Port Econ J (2019) 18:47–65
https://doi.org/10.1007/s10258-018-0143-7

ORIGINAL ARTICLE

Economic growth, public, and private investment returns in 17 OECD economies

António Afonso[1] · **Miguel St. Aubyn**[1]

Received: 10 July 2017 / Accepted: 15 February 2018 / Published online: 26 February 2018

Abstract We study the macroeconomic effects of public and private investment in 17 OECD economies through a VAR analysis with annual data from 1960 to 2014. From impulse response functions we find that public investment had a positive growth effect in most countries, and a contractionary effect in Finland, UK, Sweden, Japan, and Canada. Public investment led to private investment crowding o ut in Belgium, Ireland, Finland, Canada, Sweden, the UK and crowding-in effects in the rest of the countries. Private investment has a positive growth effect in all countries; crowds-out (crowds-in) public investment in Belgium and Sweden (in the rest of the countries). The partial rates of return of public and private investment are mostly positive. Our results are robust to the ordering of private and public investment in the VAR.

Keywords Fiscal policy · Public investment · Private investment · Crowding-in · Macroeconomic rates of return · Impulse response functions · VAR

JEL Classification C32 · E22 · E62

1 Introduction

The 2008–2009 economic and financial sovereign debt crisis led to a substantial drop in both GDP and investment levels and growth rates. Moreover, it led to substantial changes in economic policy, namely budgetary policy. Under budgetary duress, the level of government indebtedness is deemed to have a negative impact on public

✉ António Afonso
aafonso@iseg.utl.pt

Miguel St. Aubyn
mstaubyn@iseg.utl.pt

[1] REM – Research in Economics and Mathematics, UECE – Research Unit on Complexity and Economics, ISEG-UL – Universidade de Lisboa, R. Miguel Lupi 20, 1249-078 Lisbon, Portugal

investment in EMU member countries (see, for instance, Turrini 2004, for the cases in the 1980s and in the 1990s). In fact, the abovementioned changes took in several countries the form of reduced expenditure, including public investment, and increased taxation. It is expectable that these changes may well constitute a policy regime change with structural implications on previous estimations regarding the relevance of investment for long-term growth.

Additionally, such policy changes, and especially in euro area countries following adjustment programs, notably after the 2008–2009 economic and financial crisis, came with an emphasis on structural reforms that concern public spending levels and structure, and more generally, the way the economy and markets operate. It becomes then important to test if macroeconomic efficiency changes effectively occurred, and in what direction. For instance, Afonso and Jalles (2015) argue that the relevance of fiscal components differs for private and public investment developments.

Understanding and measuring linkages between public and private investment and economic growth is of crucial importance in both developed economies and emerging markets. Public investment is a part of public expenditure (typically accounted for in the General Government) and decisions are taken within the larger framework of public finance. At the same time, it constitutes an addition to public capital. The latter, together with private and human capital, labour and other inputs, is in several approaches considered as a production factor. Public investment may therefore be linked to growth prospects. However, and as it is well documented in the literature, as part of public expenditure, it may crowd other types of investment, namely private, so that in some circumstances the net impact of public investment on GDP may be negative (see, for instance, Dreger and Reimers 2016; Cavalcanti et al. 2014; IMF 2014).

At the same time, note the importance of public investment in the fiscal surveillance mechanisms of the EU, where n° 3 of Article 126 of the Treaty of the European Union (TEU 2012) reads:

> "If a Member State does not fulfil the requirements under one or both of these criteria, the Commission shall prepare a report. The report of the Commission shall also take into account whether the government deficit exceeds government investment expenditure and take into account all other relevant factors, including the medium-term economic and budgetary position of the Member State",

which indicates the preference for some Golden Rule based approach for public investment.

Moreover, the EC (2015) presented a new Investment Plan for Europe in support of its investment, structural reforms and fiscal responsibility strategy. Once more, the emphasis on investment is stressed, and a European Fund for Strategic Investments (EFSI) is created to promote the European Commission's Investment Plan for Europe, where it is mentioned, "co-financed expenditure should not substitute for nationally financed investments, so that total public investments are not decreased."[1]

[1] Regarding the so-called Juncker plan Le Moigne et al. (2016) argue, in the context of an estimated DSGE model of the Eurozone economy, that it would have had a positive growth impact if it had been implemented at the beginning of the global economic and financial crisis.

In this paper, we contribute to the literature by using a VAR analysis for 17 OECD countries between 1960 and 2014 to assess the effects of public and private investment in terms of economic growth, crowding-out and crowding-in effects. In that context, we also compute public and private investment macroeconomic rates of return, and assess the potential effect of the 2008 economic and financial crisis, by comparison with previous shorter time span research, obtained before the crisis. In practice, we deal with investment in conventional private investment goods done by either the public sector (or more specifically the general government) or the private sector.

Our analysis provides notably the following results: public investment had a positive growth effect in most countries, and a contractionary effect on output in Finland, UK, Sweden, Japan, and Canada. A positive public investment impulse implies private investment crowding-out in Belgium, Ireland, Finland, Canada, Sweden, the UK and crowding-in effect on private investment in the rest of the countries; private investment had a positive growth effect in all countries; private investment crowds-out public investment in Belgium and Sweden and crowds-in public investment in the remainder of the countries.

Moreover, the partial rate of return of public investment is mostly positive and the partial rate of return of private investment is only negative in Greece and marginally in Belgium.

Finally, our main results are kept once we assess its robustness by changing the ordering of the variables in the VAR, notably having private and public investment alternatively first (most exogenous) and second (less exogenous).

The organization of the paper is as follows. In Section 2 we briefly review the literature and previous results. Section 3 outlines the analytical framework. In Section 4 we present and discuss our results. Section 5 is the conclusion.

2 Literature

There are several techniques and results that allow for crowding-in and crowding-out effects of public investment (see Afonso and St. Aubyn 2009, 2010). Namely, and within a vector autoregression analysis, different rates of return are estimated. The total investment rate of return takes into account both private and public investment costs, while a partial rate of return only considers public investment as compared to GDP returns.

In Afonso and St. Aubyn (2009, 2010), the extent of crowding in or crowding-out of both components of investment was assessed and the associated macroeconomic rates of return of public and private investment for each country were computed from impulse response functions. Results showed the existence of positive effects of public investment and private investment on output. Crowding-in effects of private investment on public investment were more generalized then the reverse case.

These regularities are likely to be affected by major policy changes after 2009, namely due to the financial and sovereign debt crisis. In this paper, we intend to make further progress in this area of research, namely by studying the impact of the recent financial and sovereign debt crisis on the linkages between public and private investment and economic growth.

In the context of assessing fiscal consolidation in the European Union, Pereira and Pinho (2011) use a VAR set up to find that public investment crowds in both employment and private investment for several countries. Hence, there seems to be a trade-off regarding the decrease of public investment for fiscal consolidations purposes.

Within a panel assessment for the period 2000–2009, for 38 developing and developed countries, Mahmoudzadeh et al. (2013) report for that private investment reacts positively with respect to government capital formation and the complementary effect is greater than in the developing countries. On the other hand, the elasticity of private investment with respect to government consumption spending is negative notably in developed countries.

IMF (2014) documents the private investment contraction in advanced economies during and after the economic and financial crisis. The "overall weakness of economic activity" is found to be the most important factor accounting for this shrinking. Our empirical modelling clearly encompasses this important channel, as private investment may react contemporaneously and/or with lags to GDP, to public investment, to taxes and to interest rates.

Creel et al. (2015) investigate the relationship between public investment and investment decisions by firms notably in a VAR model using quarterly data in the period 1966Q1-2014Q4 (data for Germany starts in 1991Q1). They find a crowding-in effect in France, a weak crowding-out effect in the US, and no robust effect in the UK and Germany.

Some recent research provides evidence that more stringent financial conditions affect both how the economy reacts to public spending and investment and how investment responds to the economy. For the specific case of Japan, and using panel data techniques, Brückner and Tuladhar (2014) show that financial distress has a significant negative effect on the local government spending multiplier, while economic slack has a positive effect. For instance, Abiad et al. (2015) for 17 OECD economies report, via model simulations, that increasing public investment increases real growth and has a crowding-in effect on private investment.

In addition, and in the same vein, but with a VAR methodology Dreger and Reimers (2016) refer that, and in what concerns the euro area, public investment decreases could have adversely affected private investment and GDP. In an interesting variation, Xu and Yan (2014) study crowding-in and crowding-out effects in China. They also resort to a VAR analysis, and divide public capital formation in investment in public goods and infrastructure provision and investment involved in the private goods. Results suggest that the first crowds in private investment while the latter leads to crowding-out.

Still in terms of country specific analysis, Funashima and Gakuin (2017) use a spatial autoregressive panel data model for 47 Japanese prefectures in the period 2001–2013, and they mention that the crowding-out effects of public investment are quite negligible.

The reader may also refer to our earlier work for further references on this subject.

Pereira (2000) introduced the estimation of macroeconomic rates of return for public investment. His VAR-based methodology was further developed by Pina and St. Aubyn (2005, 2006), who proposed the distinction between a partial and a total-cost rate of return.

This research team, in Afonso and St. Aubyn (2009, 2010), estimated these rates of return for industrialized countries and also computed private investment rates of return,

and extended previous research by considering a more complete VAR, by computing confidence bands and by generally presenting more detailed explanations and results.

3 Analytical framework

3.1 The VAR model

We estimate a five-variable VAR model for each country throughout the period 1960–2014 using annual data. As in Afonso and St. Aubyn (2010), where more detailed explanations may be found, we include five endogenous variables: the logarithmic growth rates of real public investment, *Ipub*, real private investment, *Ipriv*, real output, *Y*, real taxes, *Tax*, and real interest rates, *R*.

The VAR lag length is determined by the usual information criteria.

The VAR is identified by means of a Cholesky decomposition. Variables are ordered from the most exogenous variable to the least exogenous one, public investment being the "most exogenous". By construction, structural shocks to private investment, GDP, taxes and the real interest rate affect public investment with a one-period lag. Private investment responds to public investment in a contemporaneous fashion, and to shocks to other variables with a lag.

The VAR model in standard form can be written as

$$X_t = c + \sum_{i=1}^{p} A_i X_{t-i} + \varepsilon_t. \quad (1)$$

where X_t denotes the (5×1) vector of the five endogenous variables given by $X_t \equiv [\Delta \log Ipub_t \;\; \Delta \log Ipriv_t \;\; \Delta \log Y_t \;\; \Delta \log Tax_t \;\; \Delta R_t]'$, c is a (5×1) vector of intercept terms, A_i is the matrix of autoregressive coefficients of order i, and the vector of random disturbances $\varepsilon_t \equiv \left[\varepsilon_t^{Ipub} \;\; \varepsilon_t^{Ipriv} \;\; \varepsilon_t^{Y} \;\; \varepsilon_t^{Tax} \;\; \varepsilon_t^{R} \right]'$ contains the reduced form OLS residuals. The lag length of the endogeneous variables, p, will be determined by the usual information criteria.

Since the ordering of the variables may play a role, in a sensitivity subsection we will asses in particular how the results are affected if, for instance, it is the case that private investment is the most exohegenous variable in the VAR.

3.2 Macroeconomic rates of return

We compute four different rates of return: r_1, the partial rate of return of public investment; r_2, the rate of return of total investment (originated by an impulse to public investment); r_3, the partial rate of return of private investment; r_4, the rate of return of total investment (originated by an impulse to private investment).

We derive these rates from the VAR impulse response functions, as explained in Afonso and St. Aubyn (2009). In the remainder of this subsection we provide the economic interpretation to these variables.

The partial rate of return of public investment, r_1, compares a (partial) cost, public investment, to a benefit, GDP change, following an impulse to public investment.

The rate of return of total investment (originated by an impulse to public investment), r_2, compares the total cost (public plus induced private investment), to the same benefit, GDP change. If more public capital induces more private investment, we will call this a crowding-in case, and r_1 will exceed r_2. Moreover, if a positive impulse in public investment leads to a private investment decrease, than r_1 will be smaller than r_2.

In some cases, a positive impulse to public investment will lead to a decrease in GDP. In those occasions, it will not be feasible to compute a rate of return. Note that a negative rate of return will arise when the benefits, albeit positive, are smaller than costs.

The rates of return r_3 and r_4 concern the measurement of consequences to positive impulses in private investment. As in the case of public investment impulses, we may have that private investment leads to the crowding-in of public investment, or else that government reacts to private investment impulse by diminishing capital formation (the crowding-out case). In the latter case, r_3 will be smaller than r_4. The detailed analytics of the computation of the macroeconomic rates of return are summarised in Appendix 1.

4 Empirical analysis

4.1 Data set

We use annual data for 14 EU countries (sample in parenthesis): Austria (1965–2014), Belgium (1970–2014), Denmark (1971–2014), Germany (1970–2014), Finland (1961–2014), France (1970–2014), Greece (1973–2014), Ireland (1971–2014), Italy (1970–2014), the Netherlands (1969–2014), Portugal (1981–2014), Spain (1979–2014), Sweden (1971–2014), the UK (1970–2014), plus Canada (1964–2004), Japan (1972–2014), and the United States (1961–2014).

In order to control for the beginning of the third stage of the Economic and Monetary Union, and the launching of the euro, on the 1st of January 1999, we have used a dummy variable that takes the value one from 1999 onwards inclusively (and zero previously). Such variable is statistically significant in several countries, notably regarding the long-term interest rate.[2]

Table 1 summarises the country-specific investment series while Fig. 1 plots the 17 country averages of private and public investment-to-GDP ratios.

In order to estimate our VAR for each country, we use information for the following data series: GDP at current market prices; price deflator of GDP; general government gross fixed capital formation at current prices, used as public investment; gross fixed capital formation (GFCF) of the private sector at current prices, used as private investment; taxes (including direct taxes, indirect taxes and social contributions); nominal long-term interest rate and the consumer price index.

GDP, taxes and investment variables are used in real values using the price deflator of GDP and the price deflator of the GFCF of the total economy.[3] A real ex-post

[2] To control for the reunification process in Germany a dummy was also used for the case of Germany in 1991.

[3] Due to the lack of information on a price deflator for private investment, we use the same deflator to compute both public and private investment variables.

Table 1 Public and private investment -to-GDP ratios

	Public investment-to-GDP ratios				Private investment-to-GDP ratios			
	1970	1980	2010	1960–14	1970	1980	2010	1960–14
AUT	4,7	4,2	3,2	3,5	19,7	20,2	18,4	20,1
BEL	4,8	5,3	2,2	2,7	22,3	19,7	20,1	19,3
DEU	4,8	3,7	2,3	2,8	21,5	19,5	17,0	19,0
DNK	4,7	3,8	3,3	3,1	20,0	16,6	14,9	17,5
ESP	2,9	2,1	4,7	3,5	23,4	20,3	18,3	20,1
FIN	4,2	4,3	3,7	4,1	23,5	23,0	18,2	20,6
FRA	4,9	4,1	4,1	4,2	20,7	20,2	17,9	18,2
GBR	6,2	3,4	3,2	2,8	17,4	18,2	12,8	16,9
GRC	2,9	2,2	3,2	3,1	25,4	29,2	14,0	19,2
IRL	4,2	5,7	3,4	3,2	19,3	23,3	12,4	17,8
ITA	3,5	3,8	2,9	3,2	21,7	21,8	17,0	18,3
NLD	6,3	4,7	4,1	4,2	22,7	18,5	15,6	18,0
PRT	2,4	4,6	5,3	3,3	21,9	24,4	15,3	21,1
SWE	8,3	5,4	4,5	4,9	18,6	17,7	17,7	17,8
CAN	3,9	2,9		2,8	17,0	19,9		17,5
JAP	4,8	5,7	3,3	4,6	32,2	25,8	16,7	22,2
USA	5,2	4,3	4,1	4,1	15,9	19,1	13,9	17,3
Max	8,3	5,7	5,3	4,9	32,2	29,2	20,1	22,2
Min	2,4	2,1	2,2	2,7	15,9	16,6	12,4	16,9

Source: EC, AMECO Database, updated on April 2015

interest rate is computed using the consumer price index inflation rate. All data are taken from the European Commission Ameco database.[4]

All variables enter the VAR as logarithmic growth rates, except the interest rate, where we used first differences of original values. Moreover, the first differenced variables are mostly stationary, I (0) time series. Table 2 shows unit root test statistics.

4.2 Crowding-out and crowding-in effects

Figures 2 and 3 show the impulse response functions from a one standard deviation shock to public investment and to private investment, respectively for the cases of Portugal and Ireland, as an illustration. It is clear from these charts that a public investment shock may have a different impact on private investment, implying a crowding-in effect in Portugal and crowding-out effect in Ireland.

Table 3 summarises the results for the long-run elasticities, the marginal productivity rates and the macroeconomic rates of return, partial and total, for both public and private investment for the period 1960–2014 for the 17 countries.

[4] The data sources are mentioned in Appendix 2.

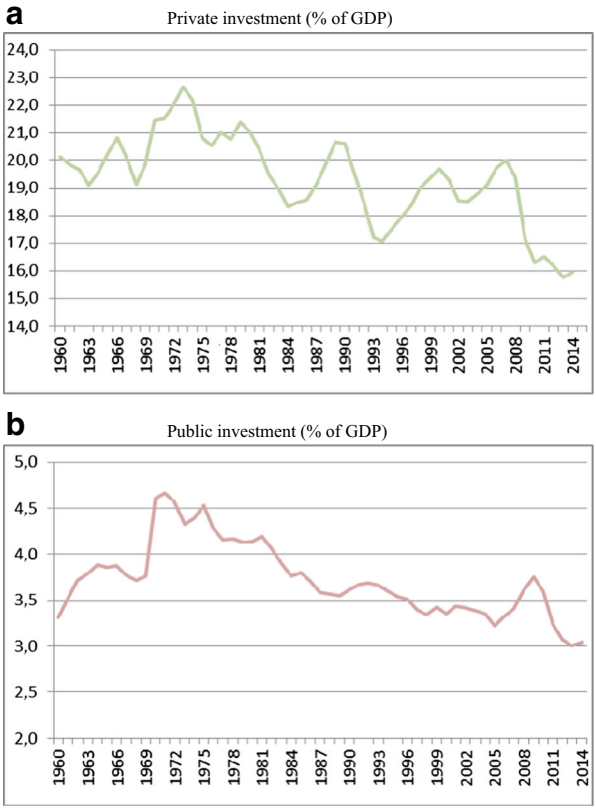

Fig. 1 Private and public investment-to-GDP ratios, average of all countries

Figure 4 displays on the vertical axis the marginal effects of public investment on private investment, allowing the assessment of the existence of crowding-in or crowding-out effects of public investment on private investment. As Fig. 4 shows, public investment has a positive growth impact in 12 countries and negative one on 5 countries (Finland, UK, Sweden, Netherlands, and Canada). Moreover, public investment has a crowding-in effect on private investment in 11 of the 17 countries analysed. Of the six countries in which public investment crowds-out effect on private investment, two (Belgium and Ireland) experience a slight output expansion, while Finland, Canada, Sweden, the UK, show a contractionary effect.

In a similar way, we report in Fig. 5 the effects of private investment on output and the existing crowding-in or crowding-out effects of private investment on public investment. Moreover, it is also possible to conclude that private investment has an expansionary effect on output for all 17 countries in the sample. Figure 5 also reveals that private investment crowds-in public investment for most countries in the sample, and crowds-out public investment in the cases of Belgium, and Sweden. This is an outcome quite in line with the results reported by Afonso and St. Aubyn (2009), for the period 1960–2004.

Table 4 provides a comparison between the results in this paper, for the period 1960–2014 and the results of Afonso and St. Aubyn (2009) covering the period

Table 2 Unit root tests, variables in first differences: Augmented Dickey-Fuller test statistics

	dlog(Y)		dlog(Ipub)		dlog(Ipriv)		dlog(tax)		dir	
	t-Statistic	critical value	t-Statistic	critical value	t-Statistic	critical value	t-Statistic	critical value	t-Statistic	critical value
Austria	−5.09	−3.56	−6.44	−3.56	−6.21	−3.56	−4.50	−3.56	−9.03	−3.57
Belgium	−5-03	−3.56	−5.88	−3.59	−4.89	−3.59	−4.02	−5.59	−9.34	−3.56
Denmark	−5.28	−3.56	−6.37	−3.59	−4.99	−3.60	−5.51	−3.59	−10.61	−3.56
Finland	−4.55	−3.56	−7.48	−3.59	−4.29	−3.59	−5.53	−3.56	−6.77	−3.56
France	−3.38	−2.92 $	−4.62	−3.59	−4.36	−3.59	−4.41	−3.59	−8.40	−3.56
Germany	−5.68	−3.56	−4.46	−3.59	−4.84	−3.59	−5.57	−3.59	−9.35	−3.56
Greece	−3.57 a	−3.50 $	−5.87	−3.59	−4.86	−3.59	−4.57	−3.59	−7.23	−3.56
Ireland	−3.66	−3.56	−3.79	−3.59	−4.37	−3.59	−5.33	−3.59	−6.56	−3.56
Italy	−7.33 a	−4.14	−6.47	−4.19	−5.06	−4.19	−6.99	−4.19	−6.55	−4.14
Netherlands	−3.58	−3.56	−5.58	−3.59	−4.51	−3.59	−5.42	−3.59	−10.17	−3.56
Portugal	−3.42	−2.92 $	−5.56	−3.59	−5.45	−3.59	−5.42	−3.59	−8.96	−3.56
Spain	−3.21	−2.92 $	−4.50	−3.59	−3.72	−3.59	−4.30	−3.59	−6.87	−3.63
Sweden	−5.49	−3.56	−6.93	−3.59	−4.32	−3.59	−4.39	−3.59	−12.04	−3.56
UK	−5.17	−3.56	−7.95	−3.59	−4.93	−3.59	−5.06	−3.59	−9.60	−3.56
Canada	−4.10	−3.56	−5.39	−3.59	−4.23	−3.64	−4.82	−3.61	−7.11	−3.56
Japan	−5.62 a	−3.56	−4.72	−3.59	−4.89	−4.18	−4.20	−3.59	−4.29	−3.56
US	−5.04	−3.56	−3.40 $	−2.93	−4.12	−3.59	−5.50	−3.59	−7.09	−3.56

Critical values are for 1% level unless otherwise mentioned

– 10% level; $ – 5% level. a – with constant and trend

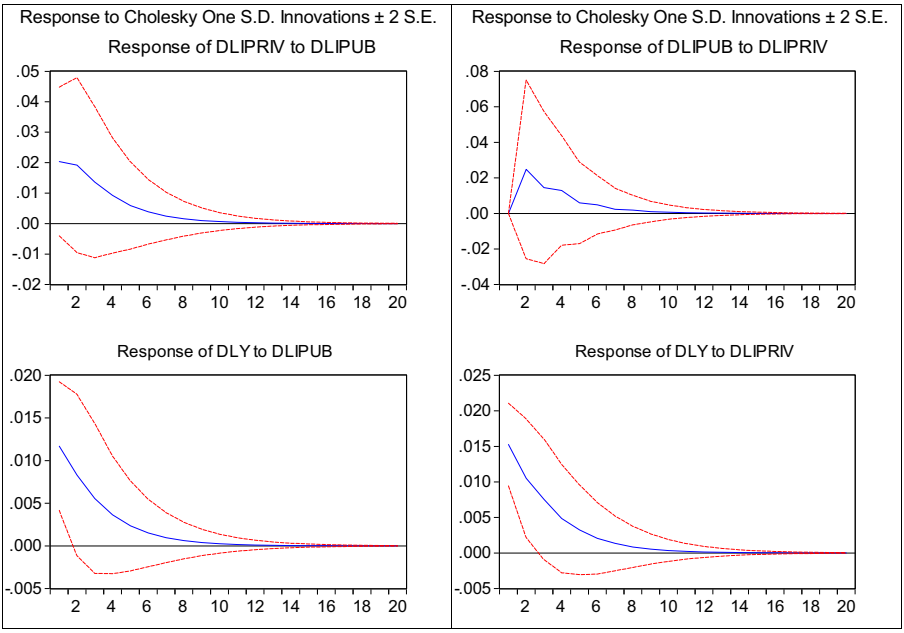

Fig. 2 Impulse response functions, Portugal (1981–2014)

1960–2004. Therefore, the current study encompasses the period of 2008–2009 economic and financial crisis.

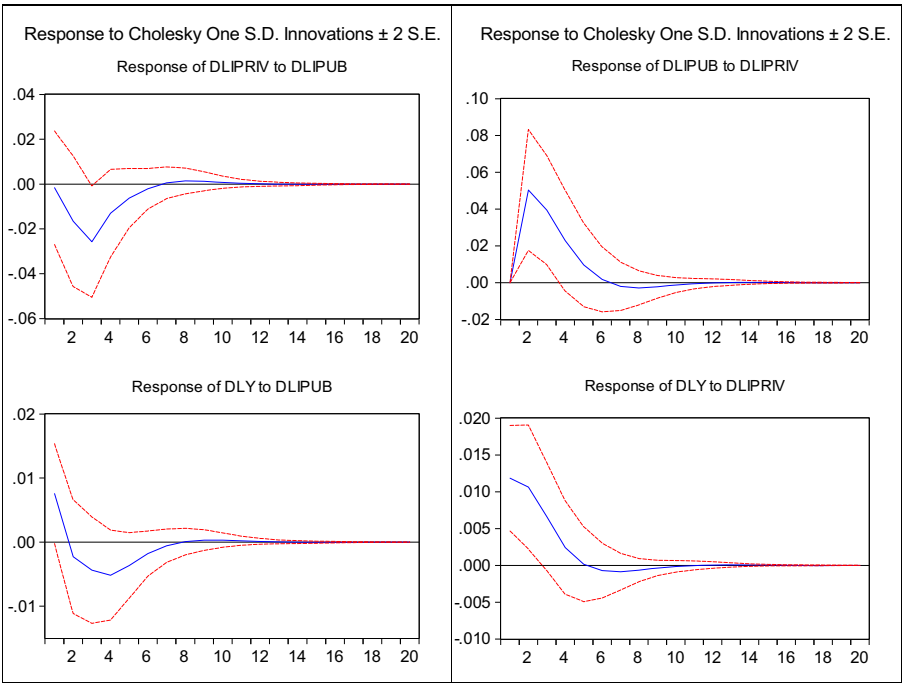

Fig. 3 Impulse response functions, Ireland (1971–2014)

Table 3 Long-run elasticities, marginal productivity and rates of return (1960–2014)

a) Impulse on public investment

	Output elasticity	*MPIpub*	Partial rate of return (%)	*MPTI*	Total rate of return (%)
Austria	0.019	0.525	−3.17	0.427	−4.16
Belgium	0.007	0.275	−6.25	−0.134	
Denmark	0.045	1.436	1.83	1.148	0.69
Finland	−0.073	−1.799		−5.977	
France	0.091	2.170	3.95	2.145	3.89
Germany	0.039	1.376	1.61	0.645	−2.17
Greece	0.191	6.246	9.59	−0.055	2.10
Ireland	0.002	0.078	−12.00	−0.055	
Italy	0.052	1.620	2.44	1.191	0.88
Netherlands	0.089	2.148	3.90	1.307	1.35
Portugal	0.073	2.231	4.09	1.383	1.64
Spain	0.102	2.949	5.56	1.192	0.88
Sweden	−0.120	−2.446		−52.819	
United Kingdom	−0.026	−0.909		0.635	−2.25
Canada	−0.315	−11.115		2.016	3.57
Japan	−0.022	−0.467		−0.409	
United States	0.302	7.396	10.52	6.193	9.55

b) Impulse on private investment

	Output elasticity	*MPIpriv*	Partial rate of return (%)	*MPTI*	Total rate of return (%)
Austria	0.239	1.192	0.88	1.142	0.66
Belgium	0.170	0.883	−0.62	0.910	−0.47
Denmark	0.181	1.034	0.17	1.000	0.00
Finland	0.264	1.284	1.26	1.259	1.16
France	0.312	1.719	2.75	1.599	2.37
Germany	0.301	1.583	2.32	1.525	2.13
Greece	0.024	0.123	−9.94	0.123	−9.94
Ireland	0.326	1.830	3.07	1.523	2.13
Italy	0.355	1.943	3.38	1.630	2.47
Netherlands	0.254	1.412	1.74	1.320	1.40
Portugal	0.319	1.512	2.09	1.397	1.69
Spain	0.304	1.515	2.10	1.197	0.90
Sweden	0.179	1.010	0.05	1.040	0.20
United Kingdom	0.175	1.034	0.17	0.943	−0.29
Canada	0.208	1.189	0.87	1.168	0.78
Japan	0.395	1.779	2.92	1.773	2.91
United States	0.339	1.958	3.42	1.935	3.36

na – not available. The rate of return cannot be computed in this case since the marginal productivity is negative. *MPIpub* – marginal productivity of public investment. *MPIpriv* – marginal productivity of private investment. *MPTI* – marginal productivity of total investment. We use the average of the GDP-to-investment ratios for the period 1960–2014 (or starting later, depending on data availability, see notably the sample sizes mentioned before)

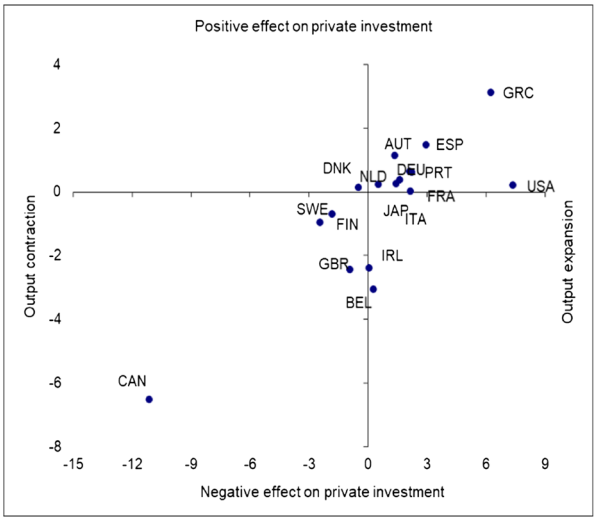

Fig. 4 Public investment: marginal productivity (horizontal) and marginal effect on private investment (vertical), (1960–2014). Note: AUT, Austria; BEL, Belgium; CAN, Canada; DEU, Germany; DNK, Denmark; ESP, Spain; FIN, Finland; FRA, France; GBR, United Kingdom; GRC, Greece; IRL, Ireland; ITA, Italy; JAP, Japan; NLD, Netherlands; PRT, Portugal; SWE, Sweden; USA, United States

For the cases where such comparison is feasible (when marginal productivity is not negative), Table 4 makes it possible to draw some additional results, for the period 1960–2014 vis-à-vis the period before the crisis. Regarding the marginal productivity of public investment, there was an increase in nine countries, while the marginal productivity of

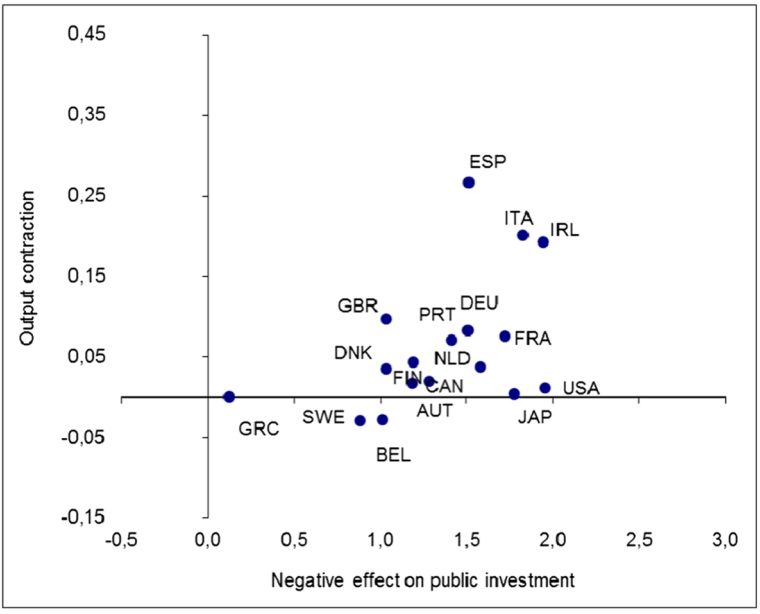

Fig. 5 Private investment: marginal productivity (horizontal) and marginal effect on public investment (vertical), (1960–2014). Note: see Fig. 4

Table 4 Marginal productivity and rates of return, 1960–2004 vs 1960–2014

		Effect of public investment shock			Effect of private investment shock		
		Marginal productivity of public investment	Marginal IPUB effect on IPRIV	Total rate of return (with feedback effects), %	Marginal productivity of private investment	Marginal IPRIV effect on IPUB	Total rate of return (with feedback effects), %
PRT	I	5.18	5.21	−0.9%	1.35	0.16	1.4%
	II	2.23	0.61	1.6%	1.51	0.27	0.9%
AUT	I	1.60	2.45	−3.8%	1.45	0.07	1.5%
	II	0.52	0.23	−4.2%	1.19	0.04	0.7%
BEL	I	−0.43	−3.02	−7.4%	0.86	−0.03	−0.6%
	II	0.27	−3.06	na	0.88	−0.03	−0.5%
DEU	I	1.72	0.53	0.6%	1.47	0.03	1.8%
	II	1.38	1.13	−2.2%	1.58	0.04	2.1%
DNK	I	2.54	1.54	0.0%	0.95	0.04	−0.5%
	II	1.44	0.25	0.7%	1.03	0.03	0.0%
FIN	I	0.44	0.34	−5.4%	1.06	0.02	0.2%
	II	−1.80	−0.70	na	1.28	0.02	0.2%
ESP	I	2.66	0.72	2.2%	1.56	0.18	1.4%
	II	2.95	1.47	0.9%	1.52	0.27	0.9%
FRA	I	1.53	−0.56	6.5%	1.35	0.06	1.2%
	II	2.17	0.01	3.9%	1.72	0.08	2.4%
GBR	I	−1.62	−2.03	2.3%	1.84	0.09	2.7%
	II	−0.91	−2.43	−2.2%	1.03	0.10	−0.3%
GRC	I	2.39	1.58	−0.4%	0.91	−0.08	0.0%
	II	6.25	3.12	2.1%	0.12	0.00	−9.9%
IRL	I	−1.60	−2.77	−0.5%	1.85	0.30	1.8%

Table 4 (continued)

		Effect of public investment shock			Effect of private investment shock		
		Marginal productivity of public investment	Marginal IPUB effect on IPRIV	Total rate of return (with feedback effects), %	Marginal productivity of private investment	Marginal IPRIV effect on IPUB	Total rate of return (with feedback effects), %
	II	0.08	−2.40	na	1.83	0.20	2.1%
ITA	I	0.51	−0.80	4.8%	1.11	−0.34	2.7%
	II	1.62	0.36	0.9%	1.94	0.19	2.5%
NLD	I	−2.72	−2.35	3.6%	1.78	0.07	2.6%
	II	2.15	0.64	1.3%	1.41	0.07	1.4%
SWE	I	0.13	0.40	−11.3%	1.08	−0.09	0.9%
	II	−2.45	−0.95	na	1.01	−0.03	0.2%
CAN	I	−2.31	−2.30	2.9%	1.28	0.03	1.1%
	II	−11.12	−6.52	3.6%	1.19	0.02	0.8%
JAP	I	0.01	−0.99	0.8%	3.09	0.43	3.9%
	II	−0.47	0.14	na	1.78	0.00	2.9%
USA	I	1.83	−2.98	na	2.03	0.06	3.3%
	II	7.40	0.19	9.5%	1.96	0.01	3.4%

I - 1960-2004 (Afonso and St. Aubyn 2009); II - 1960-2014

na, not available. The rate of return cannot be computed in this case since the marginal productivity is negative

IPUB, public investment; IPRIV, private investment. AUT, Austria; BEL, Belgium; CAN, Canada; DEU, Germany; DNK, Denmark; ESP, Spain; FIN, Finland; FRA, France; GBR, United Kingdom; GRC, Greece; IRL, Ireland; ITA, Italy; JAP, Japan; NLD, Netherlands; PRT, Portugal; SWE, Sweden; USA, United States

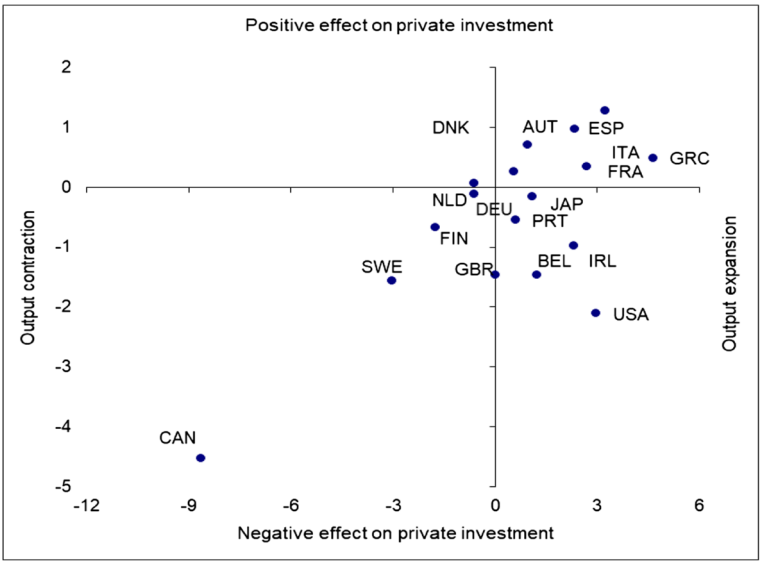

Fig. 6 Public investment: marginal productivity (horizontal) and marginal effect on private investment (vertical): private (public) investment ordered first (second) (1960–2014). Note: see Fig. 4.

private investment increased in seven cases between the two periods. In around half of the countries, the increase (decrease) in the marginal productivity of private or public investment takes place alongside the reduction (increase) in the investment-to-GDP ratio. In the remaining cases that parallel is not present given the compensating opposite effect (vis-à-vis the investment ratio) of the change in respective the output elasticity to investment.

Therefore, the total rate of return of public investment increased in three countries (Portugal, Denmark, and Greece) and decreased in seven countries (Austria, Germany, Spain, Finland, the UK, Italy and the Netherlands).[5] In addition, the total rate of return of private investment increased in five countries (Belgium, Germany, Denmark, France, and Ireland) and decreased in all the other countries but the USA, where it remained essentially unchanged.

4.3 Sensitivity analysis

Finally, we have checked the robustness of the results and its sensitivity to alternative orderings of the variables in the VAR. Specifically, we have ordered public investment second and private investment first in the VAR, allowing private investment to respond contemporaneously to public investment. In fact, one can also theoretically argue that both sequences of responses might occur, with private investment also reacting concurrently to decisions about capital spending.

Overall, we obtain similar effects, which indicate the robustness of the results vis-à-vis the ordering in the VAR, assuming alternatively that private investment and public investment is the most exogenous variable. Indeed, from Figs. 6 and 7 we can observe that public investment has a positive growth impact in 12 countries,

[5] Interestingly, Pereira and Pinho (2008) also report that public investment in durable goods has a positive effect on long-term economic performance in Portugal, using annual data for the period 1976–2003.

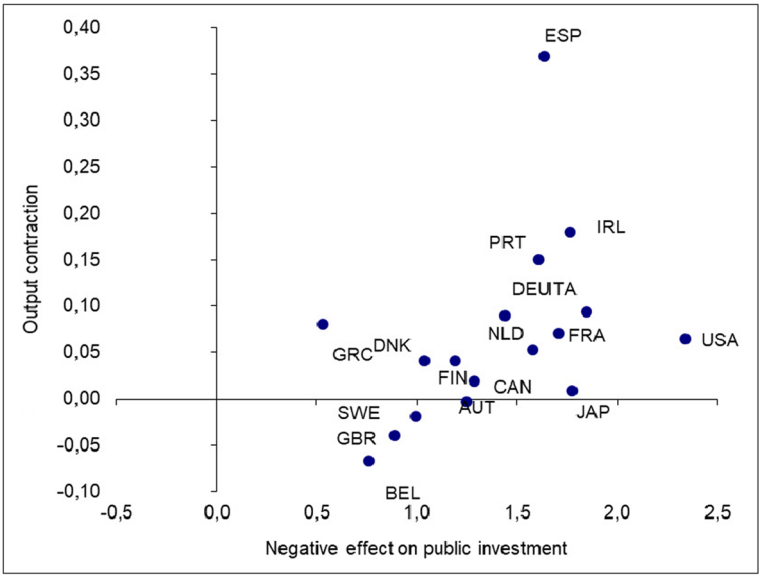

Fig. 7 Private investment: marginal productivity (horizontal) and marginal effect on public investment (vertical): private (public) investment ordered first (second) (1960–2014). Note: see Fig. 4.

as before, with the baseline ordering, and a negative one on 5 countries (Finland, UK, Sweden, Netherlands, and Canada). Additionally, public investment has a crowding-in effect on private investment in 7 countries while it crowds-out private investment in the remainder of the countries.

Finally, private investment has again an expansionary effect on output for all 17 countries. Figure 7 also reveals that private investment crowds-in public investment for most countries in the sample, and crowds-out public investment in the cases of Belgium, UK, and Sweden, essentially as in the baseline ordering.

5 Conclusion

In this paper we have used a VAR analysis for 17 countries OECD between 1960 and 2014 to assess the effects of public and private investment in terms of economic growth, crowding-out and crowding-in. In that context, we have also computed public and private investment macroeconomic rates of return, and assessed the potential effect of the 2008–2009 economic and financial crisis.

Our results for the effects of investment shocks show that:

i) public investment had a positive growth effect in most countries;
ii) public investment had a contractionary effect on output in five cases (Finland, UK, Sweden, Japan, and Canada);
iii) positive public investment impulses led to a decline in private investment (crowding-out) in six countries (Belgium, Ireland, Finland, Canada, Sweden, the UK);
iv) public investment had a crowding-in effect on private investment in the remainder 11 countries;

v) private investment had a positive growth effect in all countries;
vi) private investment crowds-out public investment in the cases of Belgium, and Sweden;
vii) private investment crowds-in public investment in the remainder 15 countries;
viii) the results for the crowding-in and crowding-out effects, together with the macro rates of returns are essentially robust to the ordering of private and public investment in the VAR set up.

Moreover, the partial rate of return of public investment is mostly positive, with the exceptions of Austria, Belgium, and Ireland, while the total rate of return of public investment is also negative in Germany and in the UK. On the other hand, the partial rate of return of private investment is only negative in Greece and marginally in Belgium, being the total rate of return of private investment negative for Belgium, Greece, and the UK.

Some policy implications are possible, notably highlighting the fact that the macro returns of both public and private investment differs across countries with different levels of development and/or per capita GDP. For instance, one can think of theoretically higher macro returns from public/private investment in countries that have a catching process ongoing. Alternatively, countries/areas with established infrastructures might actually derive higher returns from the renovation of those infrastructures. In that vein, a distinction in the analysis, for instance, between public spending for new infrastructures and for renovation could be insightful.

Finally, a possible avenue for future work, would be, on the one hand, a country specific analysis with higher data frequency (quarterly), and on the other hand, for the purpose of obtaining a possible overall result in the euro area, considering a PVAR exercise.

Acknowledgments We thank an anonymous referee, the editor, and Narcissa Balta and participants at the DG ECFIN Workshop on "Fiscal policy after the crisis", January 2016, Brussels, at the Portuguese Economic Journal Conference, July 2016, Coimbra, and at the 19th Infer Annual Conference, Bordeaux, June 2017, for useful comments and suggestions. The opinions expressed herein are those of the authors and do not necessarily reflect those of their employers.

UECE is supported by FCT (Fundação para a Ciência e a Tecnologia, Portugal).

Appendix 1 –The analytics of the macro rates of return

We compute the long-run accumulated elasticity of Y with respect to public investment, *Ipub*, from the accumulated impulse response functions (IRF) of the VAR, as

$$\varepsilon_{Ipub} = \frac{\Delta \log Y}{\Delta \log Ipub}. \tag{2}$$

The long-term marginal productivity of public investment is given by

$$MPIpub \equiv \frac{\Delta Y}{\Delta Ipub} = \varepsilon_{Ipub} \frac{Y}{Ipub}. \tag{3}$$

The partial-cost dynamic feedback rate of return of public investment, r_1, is the solution for:

$$(1 + r_1)^{20} = MPIpub. \tag{4}$$

The long-term accumulated elasticity of Y with respect to *Ipriv* can also be derived from accumulated IRF in a similar way:

$$\varepsilon_{Ipriv} = \frac{\Delta \log Y}{\Delta \log Ipriv}, \tag{5}$$

and the long-term marginal productivity of private investment is given by

$$MPIpriv \equiv \frac{\Delta Y}{\Delta Ipriv} = \varepsilon_{Ipriv} \frac{Y}{Ipriv}. \tag{6}$$

Therefore, the marginal productivity of total investment, *MPTI*, is as follows:

$$MPTI = \frac{\Delta Y}{\Delta Ipub + \Delta Ipriv} = \frac{1}{MPIpub^{-1} + MPIpriv^{-1}} \tag{7}$$

And the rate of return of total investment, from an impulse to public investment, r_2, is the solution for:

$$(1 + r_2)^{20} = MPTI. \tag{8}$$

Appendix 2

Table 5 Data sources

Original series	Ameco codes
Gross Domestic Product at current market prices, thousands national currency.	1.0.0.0.UVGD
Price deflator of Gross Domestic Product, national currency, 1995 = 100.	3.1.0.0.PVGD
Gross fixed capital formation at current prices; general government, national currency.	1.0.0.0.UIGG
Gross fixed capital formation at current prices; private sector, national currency.	1.0.0.0.UIGP
Price deflator gross fixed capital formation; total economy, national currency; 1995 = 100.	3.1.0.0.PIGT
Nominal long-term interest rates - %	1.1.0.0.ILN
National consumer price index - 1995 = 100	3.0.0.0.ZCPIN
Current taxes on income and wealth (direct taxes); general government - National currency, current prices	1.0.0.0.UTYGF; 1.0.0.0.UTYG
Taxes linked to imports and production (indirect taxes); general government - National currency, current prices	1.0.0.0.UTVGF; 1.0.0.0.UTVG
Social contributions received; general government - National currency, current prices	1.0.0.0.UTSGF; 1.0.0.0.UTSG

Series from the EC AMECO database, April 2015

1.0.0.0.UIGG - GFCF consists of resident producers' acquisitions, less disposals of fixed assets during a given period plus certain additions to the value of non-produced assets realised by the productive activity of government producer or units. Fixed assets are produced assets used in production for more than 1 year

1.0.0.0.UIGP - Gross fixed capital formation consists of resident producers' acquisitions, less disposals, of fixed tangible or intangible assets. This covers in particular machinery and equipment, vehicles, dwellings and other buildings

References

Abiad A, Furceri D, Topalova P (2015) The macroeconomic effects of public investment: evidence from advanced economies. IMF WP/15/95

Afonso A, Jalles J (2015) How does fiscal policy affect investment? Evidence from a large panel. Int J Financ Econ 20(4):310–327

Afonso A, St. Aubyn M (2009) Macroeconomic rates of return of public and private investment: crowding-in and crowding-out effects. Manch Sch 77(S1):21–39

Afonso A, St. Aubyn M (2010) Public and private investment rates of return: evidence for industrialised Countries. Appl Econ Lett 17(9):839–843

Brückner M, Tuladhar A (2014) Local government spending multipliers and financial distress: evidence from Japanese prefectures. Econ J 124(581):1279–1316

Cavalcanti C, Merrero G, Le T (2014) Measuring the impact of debt-financed public investment. World Bank, Policy Research Working Paper No. 6766

Creel J, Hubert P, Saraceno F (2015) An empirical analysis of the link between public and private investment in four OECD countries. 17th Banca d'Italia Workshop on Public Finance "Beyond the Austerity Dispute: New Priorities for Fiscal Policy", Perugia, S.A.DI.BA., 9–11 April 2015

Dreger C, Reimers H (2016) On the relationship between public and private investment in the euro area. Econ Model 58:154–158

EC (2015) Making the best use of the flexibility within the existing rules of the Stability and Growth Pact. COM(2015) 12 final, Strasbourg, 13.1.2015, COM(2015) 12 final

Funashima Y, Gakuin T (2017) Spatial crowding-out and crowding-in effects of government spending on the private sector in Japan. Faculty of Economics, University, TGU-ECON Discussion Paper Series #2017-3

IMF (2014) Is it time for an infrastructure push? The macroeconomic effects of public investment. IMF World Economic Outlook, October

Le Moigne M, Saraceno F, Villemot S (2016) Probably too little, certainly too late. An assessment of the Juncker investment plan. OFCE WP 2016–10

Mahmoudzadeh M, Sadeghi S, Sadeghi S (2013) Fiscal spending and crowding out effect: a comparison between developed and developing countries. Inst Econ 5(1):31–40

Pereira A (2000) Is all public capital created equal? Rev Econ Stat 82(3):513–518

Pereira A, Pinho F (2008) Public investment and budgetary consolidation in Portugal. Port Econ J 7(3):183–2013

Pereira A, Pinho M (2011) Public investment, economic performance and budgetary consolidation: VAR evidence for the first 12 Euro countries. J Econ Dev 36(1):1–20

Pina A, St. Aubyn M (2005) Comparing macroeconomic returns on human and public capital: an empirical analysis of the Portuguese case (1960–2001). J Policy Model 27:585–598

Pina A, St. Aubyn M (2006) How should we measure the return on public investment in a VAR? Econ Bull 8(5):1–4

TEU (2012) Consolidate version of the Treaty on the functioning of the European Union. Off J Eur Union 26.10.2012

Turrini A (2004) Public investment and the EU fiscal framework. European economy. European commission economic papers, n°202, May

Xu X, Yan Y (2014) Does government investment crowd out private investment in China? J Econ Policy Reform 17(1):1–12