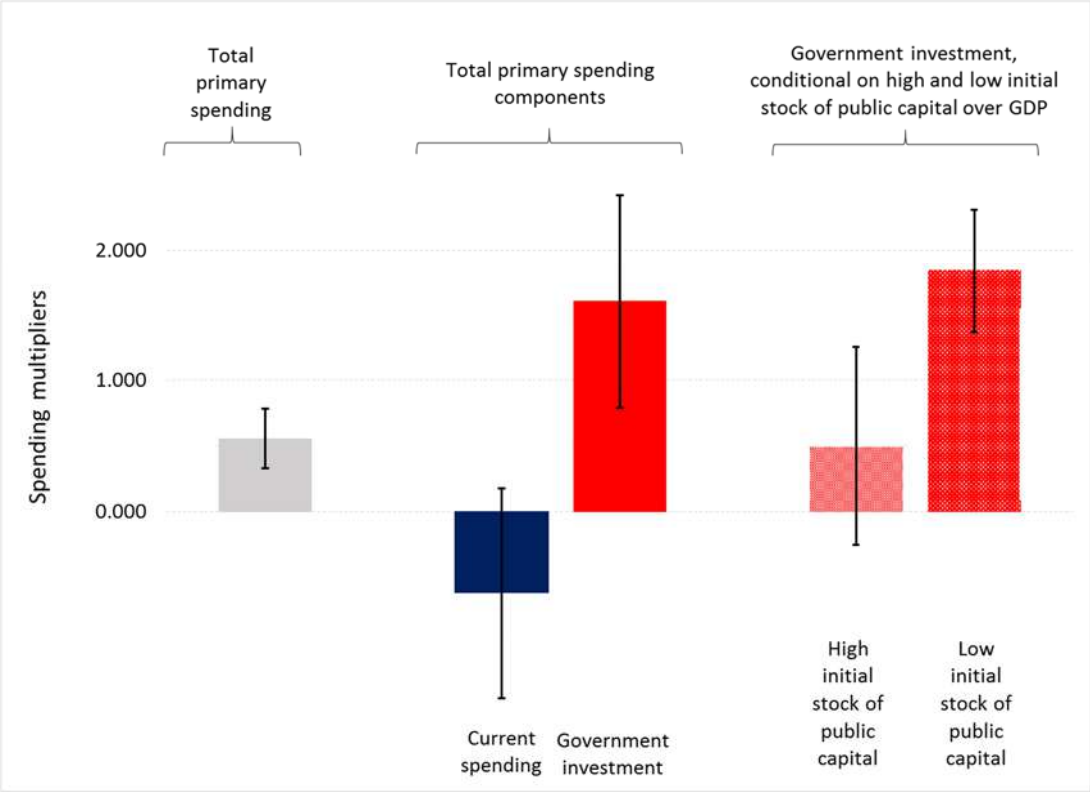


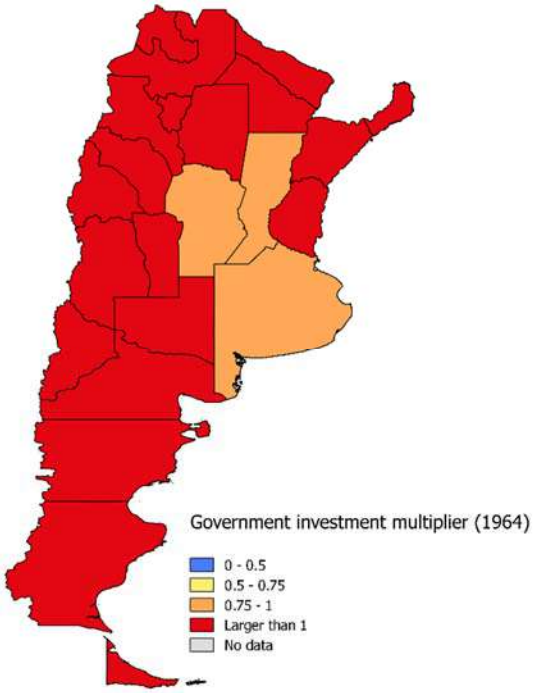
Figure 19. Multiplier of total primary spending (and its components) on output



Note: Evidence for Argentinean provinces

Figure 20. Investment multiplier for Argentina states after one year of the spending shock

Panel A. For the year 1964



Panel B. For the year 2014

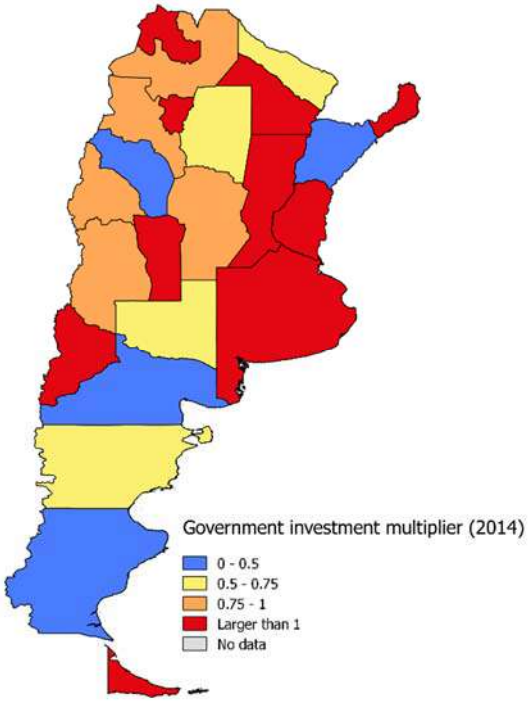


Table 1. Baseline calibration

Parameter	Description	Value
β	Subjective discount factor	0.99
δ	Depreciation rate	0.025
A	Total factor productivity	1.0
α_K	Share of private capital in production	0.30
α_L	Share of private capital in production	0.70
α_G	Share of public capital in production	0.07
ϕ_2	Capital adjustment cost parameter	10.0
$\bar{G}$	Steady state level for government consumption	Set to imply $\bar{G}/Y = 0.15$ at the steady state
ρ_g	Persistence of government spending shocks	0.30
ψ	Parameter for labor disutility	Set to imply $L = 0.20$ at the steady state
$\bar{I}^G$	Steady state level for government investment	Set to imply $K^G/Y = 0.15, 0.70, 1.25$ at the steady state in annual terms

Table 2. Cross country statistics for public capital over GDP in Europe

Descriptive statistics	Value
Mean	0.70
Std. Dev.	0.34
1st Percentile	0.15
5th Percentile	0.16
10th Percentile	0.34
25th Percentile	0.48
50th Percentile	0.63
75th Percentile	0.84
90th Percentile	1.03
95th Percentile	1.33
99th Percentile	1.79