The Impact of Public Investment on Private Investment in the Euro Area*

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Summary: This paper explores the long-term relationship between public and private investment in the euro area. A stock-flow approach is proposed to control for the integration properties of the variables. Panel econometric techniques including international spillovers are employed. Private and public capital stocks are cointegrated. However, the residuals from the stock equilibrium are not (trend) stationary, but rather include a random walk component. Nonetheless, they can be exploited to improve the model for private investment flows. In fact, standard models that include private investment flows, GDP, and the real interest rate are only valid if the deviations from the stock equilibrium are considered. The corresponding error correction equation is well behaved, as deviations from the stock relationship are crucial for explaining the changes in private investment. Thus, the lack of public investment may have been restricting private investment and GDP growth in the euro area.

1   Introduction

The Stability and Growth Pact introduces upper ceilings for public debt that are usually seen as a precondition for higher and sustainable GDPs in the Economic and Monetary Union. According to the pact, annual budget deficits should not exceed 3 percent, and debt-to-GDP ratios should not exceed 60 percent. If a member state breaches these limits, corrective actions and even economic sanctions can be implemented. While the pact was initially routinely broken and watered down, particularly at the request of large member states before the crisis, it has since become more stringent in order to restore confidence in international financial markets. To foster the sustainability of public finances, austerity measures have been implemented. They are part of the restructuring process, particularly within countries in emergency. Several euro area countries (Greece, Spain, Portugal, and Ireland) were unable to refinance their debt or bail out over-indebted banks under their supervision without supranational assistance. Greece still receives conditional support from the European Stabilization Mechanism (ESM) in exchange for structural reforms and progress in the consolidation of government finances. Lower deficits enabled Ireland, Portugal, and Spain to leave the ESM umbrella.

While fiscal austerity can be beneficial to foster GDP growth in the long term, the impacts in the short and medium term are often negative (Perotti 2011). The consolidation of public finances through a reduction of fiscal expenditures and an increase in taxes hav depressed the economy in many countries (Auerbach and Gorodnichenko 2012, Dreger and Reimers 2013). Unemployment rates exceed 25 percent in Greece and Spain, and unemployment among youth is even higher. As the recovery will likely be modest, this job crisis could persist for many years. Public investment is *de facto* exposed to a reduction in spending. Cuts in investment are easier to implement than is a reduction in social transfers. While the share of public investment in overall public spending in Greece exceeded 12 percent before the crisis, it has since dropped by more than half. Although there has been some recovery in the past few years, the share is still far below the pre-crisis level. Public investment expenditures have displayed more stability in the large euro area countries over the past two decades, but the ratios are still quite low, especially in the German economy. The small levels are the result of previous consolidation efforts. In fact, the ratio was just under 10 percent in the early 1980s (Figure 1).

The low-inflation environment makes fiscal consolidation even harder. With low inflation rates, nominal GDP growth declines, thereby raising the debt-to-GDP ratios. In addition, a fall in inflation leads to higher real interest rates if nominal interest rates are fixed at the zero lower bound. Increasing real interest rates can crowd out private consumption and investment. Fostering economic growth in times of debt is a main challenge for policymakers. The modest investment performance is one of the main reasons why the economic recovery in Europe has so far been rather weak despite still-favorable financial conditions. In fact, cuts in public investment might be responsible for this development, as lower public investment might undermine private investment activities. Therefore, this study looks at the relationship between public and private investment for the euro area.

From a theoretical perspective, evidence for positive and negative effects should be expected. If public and private sectors compete for the same resources in the economy, an acceleration of public investment will raise the user costs of capital, implying a decline in private investment. Public investment needs to be financed, which can lead to a higher tax burden or higher demand of governments for capital market funding, causing real interest rates to rise. Therefore, private

Figure 1

Public investment in several euro area countries
In percent of total public expenditures
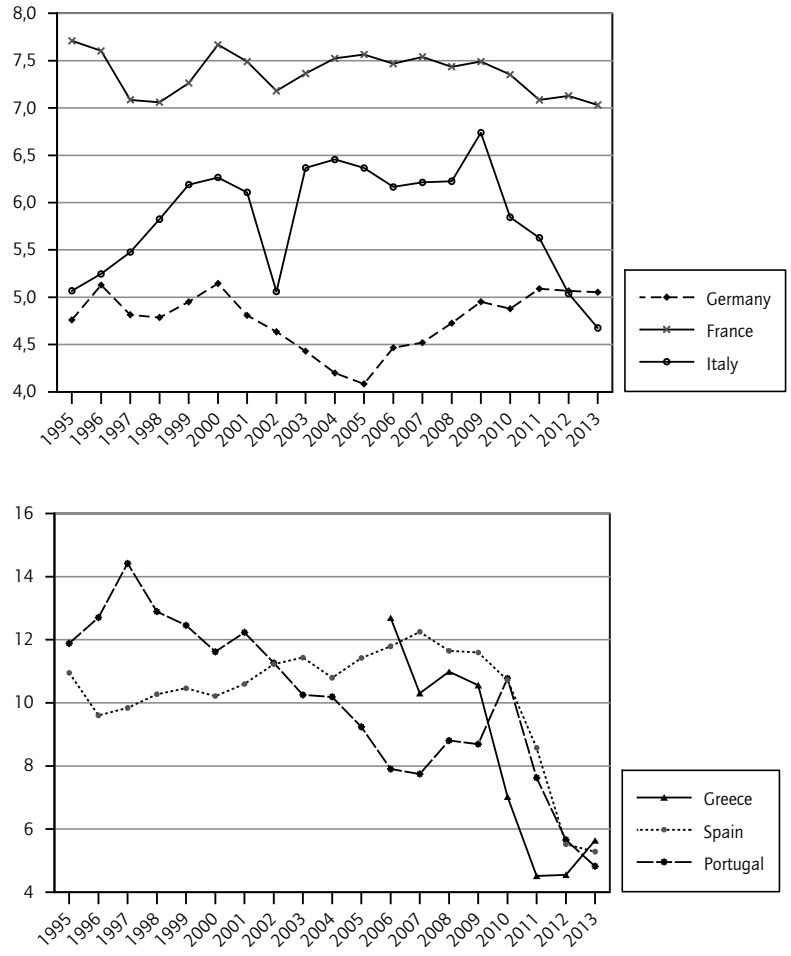
Source: AMECO database.

investment's crowding-out effects are to be expected and tend to be reinforced in times of crisis, as higher government debt can increase country-specific risk premia and interest rates. This argument would be even more valid for highly indebted countries. However, public investment may also create more favorable conditions for private investment: for example, by providing better infrastructure. The existence of facilities and the availability of common public goods can raise the productivity of private investment, which might take advantage of improved business conditions. For example, public investment in energy, telecommunications, or other network industries may have stimulated private investment (Pereira and Andraz 2013).

Because of the opposite effects, the net impact of public investment on private investment cannot be determined in advance, and must be examined on empirical grounds. Previous studies have delivered inconclusive results. As the net impact comprises both static and dynamic effects, any analysis should distinguish between the short run and the long-run. While crowding-out is mainly a short-run effect related to restrictions on available resources, crowding-in is long-lasting and can be traced to the higher productivity of private capital.

Using a neoclassical production function approach, Aschauer (1989) emphasized the possibility that public investment may induce private investment. Although higher public capital accumulation tends to raise overall investment above the level chosen by rational agents, crowding-in effects will dominate in the end. An expansion of public capital is expected to increase the rate of return to private capital, thereby leading to higher private capital accumulation and economic growth. Similarly, Baxter and King (1993) argued that public investment could stimulate private investment and output. Research based on regional production functions, disaggregated public capital, and industries arrived at similar results, particularly for roads and highways. Argimón, González-Páramo, and Roldán (1997) reported significant crowding-in effects of public investment on private investment for OECD countries due to the positive impact of infrastructure on productivity. In contrast, government consumption will crowd out private investment.

The positive view of public investment lacks robustness, as the empirical methodology plays a crucial role. The aforementioned studies take the time series in levels, thereby ignoring their nonstationarity. In addition, fixed effects are neglected in pooled models. If production functions are estimated using differenced data instead of the level series, or if pooled regressions are carried out with fixed effects, crowding-in findings seem to diminish. Even negative marginal products of public capital are detected in some cases (Perotti 2007). According to Afonso und Aubyn (2009), the effects are heterogeneous across countries. The estimated elasticities are also biased due to simultaneity. An acceleration of private investment raises the GDP and increases tax revenues that can be used for public investment.

This paper provides new evidence on the relationship between private and public investment. An approach encompassing stocks and flows is proposed. Although the distinction between stocks and flows is justified from the theoretical perspective, it has been largely ignored in the aforementioned studies. In fact, deviations from the equilibrium between the capital stocks can be relevant to drive private investment flows. Indeed, there is strong evidence for an equilibrium between the stocks, but the deviations are not stationary. Nonetheless, their inclusion in flow models can substantially improve the performance of standard investment equations. The corresponding error correction equation is well behaved and can explain the changes in private investment flows.

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 reviews the econometric methodology, Section 4 holds the empirical results. Finally, Section 5 concludes with some policy recommendations.

2   Long-term equilibrium between private and public capital

To address the possible existence of crowding-in effects of public investment spending, it is necessary to investigate 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, labor L, private capital K, and public capital G, i.e.

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

The parameters α, β, and γ denote production elasticities, while the marginal product of private capital is $\beta Y/K$, and the marginal product of public capital is $\gamma Y/G$. In equilibrium, the marginal products should be equal to the real interest rates

$$\beta Y_t / K_t = rp_t, \quad \gamma Y_t / G_t = rg_t \tag{2}$$

in the private (rp) and public sector (rg). As the interest rates are subject to arbitrage, they will move in parallel, despite possible differences related to risk premia (Hatano 2010). In the case of a constant ratio between the interest rates, $rp = \lambda rg$, one can obtain

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

implying that private and public capital stocks are well connected in the long-run. If the marginal products are equalized, the cointegration parameter will 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 equilibrium between the capital stocks might be crucial for driving private investment flows apart from the standard determinants such as economic activity and user costs of capital.

3   Panel integration and cointegration

Because the variables involved are non-stationary, an integration and cointegration analysis is the way to proceed. This is done within a panel framework, where the euro area countries constitute the cross section. Since the time series dimension is extended by the cross section, the panel environment will increase the power of tests compared to time series alternatives. For this reason, the panel evidence should be more reliable. However, no country-specific evidence can be extracted. A further problem arises if the panel members are not independent, as cross-sectional correlation can distort the test statistics. Dependencies are rather likely for the current application, as the euro area countries are exposed to common shocks. Therefore, tests to check the integration and cointegration properties should take potential international spillovers into account.

The CADF test suggested by Pesaran (2007) is applied to check for the non-stationarity of the variables in the study. It extends the standard IPS test with a factor controlling for cross-sectional correlation. The cointegration properties are examined using the panel and group mean statistics suggested by Westerlund (2007). These tests do not rely on inappropriate common factor restric-

tions such as tests based on 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 in a conditional panel error-correction model is equal to zero. Error-correction models are estimated separately for the panel members. Thus, heterogeneity between countries can be embedded, but it is restricted to the deterministic components like constant and trends, and to the short-run dynamics. Afterwards, the statistics for the feedback parameter 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 countries in the case of the panel statistic, and at least for one country in the group statistic. Since the cross sections are not independent, critical values are obtained using bootstrap methods.

Note that panel cointegration tests do not reveal the long-run parameters. Their aim is to identify reliable empirical models of nonstationary 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 is confirmed in the previous step. While the intercept, short-run coefficients, and error variances can differ across the panel members, the long-run coefficients are kept the same 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 twelve euro area member states, including Germany, France, Italy, Spain, Portugal, Greece, Ireland, Austria, Finland, Netherlands, Belgium, and Luxembourg. Countries that only recently joined the monetary union 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 ensure the robustness of the results. Real GDP and real interest rates are included as a proxy for overall demand and for financing costs to invest, respectively. To obtain real GDP, the nominal series are 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 could 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) reported a negative effect of high public debt on public investment in a panel cointegration model for EU member states. According to the Maastricht criteria, the debt ratio is the ratio be-

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Table 1

Tests for integration properties

	Levels	First differences	Decision
CS_PRI	0.695 (0.756)	0.624 (0.734)	I (2)
CS_PUB	0.215 (0.585)	–1.402 (0.080)	I (2)
PRI	0.341 (0.633)	–2.859 (0.002)	I (1)
PUB	–0.245 (0.403)	–3.561 (0.000)	I (1)
Y	0.205 (0.581)	–2.264 (0.012)	I (1)
R	1.203 (0.886)	–3.105 (0.001)	I (1)
DEBT	1.000 (0.841)	–3.418 (0.000)	I (1)

Note: Test according to Pesaran (2007). 12 euro area countries (Germany, France, Italy, Spain, Portugal, Ireland, Austria, Finland, Nether-lands, Belgium, Luxembourg and Greece, 1991–2012). Variables are private investment (*PRI*), public investment (*PUB*), GDP (*Y*), real interest rate (*R*), government debt to GDP 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.

Source: Own calculations.

tween gross government debt and GDP. All variables are measured in logs except for real interest rates, which are measured in percent.

The non-stationarity properties of the variables are exhibited in Table 1. According to the evidence, capital stocks include two unit roots. This stands in contrast to results obtained by Calderón, Moral-Benito, and Servén (2014), who find that the capital stock includes only one unit root in a panel of 88 countries that includes both rich and developing countries. All other variables are nonstationary in levels and stationary in their first differences, i. e. integrated of order one, $I(1)$. As real interest rates and government debt ratios cannot move without bounds, the outcome for these variables may be dubious from a theoretical standpoint. However, they appear to be integrated in a statistical sense and should be treated as such in the empirical analysis.

While private and public capital stocks are both $I(2)$, they are connected in the long-run. In fact they are cointegrated, according to both the panel and group statistics (Table 2). The deviations from the cointegrating relationship are non-stationary (test statistic –0.108, *p*-value 0.457), but due to the cointegration result, they possess only one unit root, as their difference is clearly stationary (test statistic –2.820, *p*-value 0.002). Apart from country fixed effects, the deviations from the stock relationship evolve according to

$$DEV_t = CS\_PRI_t - \underset{(0.002)}{0.604}\,CS\_PUB_t \quad \sim \quad I(1) \tag{4}$$

where the cointegrating vector has been normalized to the coefficient of the private capital stock, and standard errors are displayed in parentheses. A one percent increase in the public capital

Table 2

Tests for cointegration properties

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

Note: See Table 1. Tests according to Westerlund (2007). 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.

Source: Own calculations.

stock is associated with a 0.6 percent rise in the private capital stock. The deviations can extend the set of $I(1)$ variables to improve standard models for private investment demand. Note that the capital stocks can enter these models only implicitly 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 defines the benchmark model, which is subsequently enlarged. If the government debt to GDP 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, as emphasized by Brautzsch and Dreger (1999), this result does not generalize to the entire euro area. Despite the fact that the capital stocks are related in the long-run, gross investment flows are definitely not. This explains why many authors, such as Afonso and Aubyn (2009), preferred models in first differences to study the linkages between private and public investment. 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 every case. Overall, the model that includes private investment flows, GDP, the real interest rate, and the deviations from the capital stock relationship is superior. Apart from country fixed effects, the long-run equation is given by

$$PRI_t = \underset{(0.044)}{1.058}\, Y_t - \underset{(0.002)}{0.027}\, R_t - \underset{(0.023)}{0.384}\, DEV_{t-1} \tag{5}$$

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

Table 3

Error correction models for private investment

	ΔPRI	ΔPRI
ΔPUB		0.008 (0.016)
ΔY		0.631 (0.062)
ΔR		−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-sectional 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.

Source: Own calculations.

capital stock increases relative to the public capital stock, private investment will consequently be reduced.

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 (5). The other one accounts for additional short-run effects. An error correction mechanism is highly significant and correctly signed, and the coefficient is of similar size in both specifications. While fluctuations in GDP and the real interest rate are also relevant to explain private investment growth, there is no short-run effect of public investment. Nevertheless, there is a crowding-in of public investment in the long-run due to the cointegration property between the capital stocks.

5 Conclusions

This paper explores the long-term relationship between public and private investment in the euro area. In contrast to previous studies, a stock-flow approach is employed to control for the different stochastic trends embedded in stock and flow variables. Panel econometric techniques are employed. Private and public capital stocks are cointegrated, but the deviations from the stock equilibrium are not (trend) stationary. However, utilizing them in a model for investment demand improves the cointegration evidence between the flows. In fact, private investment flows, GDP, and the real interest rate appear to be cointegrated only if the deviations from the stock equilibrium are included. The corresponding error correction equation is well behaved.

Overall, 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 proper design of future fiscal austerity programs to combat the euro area debt crisis. In particular,

economic growth in the euro area could benefit from further fiscal reforms. Excluding national co-funding of EU-supported investment programs from the fiscal indicators covered by the Stability and Growth Pact could be a sensible strategy for supporting the investment performance and overall economic development in the euro area (Barbiero and Darvas 2014). The recently introduced European Semester, created to better monitor fiscal planning for individual countries, should encourage higher investment activities in member states, especially among those with rather healthy public finances and low public investment rates. This could be part of an integrated approach to overcome the crisis and achieve a path of stronger GDP growth in the future.

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