# Does public investment stimulate private investment? Evidence for the euro area

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**Abstract.** This paper explores the long run relationship between public and private investment in the euro area. Panel econometric techniques allowing for international spillovers are employed. Private and public capital stocks are both *I*(2) and cointegrated. The deviations from the stock equilibrium are not (trend) stationary, but *I*(1). Utilizing them in a model for investment flows improves the cointegration evidence between the *I*(1) variables. In fact, private investment flows, GDP and the real interest rate appear to be cointegrated when the deviations from the stock equilibrium are included. The corresponding error correction equation is well behaved if changes in private investment flows are explained. Therefore, the lack of public investment may have restricted private investment and GDP growth in the euro area. The results have strong implications for the future direction of fiscal austerity programs to combat the euro area debt crisis.

JEL: C23, E22, E62

Keywords: Public and private investment, capital stocks, fiscal austerity

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## 1 Introduction

While fiscal austerity can be beneficial for GDP growth in the long run, the impacts in the short and medium run are often negative, as witnessed by the public debt crisis in the euro area (Perotti, 2011). The consolidation of public finances through a reduction of fiscal expenditures and an increase in taxes contributed to deep recessions in many countries (Auerbach and Gorodnichenko, 2012, Dreger and Reimers, 2013). Austerity measures may also encompass a decline of public investment, at least in part. From the government perspective, cuts in investment are usually easier to implement than a reduction of social transfers. However, it might imply additional losses in terms of economic growth, as it might cause lower private investment activities. To foster economic growth in times of debt is a main challenge for policymakers.

Therefore, this study investigates the relationship between public and private investment for the euro area countries. From a theoretical perspective, there is evidence for effects in both directions. On the one hand, if public and private sectors compete for the same resources, the costs for private investment can increase. Public investment needs to be financed, which may imply a higher tax burden or higher demand of governments for funds in capital markets, therefore causing interest rates to rise. Even in standard ISLM models, crowding-out effects of private investment are expected. They will be reinforced in times of a crisis, since higher government debt can raise country-specific risk premia and interest rates. In addition, implementation delays, i.e. substantial time-to-build lags can make expansionary government investment contractionary in the short run (Leeper, Walker and Yang, 2010). On the other hand, public investment may create more favourable conditions for private investment, for example, by providing better infrastructure. This can lead to expansionary effects especially in the long run. The existence of facilities can increase productivity of private investment, which might take advantage of improved business conditions. For example, government investments in energy, telecommunications or other network industries may have stimulated private investment activities (see also Pereira and Andraz, 2013).

Due to the opposite effects, the net impact of public on private investment cannot be determined on a priori grounds. Consequently, previous studies have delivered inconclusive results with respect to crowding-out or crowding-in effects. As the net impact comprises both static and dynamic reactions, any analysis should distinguish between the short and long run of the direction. While crowding-out is mainly a short-run phenomenon related to restrictions on

available resources, crowding-in is long-lasting and traced to higher productivity of private capital. Thus, if crowding-in effects are at work, they may be eventually more visible in a long run analysis.

Using a neoclassical production function approach, Aschauer (1989) emphasized the possibility that public investment may induce private investment. In general higher public capital accumulation tends to raise the overall investment rate above the level chosen by rational agents. This would imply an ex ante crowding out of private investment. However, crowding-in effects will finally dominate. An expansion of public capital is expected to increase the rate of return to private capital, thereby leading to higher private capital accumulation and GDP growth. Hence, active fiscal policies could stimulate private investment through productivity gains stemming from public capital. Similarly, Baxter and King (1993) argued that public investment can have dramatic effects on private investment and output. These results suggest that private investment will raise permanently by more than one to one for every unit of non-defense public capital. Subsequent research based on regional production functions, disaggregated public capital or industries arrived at similar conclusions, particularly for roads and highway capital. Argimón, González-Páramo and Roldán (1997) reported significant crowding-in effects of public on private investment for OECD countries because of the positive impact of infrastructure on productivity. In contrast, government consumption will crowd out private investment. Thus, debt reductions engineered through cuts in public investment can severely impinge on private investment and growth prospects.

The positive assessment of public investment expenditures lacks robustness, as the empirical specification plays a crucial role. If production functions are estimated with differenced data or if pooled regressions are carried out with fixed effects, crowding-in effects seem to diminish. Even negative marginal products of public capital can be detected in some cases, see Perotti (2007). According to the VAR presented by Kamps (2005) shocks to public capital tend to have significant positive GDP effects for the majority of OECD countries, but the elasticities are usually well below unity. Eventually, the high returns to public capital obtained for some countries by the production function approach might be related to the inappropriate exclusion of feedback effects running from output to public capital. Similarly, Afonso und Aubyn (2009) reported mixed evidence. Crowding-in effects of public investment dominate for some countries, but crowding out effects for others. The reversed causation appears to be even more general. In fact, an acceleration of private investment raises GDP and increases tax revenues to spend for public investment. Based on a panel VAR approach Marattin and Salotti (2011) concluded that

shocks in fiscal spending exert positive effects on private consumption and investment in the euro area. Using meta regression techniques, Bom and Ligthart (2009) find rather high output elasticities of public investment close to the evidence presented in the early time series literature.

The integration properties of the variables have been often neglected in many studies. Therefore, this paper provides new evidence on the relationship between private and public investment. In contrast to previous papers, an approach encompassing stocks and flows is considered. In fact, deviations from a long run equilibrium between the capital stocks might be relevant to drive private investment. Both the private and public capital stocks are integrated of order two, $I(2)$. Therefore, potential cointegration between the capital stocks does not imply a (trend) stationary equilibrium error. Indeed, there is strong evidence for cointegration between the stocks, but the deviations from the relationship are $I(1)$. Utilizing them in a model for gross investment flows improves the cointegration evidence between the other $I(1)$ variables. Private investment, GDP and the real interest rate appear to be cointegrated, especially if the deviations from the stock equilibrium are added. The corresponding error correction equation is well behaved to explain changes in private investment flows. As a similar equation does not hold for public investment, the latter series can be seen as weakly exogenous with respect to the stock equilibrium. Thus, the lack of public investment may have restricted private investment and GDP growth in the euro area.

The results have strong implications for the appropriate design of future fiscal austerity programs to combat the euro area debt crisis. In particular, economic growth could benefit from fiscal reforms. For example, the exclusion of national co-funding of EU-supported investments programs from the fiscal indicators covered by the Stability and Growth Pact can be a sensible strategy to support the economic development (Barbiero and Darvas, 2014). The recently introduced European Semester directed to better monitor fiscal planning at the individual country level should encourage higher investment activities in the member states, especially of those with rather healthy public finances and low public investment rates.

The rest of the paper is structured as follows. The next section (Section 2) motivates a long-run equilibrium between private and public capital stocks. While Section 3 discusses the econometric methodology, Section 4 holds the empirical results. Finally, Section 5 concludes with some policy recommendations.

## 2 Long run equilibrium between private and public capital

To address the possible crowding-in effect of government investment spending it is necessary to examine the relationship between private and public capital. Assuming a Cobb-Douglas production function with constant returns to scale, output *Y* is related to technical progress *A*, labour *L*, private capital *K* and public capital *G*, i.e.

(1) $$Y_t = A_t L_t^{\alpha} K_t^{\beta} G_t^{\gamma}$$

The parameters *α*, *β* and *γ* denote production elasticities. While the marginal product of private capital is *βY*/*K*, the marginal product of public capital is *γY*/*G*. In equilibrium, the marginal products should be equal to the respective real interest rates

(2) $$\beta Y_t / K_t = rp_t \quad , \quad \gamma Y_t / G_t = rg_t$$

in the private (*rp*) and public sector (*rg*). As the interest rates are subject to arbitrage, they will eventually move in parallel, despite possible differences related to risk premia (Hatano, 2010). If the interest rates maintain a constant ratio, *rp*=*λrg*, one can obtain

(3) $$K_t = \frac{\beta}{\lambda\gamma} G_t$$

implying that private and public capital stocks are cointegrated. If the marginal products are equalized, the cointegration parameter will simply reflect the ratio of the production elasticities. Note that a direction of causality is not assumed by the argument. However, if public investment can be considered as exogenous, private investment will react to deviations from the long run, implying that deviations from the cointegrating relationship can be seen as a driver for private investment. The potential long run equilibrium between the capital stocks might be crucial to drive private investment flows, besides the standard determinants such as economic activity and user costs of capital.

## 3 Panel integration and cointegration

The integration properties of the variables involved determine the appropriate specification of the empirical model. However, it has been widely acknowledged that standard unit root and cointegration tests can have low power against stationary alternatives. Panel tests make pro-

gress in this respect. Since the time series dimension is extended by the cross section, inference relies on a broader information set. Gains in power are expected, and more reliable evidence can be obtained. In the case of dependent panel members, cross section correlation can distort the results. To obtain reliable evidence, the integration and cointegration tests should take international spillovers into account. In order to check the unit root properties of the variables involved, the CADF test suggested by Pesaran (2007) is applied. The standard ADF equation

$$(4) \qquad \Delta y_{it} = \alpha_i + \delta_i y_{it-1} + \lambda_i \bar{y}_{t-1} + \theta_i \Delta \bar{y}_{t-1} + u_{it} \quad , \quad \bar{y}_t = N^{-1} \sum_{i=1}^{N} y_{it}$$

is extended with cross section averages of the lagged levels and first differences of the series of interest. The regression is estimated for each panel member and can be extended by lagged values of the endogenous variable to account for serial correlation in the residuals. Testing for the null hypothesis of a unit root is based on the *t*-ratio of the first order autoregressive parameter ($\delta$). To construct the panel statistic, the *t*-values are pooled across individuals. A standardized version is asymptotically distributed as standard normal under the joint null hypothesis of nonstationarity for all individuals. If the null is rejected, the series is stationary at least for one panel member.

The cointegration properties are investigated by the panel and group mean statistics suggested by Westerlund (2007). They do not rely on a potential inappropriate common factor restriction such as tests based on the residuals obtained from static relationships; see Kremers, Ericsson and Dolado (1992). The null hypothesis of no cointegration between *y* and *x* is evaluated by testing whether the feedback parameter ($\gamma$) in a conditional panel error-correction model

$$(5) \qquad \Delta y_{it} = \alpha_i + \gamma_i y_{it-1} + \lambda x_{it-1} + \sum_{j=1}^{p} \theta_i \Delta y_{it-j} + \sum_{j=-q}^{p} \beta_i \Delta x_{it-j} + u_{it}$$

is equal to zero. Error-correction models are estimated separately for the panel members and the statistics are pooled along different principles. Testing can be done under two variants of the alternative. If the null hypothesis is rejected, cointegration is assumed to hold for all units in case of the panel statistic, and at least for one country in the group statistic. All tests are asymptotically distributed as standard normal and can account for individual short-run dynam-

ics, trend and slope coefficients. Leads and lags of differenced variables can be included due to information criteria. Since the cross sections are not independent, critical values are obtained by bootstrap methods.

Note that panel cointegration tests do not reveal the long run parameters. Their aim is to identify reliable empirical models of integrated variables to avoid spurious regressions. Therefore, after testing for cointegration, the long run is estimated via panel regression with fixed effects and contemporaneous correlation in the residuals. This approach is valid, if cointegration has been confirmed, i.e. if spurious regressions can be excluded. While the intercept, short run coefficients and error variances can differ across the panel members, the long run coefficients are restricted to be identical over the cross section.

## 4 Data issues and empirical evidence

Evidence on the link between public and private investment is based on annual data for the 1991-2012 period. The panel is based on 12 euro area member states, comprising Germany, France, Italy, Spain, Portugal, Greece, Ireland, Austria, Finland, Netherlands, Belgium and Luxembourg. Countries that joined the monetary union in recent years are excluded due to the lack of data. All series are taken from the AMECO database which is provided by the European Commission.

While net investment flows are available at the sectoral level, capital stock data refer to the entire economy. To construct private and public capital stocks, net investment flows are cumulated. Starting values result from a decomposition of the total capital stock in an initial period (1990). In fact, the share of public capital is assumed to be equal to the ratio of cumulated net public investment to cumulated net overall investment, where the 1980s are taken as the reference period. The variables are divided by the appropriate deflator (2005=100) to obtain series in real terms.

Fundamental determinants of investment are also considered to assess the robustness of the results. Real GDP and real interest rates are included as a proxy for overall demand and financing costs to invest, respectively. To obtain real GDP, the nominal series is deflated by the GDP deflator (2005=100). Real interest rates are defined in an ex post manner as the difference between the long term nominal interest rate and inflation, i.e. the annual change in the GDP deflator. Furthermore, Brautzsch and Dreger (1999) noted that the government debt ratio can

potentially explain private investment in Germany. An increase in the debt ratio worsens the financial conditions via higher real interest rates and could restrict future demand, as investors might fear stronger efforts towards fiscal consolidation in later periods. Mehrotra and Välilä (2005) found a negative effect of high public debt on public investment in a panel cointegration model for EU member states. In line with the Maastricht criterion, the debt ratio is defined as the ratio between gross government debt and GDP. All variables are measured in logs, except of real interest rates.

*-Table 1 about here-*

The unit root properties of the variables are exhibited in Table 1. According to the evidence capital stocks include two unit roots. This is in contrast to results of Calderón, Moral-Benito and Servén (2014), who find that the capital stock is *I*(1) in panel of 88 countries including rich and developing countries. The other variables are nonstationary in levels and stationary in their first differences. As real interest rates and government debt ratios cannot move without bounds, the outcome may be doubted for these variables from a theoretical perspective. However, they appear to be integrated in a statistical sense and should be treated as such in the empirical analysis.

*-Table 2 about here-*

The cointegration evidence is exhibited in Table 2. Private and public capital stocks tend to move together in the long run. This result can be detected both in terms of the panel and group statistics. Apart from country fixed effects, the deviations from the long run relationship evolve according to

$$DEV_t = CS\_PRI_t - \underset{(0.002)}{0.604} CS\_PUB_t . \quad (6)$$

The cointegrating vector has been arbitrarily normalized to the coefficient of the private capital stock, and standard errors are given in parentheses. A one percent increase in the public capital stock is associated with a 0.6 percent rise in the private capital stock. According to the

evidence shown in Table 1, the deviations from the cointegration relationship are not stationary, but include a random walk component. Therefore, the subsequent analysis can be done in terms of *I*(1) variables, where the capital stocks are implicitly embedded through their linear combination.

Table 2 holds the cointegration properties for several subsets of variables. The aim is to identify suitable environments for cointegration. The standard determinants for private investment are related to economic activity and user costs of capital. While the former is usually measured by GDP, the latter is proxied by the real interest rate (Eklund, 2013). This constitutes the benchmark model, which is subsequently enlarged. If the government debt ratio or public investment are added to the variables, the cointegration property is lost. Although government debt might be relevant for private investment in Germany, such a result does not generalize to the entire euro area. Despite the fact that the capital stocks are cointegrated, gross investment flows are probably not. This explains why many authors preferred models in first differences to study the linkages between private and public investment, such as Afonso and Aubyn (2009). Evidence for cointegration is mixed even in the benchmark specification, comprising private investment, GDP and the real interest rate, as panel and group statistics point to the opposite direction. However, if deviations from the stock equilibrium are added, cointegration holds in any case. Thus, the model including private investment flows, GDP, the real interest rate and the deviations from the long run between the capital stocks is superior. Apart from country fixed effects, the long run relationship is given by

$$PRI_t = \underset{(0.044)}{1.058} Y_t - \underset{(0.002)}{0.027} R_t - \underset{(0.023)}{0.384} DEV_{t-1} \tag{7}$$

All variables are correctly signed and highly significant, where standard errors are given in parentheses. As expected, private investment flows will be stimulated by GDP in the long run. In contrast, a rise in the real interest rate will trigger a decline in private investment activities. Note that the lagged deviations from the stock equilibrium enter with a negative sign. If the private capital stock increases relatively to the public capital stock, private investment will be reduced subsequently.

Two error correction specifications are run to explain private investment growth (Table 3). The first one includes only the error correction term, i.e. the lagged deviations from equation (7). The other one accounts for short run effects. An error correction mechanism is highly significant, correctly signed and the coefficient is of similar size in both specifications. While fluctua-

tions in GDP and the real interest rate are additionally relevant to explain private investment growth there is no short run effect of public investment. Nonetheless, there is a long run crowding in effect of public investment due to the cointegration property between the capital stocks.

## 5 Conclusions

This paper explores the long run relationship between public and private investment in the euro area. Panel econometric techniques allowing for international spillovers are employed. Private and public capital stocks are both I(2) and cointegrated. The deviations from the stock equilibrium are not (trend) stationary, but *I*(1). Utilizing them in a model for investment flows improves the cointegration evidence between the *I*(1) variables. In fact, private investment flows, GDP and the real interest rate appear to be cointegrated when the deviations from the stock equilibrium are included. The corresponding error correction equation is well behaved if changes in private investment flows are explained.

Thus, the lack of public capital as a result of weak public investment might have restricted private investment and GDP growth in the euro area. The results have strong implications for the future direction of fiscal austerity programs to combat the euro area debt crisis. In particular, economic growth in the euro area could benefit from further fiscal reforms. A modified framework should encourage higher investment by the member states, in particular of those with healthy public finances and low public investment rates. This would be part of an integrated approach to overcome the crisis and to achieve a path of stronger GDP growth in the future.

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Table 1: Tests for integration properties according to Pesaran (2007)

| | Levels | First differences | Decision |
|---|---|---|---|
| *CS_PRI* | 0.695<br>(0.756) | 0.624<br>(0.734) | *I*(2) |
| *CS_PUB* | 0.215<br>(0.585) | -1.402<br>(0.080) | *I*(2) |
| *PRI* | 0.341<br>(0.633) | -2.859<br>(0.002) | *I*(1) |
| *PUB* | -0.245<br>(0.403) | -3.561<br>(0.000) | *I*(1) |
| *Y* | 0.205<br>(0.581) | -2.264<br>(0.012) | *I*(1) |
| *R* | 1.203<br>(0.886) | -3.105<br>(0.001) | *I*(1) |
| *DEBT* | 1.000<br>(0.841) | -3.418<br>(0.000) | *I*(1) |
| *DEV* | -0.108<br>(0.457) | -2.820<br>(0.002) | *I*(1) |

Note: 12 euro area countries (Germany, France, Italy, Spain, Portugal, Ireland, Austria, Finland, Netherlands, Belgium, Luxembourg and Greece, 1991-2012). Variables are private investment (*PRI*), public investment (*PUB*), GDP (*Y*), real interest rate (*R*), government debt ratio (*DEBT*). *CS_PRIV* and *CS_PUB* refer to the private and public capital stock, respectively. Selection of lags and deterministic terms are based on Akaike criterion. Entries are test statistics, *p*-values in parentheses.

Table 2: Tests for cointegration properties according to Westerlund (2007)

| | Panel statistic | Group statistic |
|---|---|---|
| *CS_PRI, CS_PUB* | -5.522<br>(0.000) | -3.768<br>(0.002) |
| *PRI, Y, R* | -2.513<br>(0.030) | -1.097<br>(0.110) |
| *PRI, Y, DEBT* | 0.079<br>(0.445) | 0.493<br>(0.445) |
| *PRI, PUB, Y, R* | -0.401<br>(0.195) | 0.311<br>(0.285) |
| *PRI, Y, R, DEV* | -3.344<br>(0.000) | -4.182<br>(0.005) |

Note: See Table 1. Selection of lags and deterministic terms are based on Akaike criterion. Entries are test statistics, *p*-values in parentheses. The *p*-values are based on bootstrap methods, where 200 replications are used. See Persyn and Westerlund (2008) for details.

Table 3: Error correction models for private investment

| | Δ*PRI* | Δ*PRI* |
|---|---|---|
| Δ*PUB* | | 0.008 (0.016) |
| Δ*Y* | | 0.631 (0.062) |
| Δ*R* | | -0.009 (0.001) |
| ECM(-1) | -0.215 (0.027) | -0.326 (0.036) |
| *R-Squared* | 0.213 | 0.493 |
| *F-Statistic* | 6.384 (0.000) | 16.467 (0.000) |

Note: See Table 1. Panel regression with country fixed effects and cross section correlation in the residuals. Figures in parentheses denote standard errors, and *p*-values in case of the *F*-statistic. R-Squared is the adjusted coefficient of determination.