CHAPTER 3

Does public debt produce a crowding out effect for public investment in the EU?

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ABSTRACT

The combination of the sovereign debt crisis that started in 2009 in the EU and the fiscal consolidation policies that were implemented as a result, has significantly hampered economic growth and inflated debt levels. This paper exploits a panel dataset for 26 EU countries between 1995 and 2015 to examine the extent to which increased levels of public debt have led to reduced public investments, the so-called 'debt overhang' hypothesis. To address endogeneity concerns, we use an instrumental variable approach based on a GMM estimation. Our results validate the debt overhang hypothesis and remain robust across various estimation techniques; the GMM estimation with year dummies, for example, indicates that a 1 percentage point increase in public debt in the EU brings about a reduction in public investment of around 0.30 percentage points. Given the level of public investment prevalent in 2015, this is equivalent to a €1.85 billion euro drop. Interestingly, we find evidence that the impact of this causal relationship exists only for high debt countries. In addition, our results suggest that the negative impact of debt on investment is slightly smaller in the Eurozone than in the entire EU, which might suggest that the institutional framework of the Eurozone does not act as a ‘straightjacket’ for countries that experience high debt levels. Moreover, we find that both the stock and flow of debt have played a role in reducing public investment, and that the latter’s impact was more profound.

Keywords

Public Investment, Debt Overhang, Credit Rationing

1. Introduction

The European Union (EU) has experienced a considerable increase in public debt as a result of the Sovereign Debt Crisis. A significant amount of literature has been devoted, especially in the last decade, to studying the impact of this rise in debt on economic growth (e.g. Reinhart & Rogoff, 2010; Baum, Checherita-Westphal & Rother, 2013). In general, higher levels of debt can result in lower growth in three ways. Firstly, given the finite pool of financial resources, the more the government taps into the pool of loanable funds, the less capital there will be available for private enterprises, which pushes up their borrowing cost, essentially crowding out private investment (Spencer & Yohe, 1970). Secondly, if financial markets start questioning the sustainability of a country, they will demand higher interest rates in order to compensate for the increased default risk. Higher interest rates for the sovereign, in turn, get transmitted to the private sector as government bonds are perceived as the safest investment, in effect acting as a lower bound for interest rates (Das, Papaioannou & Trebesch, 2010). Finally, Ricardian equivalence suggests that companies and households might anticipate a tax increase when the fiscal sustainability of a country is in doubt, resulting in reduced investment and consumption (Barro, 1996).

In addition, recent research has shown that at least part of the lacklustre recovery after the recent Global Financial Crisis (GFC) can be attributed to the elevated levels of public debt (e.g. Reinhart, Reinhart & Rogoff, 2012; Chatterjee, 2013). When a country with a high level of sovereign debt faces a crisis, its ability to respond to that crisis, for example by adopting countercyclical fiscal policy, is severely impeded (Jordà, Schularick & Taylor, 2014).

Little research, however, has been devoted to the causal impact of high debt levels on the flow of public investment. This is rather surprising, as policymakers have clearly recognized the fact that the volume of public investment has declined over the past decade and that considerable efforts need to be undertaken to bridge this investment gap (e.g. Juncker, 2015). Moreover, there is little consensus, both in academic and policy circles, on the factors driving this drop in investment. On the one hand, the decrease in public investment might be primarily caused by the GFC as countries choose the path of least resistance when implementing fiscal austerity, and simply cut public investment rather than reducing public expenditure. On the other hand, the decline might be caused by more secular factors and driven by economic fundamentals: an advanced and aging economy has less need for investment in public infrastructure.

The literature which does focus on the impact of sovereign debt on investment has mainly been applied to developing countries, and more specifically on highly indebted and poor countries (HIPCs). The Latin-American debt crisis of the 1980s brought about a considerable amount of contributions on the effect of high public debt on investment in less developed countries (LDCs) (e.g. Krugman, 1988; Sachs, 1989).

Focusing on 26 EU countries over the period 1995-2015, this paper studies whether Europe suffers from a ‘debt overhang’. We analyze whether the increase in public debt in Europe resulted in a decrease in public investment, offering a richer specification than the existing literature. More specifically, we study whether this effect is more pronounced (i) in high debt than in low debt countries, (ii) pre crisis vs. post crisis, (iii) in Eurozone than in non-Eurozone countries, and (iv)

whether there is a threshold effect. Finally (v), we analyze whether it is only the stock of debt that matters, or also the flow of public debt. To tackle this research question and the accompanying endogeneity concerns, we employ diverse econometrical approaches: we estimate our model starting with a basic Pooled Ordinary Least Squares (POLS), after which we include fixed effects (FE). Finally we apply an instrumental variable approach and estimate our model using GMM (Generalized Method of Moments). We contribute to the existing literature by incorporating a broader set of explanatory variables to explain public investment. Moreover, we address the issue of reverse causality by using a GMM model, based on the linear GMM estimator of Arellano & Bond (1991).

The paper proceeds as follows: Section 2 provides some background on the sovereign debt crisis; Section 3 makes a literature review; Section 4 describes the empirical analysis and its extensions and we conclude in Section 5.

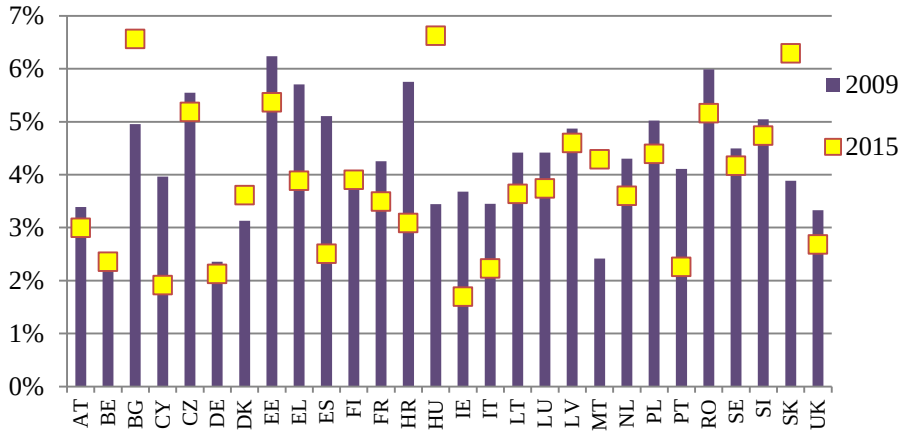
2. Background on sovereign debt crisis

At the end of 2009, the European Union started to suffer from a sovereign debt crisis. The causes of this crisis are rather diverse and extend beyond the scope of this paper (see e.g. Albanesi, De Giorgi & Nosal, 2017; Bayoumi, 2017; Martin & Philippon, 2014). To deal with this crisis, some governments implemented fiscal consolidation policies, raising taxes and lowering spending. However, these measures mainly resulted in lowering growth further, especially in the short run, which pushed up debt levels even higher; since 2007, the average public debt-to-GDP level has increased by 66.66% in the European Union and by 70.23% in the Eurozone. However, some countries experienced an even steeper growth in public debt; in the so-called PIIGS countries (i.e. Portugal, Italy, Ireland, Greece and Spain) the debt-to-GDP ratio has increased by 86.52% since 2007.

At the same time public debt levels in Europe surged, public investment plummeted. This decline in public investments is quite puzzling given the highly accommodative monetary policy implemented by the European Central Bank (ECB) over the past years. Public investment, measured by gross fixed capital formation (GFCF), decreased by 6.32% in the EU since 2007. In the Eurozone (EZ), the decrease was more pronounced; public investment, as a percentage of GDP, declined by 11.08% since 2007. The PIIGS suffered an even sharper decline; GFCF-to-GDP decreased by 37.87% since 2007.

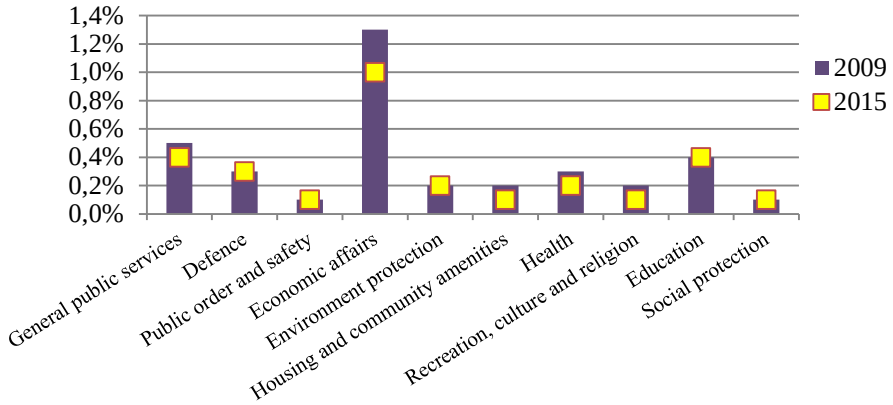
Figure 1 shows public investment (as a percentage of GDP) declined substantially between 2009 and 2015 for 21 out of 28 European countries. In Figure 2, we decompose public gross fixed capital formation expenditure by its socio-economic function in order to see how its main components have changed since 2009. Five out of the ten groups used in this classification show a clear decline, while the other five categories remain relatively unaltered. In particular, the current level in health investments is quite low, which is especially worrisome, given that this is found to be a very significant determinant of long-term growth (OECD, 2016).

Figure 1: Public investment-to-GDP ratio



Source: Eurostat[1]

Figure 2: European Union (EU28) public investment-to-GDP ratio divided by function



Source: Eurostat (COFOG database)

There are numerous reasons why a sufficient level of public investment is warranted. Firstly, as mentioned before, public investments can positively impact long-term growth and labour productivity (e.g. OECD, 2016, Abiad, Furceri & Topalova, 2015; Ganelli & Tervala, 2016). Secondly, public investment in areas such as education can produce significant spillover effects for the private sector, as firms benefit from a highly educated workforce. Thirdly, government investment in transport, for example, can lead to a crowding in effect of private investment, as companies can more easily get their products to consumers. Fourthly, an adequate level of public investment in defence and security helps in dealing with terrorist threats. Fifthly, investment in basic infrastructure, such as water supply, are preconditions for a normal life. Finally, public investment can also be considered as a potentially useful counter-cyclical fiscal tool, something which has not been considered extensively in the literature. Most studies show that public investment is pro-cyclical, mainly due to political motivations (Bove, Efthyvoulou & Navas, 2017). Political considerations might even result in too

[1] All Eurostat data in this paper are retrieved from the *National Accounts* database or the *Government Statistics* database.

large cuts in public investment when consolidation measures need to be introduced during or after an economic downturn, increasing the pro-cyclicality of public investment. This suggests a certain degree of state-dependency for GFCF, which is important to contemplate, especially when hysteresis is a concern (OECD, 2016a; Fatas & Summers, 2018)[2].

The aforementioned benefits of public investment are also reflected in 'Europe 2020' (EC, 2010), the 10-year strategy proposed by the European Commission for advancement of the economy of the EU as it promotes "*public funding for R&D*", "*efficient investment in education and training systems at all levels*" and "*key infrastructure investments in cross-border energy and transport networks, and low-carbon technology*". It also says that "*budgetary consolidation programmes should prioritise growth-enhancing items such as education and skills, R&D and innovation and investment in networks, e.g. high-speed internet, energy and transport interconnections*".

3. Literature review

The debt overhang hypothesis was initially introduced by Myers (1977) when analyzing the determinants of corporate borrowing and more specifically in the context of the impact of having excessive debt on investment decisions at the firm level. Due to the Latin-American debt crises of the 1980s, several studies extended the analysis on debt overhang from a corporate context to a country based approach. The aim of these studies was to explain the effect of higher sovereign debt on investment in less developed countries (e.g. Krugman, 1988; Krugman, 1989; Obstfeld & Rogoff, 1996). Subsequently, the scope of this theory was extended to consider also how high debt might reduce the government's incentives to undertake structural reforms (Clements, Bhattacharya & Nguyen, 2003).

Table 1 shows a brief overview of papers which are relevant to our research. We have focused solely on empirical literature, as this is most relevant to our paper. To the authors' knowledge, this overview is exhaustive. The different papers will be discussed in more detail in the following subsections.

3.1 Debt overhang, only in developing countries?

The debt overhang hypothesis has been tested mainly for highly indebted and poor countries. In general, two ways to test the debt overhang hypothesis have been used. In the first one, an investment function is estimated, in which a specific term is added to account for debt overhang. In a second one, different econometric techniques are used to study the causal relationship between high debt and low investment.

A seminal paper in the first category is Borensztein (1990a) in which the topic is studied first from a theoretical point of view, followed by an empirical approach (Borensztein, 1990b). The author estimates a neoclassical investment function, introducing various types of debt (e.g. sovereign debt, private debt or excess debt) as explanatory variables to test the debt overhang hypothesis in the

[2] In presence of hysteresis, the effect of a public investment stimulus might indeed be stronger (OECD, 2016b).

Philippines in the 1980s. He finds that the stock of foreign debt acted as a disincentive to private investment, and especially so after 1982.

Table 1: Overview of relevant literature

Author	Countries	Dependent Variable	Econometric approach	Debt variable
Antonakis (2014)	12 EZ countries	GDP growth	2SLS, GMM	Public debt
Balassone et al. (2011)	Italy	GDP growth	OLS, 2SLS	External debt
Borensztein (1990)	Philippines	Private investment	OLS	Private debt
Clements et al. (2003)	55 HIPCs	GDP growth, public investment	FE, GMM	External debt, external debt service
Checherita & Rother (2012)	12 EZ countries	GDP growth, public investment	FE, 2SLS, GMM	Public debt
Cohen (1993)	81 LDCs	Domestic investment	OLS	Debt service, debt-to-export ratio
Cordella et al. (2010)	79 HIPCs	GDP growth	OLS, FE, GMM	External debt, public debt, debt service, private debt
Deshpande (1997)	13 SICs	Domestic investment	OLS, FE, LSDV	External debt
Eberhardt & Presbitero (2015)	118 DCs, EMs and AEs	GDP growth	Error Correction Model	Total debt (external plus domestic)
Heinemann (2006)	16 OECD countries	Public investment	OLS, FE	Public debt
Reinhart et al. (2012)	26 AEs	GDP growth	Descriptive analysis	Public debt
Reinhart & Trebesch (2016)	12 AEs and 41 EMs	GDP growth	Difference-in-difference regression	Public debt, external debt, debt service
Turrini (2004)	14 EU countries	Public investment	FE, IV	public debt
Välilä & Mehrotra (2005)	14 EU countries	Public investment	OLS, FE	Public debt
Vanlaer et al. (2015)	26 developed countries	GDP growth	Descriptive analysis	Public debt, private debt, total debt

Note: EZ stands for Eurozone, HIPCs for highly indebted and poor countries, LDCs for least developed countries, SICs for severely indebted countries, AEs for advanced economies and EMs for emerging markets.

One of the most important contributions in the second category is provided by Deshpande (1997). The author uses a panel approach to find a significant negative impact of debt on investment for 13 severally indebted countries (SICs) during 1971-1991. She also introduces a time variable in order to capture the different investment climates over the period studied. She finds that this time variable had a positive impact on investment until 1984, after which it largely became negative. In another

paper (Despande, 1993), the author shifts the focus to several HIPCs over the period 1970-1990 and again finds significant evidence for a negative link between debt and investment.

There are also several contributions to the literature that do not find evidence for the debt overhang hypothesis. Cohen (1991, 1993) finds no evidence of debt overhang for the LDCs in the 1980s. His results suggest that it is not the level of debt, but rather the debt servicing costs[3] which act as a drag on growth: 1% of GDP paid abroad reduces domestic investment by 0.3% of GDP. Hence, according to this paper, high debt cannot be seen as a predictor of low investment. Similarly, Karagol (2005) argues that it is misguiding to make generalizations on the relationship between (external) debt and growth as each country has an idiosyncratic combination of social, economic and political elements.

Testing the link between debt and investment is also important from a policymaking perspective. Indeed, if a high stock of debt results in decreased investment, debt relief might be an effective way to aid heavily indebted countries. Several papers investigate the empirical validity of the debt overhang hypothesis for HIPCs. Arslanalp & Henry (2004, 2005) show the effectiveness of debt relief where debt overhang, and not weakness of institutions or poor infrastructure, is the main impediment to growth. Similarly, Cordella, Ricci & Ruiz-Arranz (2010) find that the effectiveness of debt relief depends on a country's characteristics, such as the quality of its policies and institutions.

3.2 What is the link between debt and growth?

Another strand of literature takes a broader view and looks at the link, not between debt and investment, but between debt and growth (see Panizza & Presbitero (2013) for a review). This is relevant for our research in two ways. Firstly, the literature on the link between debt and growth helps identifying control variables for our model. Secondly, one channel through which high debt can result in low growth is through reduced public investment, which is exactly the focus of this paper. Some papers identify a non-linear relationship between (external) debt and growth, the so-called Debt Laffer curve[4] (e.g. Pattillo, Poirson & Ricci, 2011; Clements et al., 2003; Reinhart et al., 2012).

Clements et al. (2003), focusing on 55 low income countries (classified as eligible for the IMF's Poverty Reduction and Growth Facility) in 1970-1999, show that high external debt can negatively affect growth through both a direct and an indirect effect. A direct effect is in place if a certain threshold is reached (50% for the ratio of external debt-to-GDP and 20-25% for the present value of this ratio) after which growth significantly slows down. An indirect effect works through the investment channel; the authors find that a 1% reduction in the external debt service results in a 0.2% increase in investment, which in turn leads to higher growth through an increase of the capital

[3] However, Deshpande (1993) argues against the use of debt service as an explanatory variable because it may be influenced by a rescheduling process allowed in the past from creditor countries.
[4] The Debt Laffer curve is a concept often used in the sovereign debt restructuring literature. It refers to an inverse U-shaped curve that links the amount of debt of a debtor country to the creditor's expected repayment. This curve is used to explain that creditors have an interest in forgiving part of the debt of a debtor country since it will increase their expected repayment.

stock and the immediate impact on aggregate demand. Hence, the authors conclude that a debt reduction initiative for HIPCs might be useful as it results in an increase in the growth rate.

Reinhart et al. (2012) study 26 cases of public debt accumulation in advanced countries since 1800. They find that the relationship between real GDP growth and the public debt-to-GDP ratio is rather weak for sovereign debt below 90% of GDP. For debt levels above 90% however, economic growth reduces by around 1.2%. This 90% threshold for the negative effect of debt over growth is also observed in Checherita-Westphal & Rother (2012). Conversely, Eberhardt & Presbitero (2015) find evidence for the negative relation between debt and growth but not for the presence of a common debt threshold. Their research indicates that the link between total debt (domestic plus external debt) and long-run growth differs significantly across countries. Hence, this suggests that there is substantial heterogeneity in the long-run relationship between these two variables. Balassone, Francese & Pace (2011) also study the negative link between debt and growth focusing on Italy for the period 1861-2009. They find that external debt had a large negative effect on GDP growth, in particular before WWI. Critics argue that, while there may very well be a negative relationship between public debt and economic growth, the effect might work in the opposite direction: low growth causes the state revenues to fall and public expenditures to rise, thus resulting in a higher level of public debt (e.g. Vanlaer, Marneffe, Vereeck & Van Overtveldt, 2015).

3.3 What determines public investment?

Due to the Sovereign Debt Crisis in Europe, several EU countries, notably Portugal, Italy, Ireland, Greece and Spain, have faced or are facing debt problems similar to the ones that the HIPCs have faced. In order to test whether high sovereign debt results in low public investment, we must first develop a framework that incorporates the different determinants of public investment in general. Only a relatively small amount of studies investigate which factors have an impact on the evolution of public investment, especially for AEs. In addition, most studies focus on one country (e.g. Aubin, Berdot, Goyeau & Lafay (1988) on France, Herenkson (1988), Kirchgassner & Pommerehne (1988) on Germany and Switzerland, Sorensen (1988) on Norway), with only a limited number of papers looking at a panel of different countries (e.g. Haan, Sturm & Sikken (1996) for 22 OECD countries). The explanatory variables that are used in the literature can be categorized into two groups. The first category includes macroeconomic variables, such as the rate of unemployment or the growth rate of real GDP (Turrini, 2004), whereas the second category includes politico-institutional variables, such as the degree of fiscal federalism and the size of the public sector.

The number of papers which specifically examine the determinants of public investment in Europe is even more limited. Välilä & Mehrotra (2005), using a panel co-integration model, study the evolution of public investment and public capital stock over the period 1972-2003 for 14 EU countries. They find that public investment has been mainly determined by national income, the fiscal stance and considerations on fiscal sustainability whereas the Maastricht criteria required to join the EMU do not seem to play a significant role.

Going one step further, there are hardly any papers that look at whether public debt has an impact on public investment in Europe. Heinemann (2006) tries to explain the declining level of public

investment in 16 OECD countries, most of which are European. The results indicate that increases in public debt since the 1970s severely restricted the ability to finance new investments. Similarly, Bacchiocchi, Borghi & Missale (2011) shows how high debt levels result in a decrease in public investments in all OECD countries, without specific differences between EZ/EU countries and non-EZ/EU countries. With a focus on just 12 EZ countries, Checherita-Westphal & Rother (2012) claim that public investment is one of the main channels through which debt can negatively affect economic growth.

In summary, the existing literature on debt overhang suffers from three major limitations. Firstly, most research focuses on developing economies (e.g. Borensztein, 1990b; Desphande, 1993) and those papers which do devote attention to developed economies, only look at a limited number of countries or at least not at the entire European Union (e.g. Heinemann, 2006; Checherita-Westphal & Rother, 2012). Secondly, the problem of endogeneity is not always tacked properly (e.g. Välilä & Mehrotra, 2005); a rudimentary OLS regression is not sufficient to capture the potential endogeneity between public investment (i.e. the dependent variable) and several explanatory variables, such as public debt and the government deficit. Thirdly, the literature on the determinants of public investment, especially in advanced economies, is rather limited and generally focuses on just one country (e.g. Herenkson, 1988; Kirchgassner & Pommerehne, 1988). Hence, we add to the existing literature by taking into account a richer set of explanatory variables to determine public investment, focusing on 26 EU countries and address the issue of endogeneity by using a GMM model exploiting the instrumental variable approach based on the linear GMM estimator of Arellano & Bond (1991).

4. Analysis

4.1 Data Description

As discussed above, the central aim of this paper is to test the debt overhang hypothesis in developed countries, rather than in developing ones, where most literature focuses on. More specifically, we study whether, in Europe over the period 1995-2015, higher levels of public debt produced a crowding out effect for public investment. In order to do so, we start from an empirical model containing the determinants of public investment. Hence, in this section, we discuss all the different variables which are included in our model. These variables were identified through the literature review discussed in Section 3. Table 2 below provides a description of the variables in our dataset.

Table 2: Variables description

Variable name	Description
Public investment	Government gross fixed capital formation in percentage of GDP
Borrowing rate (LT)	Sovereign long-term nominal interest rate
Public debt	General consolidated government gross debt in percentage of GDP
Public expenditure	General government total expenditure in percentage of GDP
Trade openness	Summation of export and import divided by GDP
Private investment	Private gross fixed capital formation in percentage of GDP
Income	Gross national disposable income per capita
Business cycle	Deviation of the actual from the trend GDP growth rate
Production expectations	Production expectations for the 3 months ahead + Selling price expectations for 3 the months ahead

Given that our variable of interest is public investment, we focus on general government[5] gross fixed capital formation (GFCF)[6]. More specifically, we consider this variable as a percentage of GDP in order to overcome differences deriving from countries' welfare level.

For what concerns the determinants of public investment, we can categorize our control variables in three groups: (i) variables related to the government's balance sheet, (ii) variables explaining the country's relationship with the rest of the world, and (iii) variables related to a country's internal characteristics.

In the first group, we consider the interest rate, debt, and public expenditure. For interest rates, we focus on the long-term interest rate[7] and more specifically the 10-year government bond yield[8], which is included as a measure of long-term funding costs. Higher borrowing costs put pressure on government's finances as interest expenses increase, in turn potentially affecting the government's decision on how much to spend on public investment (i.e. a country's fiscal space). For debt[9], we look at general government consolidated gross debt[10] as a percentage of GDP. As explained before,

[5] According to Eurostat, the general government sector includes the central government, state governments, local governments, and social security funds.
[6] Data comes from Eurostat, which defines GFCF as resident producers' investments, less disposals, of fixed assets plus the additions to the value of non-produced assets deriving from the productive activity of government producer or institutional units. Fixed assets are considered as the produced assets used continuously in the production processes for more than one year. They do not include inventory investments (that might introduce a large degree of volatility), the ownership of companies, public-private partnerships projects (PPPs) and investment by state-owned enterprise.
[7] Data come from Eurostat.
[8] This is an important rate because it is the basis of the Maastricht criterion for the long-term interest rates that must be respected by the EMU candidate countries.
[9] In the empirical literature on debt overhang, External Debt is generally used as the main explanatory variable. This is due to the fact that this hypothesis has mainly been tested for emerging market or less developed countries where basically external debt is the most important debt component. In this paper instead, we focus on a group of advanced countries. Hence, the most important debt component to consider is represented by general government consolidated gross debt.
[10] It is defined in the Maastricht Treaty as the outstanding consolidated general government gross debt at nominal value at the end of the year. According to ESA2010, it is made up of the following categories of government liabilities: currency and deposits, debt securities and loans.

this variable is taken into account to test the public debt overhang hypothesis, which is the focus of this paper.

For public expenditure, we focus on general government total expenditure[11] expressed as a percentage of GDP[12]. This variable is taken into account to test whether the total amount of public expenditure can influence its composition. In particular, when there is a necessity to adjust government expenditure, public investments might be postponed and/or reduced. It is often 'politically easier' to cut government investments than it is to reduce other expenditure components, such as the wages of civil servants. Large expenditure now might in fact lead to restrictive future fiscal policies and there is strong evidence (see Oxley & Martin, 1991; Roubini & Sachs, 1989; Haan et al., 1996; Keman, 2010) that during periods of fiscal consolidation capital expenditure is often reduced, sometimes in a drastic way.

From an international point of view, the interactions between countries might also play an important role in explaining the flow of public investment. Therefore, in the second group of variables, we consider trade, which is defined as the sum of exports and imports of goods and services (as a percentage of GDP)[13]. In particular, we consider the trade-to-GDP ratio as a proxy for the openness of a specific country. The rationale behind this being that countries that are more open to trade are subject to more foreign competition and consequently need larger public investments in order to compete in international markets (e.g. by offering appropriate public infrastructure) (Sturm, 2001).

In the third group of variables, we consider private investment, gross national disposable income (GNDI) per capita, production expectations and a proxy for the business cycle. For private investment we consider gross fixed capital formation of the private sector[14] at current prices in euro and we divide it by the level of GDP[15]. This variable is taken into account in order to see if there is a potential displacement effect for public gross fixed capital formation; larger investments from the private sector might produce a crowding-in (i.e. an increase) or crowding-out (i.e. a decrease) effect for public investments. In other words, this allows for testing whether private and public investments are substitutes or complements.

The variable GNDI per capita[16] is taken into account in order to measure the 'maturity' of the economy[17]. In a country with low GNDI per capita (such as a less advanced economy), one might expect that the investment needs are larger than those in a more mature economy. However, a priori it is difficult to establish the causal relation between this variable and public investments since it might also be that a less developed economy has a lower demand for infrastructures from its population and therefore investments will be lower.

[11] According to the IMF, it is defined as total expense plus the net acquisition of nonfinancial assets.
[12] Data come from the IMF's WEO database and from Eurostat, respectively.
[13] Data come from the IMF and WDI, respectively.
[14] It includes financial and non-financial corporations, households and non-profit institutions serving households.
[15] Both data are taken from AMECO.
[16] It is defined as "*Gross national income (at market prices) minus current transfers (current taxes on income, wealth etc., social contributions, social benefits and other current transfers) payable to non-resident units, plus current transfers receivable by resident units from the rest of the world*".
[17] Data come from AMECO.

Next, we compute the following variable in order to proxy the business cycle (Hallerberg & Strauch, 2002):

$$\Delta \log y_{it} - \Delta \log \bar{y}_{it}$$

where Δ is the first-difference operator, y_{it} is the real output and $\bar{y}_{it}$ is the trend output[18]. Basically, this measure represents the deviation of the actual from the trend GDP growth rate. It might also provide information on whether a government uses public investment as counter-cyclical policy tool, in which case we would observe a negative relation between this measure and GFCF.

In order to deepen the discussion about pro-cyclicality, we also take into account a proxy for expectations on the economic outlook. More specifically, we want to consider whether a positive outlook can influence the investment decisions of the government today. If governments increase their public investment efforts when they have a positive view on the future, this would suggest that public investment decisions are generally pro-cyclical. More specifically, we consider production expectations that are computed by the European Commission as the summation between production and selling price expectations for the 3 months ahead[19]. These expectations are evaluated through qualitative surveys and the final values are computed as simple average of the answers to specific questions[20].

Descriptive statistics for all variables in the period studied are displayed in Table 3 below. A detailed descriptive analysis of the two variables which are most essential to examine whether high debt leads to low investment, i.e. public investment and public debt, is provided in Section 4.2. Most control variables show substantial variation. For example, whereas average trade openness (i.e. the sum of imports and exports, expressed as percentage of GDP) is 108.62, it ranges from 37.11 to 438.16. Similarly, the proxy for the business cycle averages -0.04, but reaches a low of -18.85 and goes as high 17.50.

Table 3: Descriptive statistics

Variable	No. Obs.	Mean	Std. Dev.	Min.	Max.
Public investment	582	3.70	1.10	0.56	7.33
Public debt	574	54.57	31.95	3.70	179.70
GNDI per capita	588	19.61	13.10	0.84	64.04
Business cycle	560	-0.04	2.87	-18.85	17.50
Private investment	582	18.72	3.69	4.73	32.29
Public expenditure	577	44.49	6.84	29.47	65.29
Borrowing rate (LT)	484	4.86	2.32	0.37	22.50
Trade openness	588	108.62	60.54	37.11	438.16
Production expectations	536	8.91	11.28	-24.10	55.43

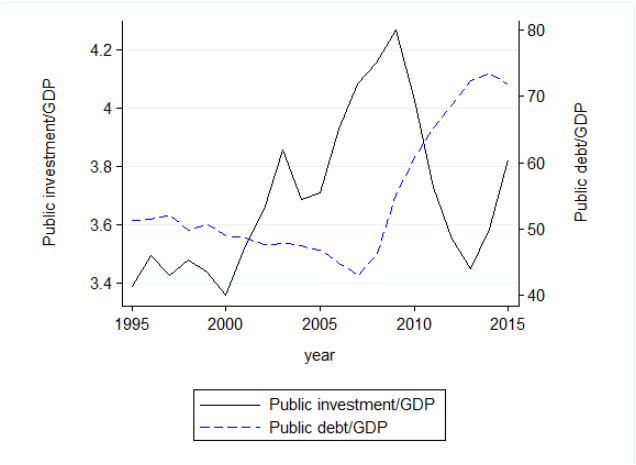
[18] Data come from AMECO and they are computed taking 2010 reference levels.
[19] Data are taken from the European Commission.
[20] For more information see European Commission (2017).

4.2 Descriptive analysis

The two most important variables that must be considered in order to test the debt overhang hypothesis are (i) public gross fixed capital formation and (ii) general government consolidated gross debt. Appendix 1 contains some descriptive statistics of these variables for each EU country included in our analysis. Public GFCF averaged 3.66% over the period under consideration but is subject to a considerable degree of variation, even within one country. For example, in Hungary public investment hit its peak in 2003 at 7.33% but went as low as 0.56% in 1995. The variability in public debt is even more substantial, averaging 56.24% but reaches 3.70% in Estonia in 2007 and 197.70% in Greece in 2015.

Figure 3 below shows the evolution of public investment (scale represented on the left hand axis) and public debt (scale represented on the right hand axis). As of the start of the GFC in 2007, it indeed appears as if public debt increases, whereas public investment decreases.

Figure 3: Public investment and public debt as a percentage of GDP for 26 EU countries, 1995-2015

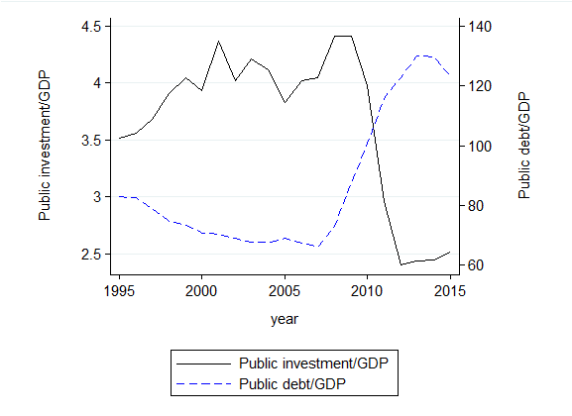


Source: Eurostat (2017)

While average public debt in the EU has increased by 66.67% since 2007 and by 30.43% since the Eurozone Sovereign Debt crisis in 2009, average public investment in the EU has moved in the opposite direction, decreasing by 6.30% since 2007 and by 10.40% since 2009. Another important stylized fact that can be derived from Appendix 2, which shows the individual paths of the public investment-to-GDP ratios for all EU countries, is that average public investment has been quite volatile, especially until 2009.

Figure 4 depicts the situation for the most highly indebted EU countries, the so-called PIIGS: Portugal, Ireland, Italy, Greece and Spain. From this picture, it is even more apparent that public debt and public investment have taken opposite paths since 2008.

Figure 4: Public investment and public debt as a percentage of GDP for the PIIGS, 1995-2015



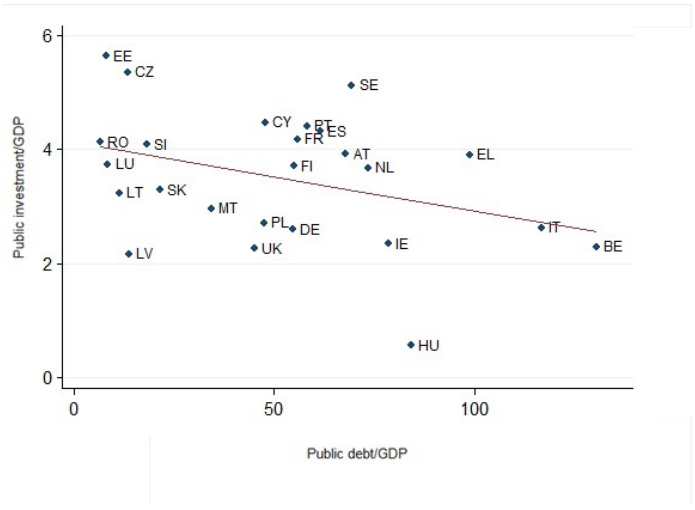
Source: Eurostat (2017)

For these countries the increase in the average debt level and the decrease in the average public investment have been quite extraordinary: public debt rose by 86.52% since 2007 and by 41.09% since 2009 while public investment fell by 37.87% since 2007 and by 42.97% since 2009.

In Appendix 3, we compute the correlation between public debt and public investment. These results demonstrate that the simple correlation between public debts and public investments does not provide much explanatory power. No clear pattern emerges from these correlations.

Finally, in Figure 5, we plot the average public debt and the average public investment (i.e. the country averages) for each country for the period 1995-2015, which again shows a negative link between both variables.

Figure 5: Relationship between the average debt-to-GDP ratio and the average investment-to-GDP ratios for 26 EU countries, 1995-2015



Authors' computation based on Eurostat (2017)

4.3 Model specification: static model

In order to test the debt overhang hypothesis, we start by using a Pooled Ordinary Least Squares (POLS) estimator[21]. The equation that we want to estimate, builds on Checherita-Westphal & Rother (2012) and can be represented as follows:

$$Public\ investment_{it} = \beta Public\ debt_{it-1} + \sum_{c=1}^{4} \gamma_c\ (Controls1)_{it-1}^{c} + \sum_{j=1}^{2} \gamma_j\ (Controls2)_{it}^{j}$$

$$+ \rho Production\ expectations_{it+1} + \varepsilon_{it} \qquad \text{(Eq. 1)}$$

for i = 1, …, 26 EU countries[22] and t = 1995, …, 2015. $Public\ investment$ is the public gross fixed capital formation-to-GDP ratio, $Public\ debt$ the public debt-to-GDP ratio and $Controls1$ is a set of control variables for which we take lagged values and includes the following variables: $Private\ investment$ is private gross fixed capital formation-to-GDP ratio, $Public\ expenditure$ is the public expenditure-to-GDP ratio, $Borrowing\ rate$ is the yield on the 10-year government bond, $Trade\ openness$ is the amount of trade in percentage of GDP. $Controls2$ is a set of control variables for which we look at contemporaneous relation with public investment and includes the following variables: $Income$, which is the logarithm of gross national disposable income per capita and $Business\ cycle$ that represents the business cycle measure. $Production\ expectations\ is$ the proxy for the economic outlook[23] and ε_{it} represents the observation-specific errors (i.e. the disturbance terms). Then we augment this equation adding a year dummy that controls for year fixed effects and captures factors that varies over time but affects all countries (e.g. the effects of the Global Financial Crisis).

A first important issue that must be acknowledged is the reverse causality that can appear in the relationship between public investment and several explanatory variables. Indeed, variables like public debt, private investments and government public expenditure are determined simultaneously with our dependent variable and therefore the causality can also work in the opposite direction. For example, public investment might be a determinant of a larger public debt or of higher public expenditure and this could bias the coefficients of the regression[24]. In order to mitigate this reverse causality problem, we follow Checherita-Westphal & Rother (2012) and take the (1-year) lagged value for the first set of control variables[25]. Next to endogeneity concerns, there is a second reason to take lagged value for our explanatory variables, as discussed in Välilä & Mehrotra (2005): the fiscal authority generally decides the amount of public investment in year t based on information for

[21] We use standard errors clustered at country level, asymptotically robust to both heteroscedasticity and autocorrelation.
[22] Estonia is dropped because of missing data for 10-year government bond yields and Ireland is dropped because of missing data for production expectations.
[23] Due to the way this variable is constructed, we take the values for year t+1.
[24] Public investment is usually financed through government debt issuances. Therefore, public investment (which is a flow variable) will not affect *directly* public debt (which is a stock variable) but rather the change in public debt. Hence, there is reverse causality in the sense that public investment is funded through debt issuance and then this translates in a larger stock of debt.
[25] Even if taking lagged values of potentially endogenous variables is not a proper way to tackle reverse causality, this is standard practice in the literature on debt overhang (e.g. Greene & Villanueva, 1991; Cordella, Ricci & Ruiz-Arranz, 2010).

most variables from year t-1[26]. More specifically, we take 1-year lagged values for all explanatory variables, except for $Income$, $Business\ cycle$ and $Production\ expectations$.

Results are presented in column 1 of Table 4 below. Subsequently, we estimate Equation 1 adding year dummies. Results are reported in column 2. Next, we include country dummies to account for the existence of unobserved social and economic characteristics that are specific to each country in the sample but that stay broadly constant over time:

$$Public\ investment_{it} = \beta Public\ debt_{it-1} + \sum_{c=1}^{4} \gamma_c\ (Controls1)_{it-1}^{c} + \sum_{j=1}^{2} \gamma_j\ (Controls2)_{it}^{j}$$

$$+ \rho Production\ expectations_{it+1} + v_i + \varepsilon_{it} \qquad \text{(Eq. 2)}$$

with v_i representing the unobserved time invariant country-specific effects. Results are reported in column 3. Finally, we also estimate Equation 2 adding year dummies. Results are reported in column 4. Summary statistics for the subsample used in these regressions are reported in Appendix 4[27].

4.4 Static model: estimation results

The results from our initial analysis support the debt overhang hypothesis in the EU. The coefficient of the debt-to-GDP ratio is negative and significant across every estimation. More specifically, a 1 standard deviation increase in public debt reduces public investment between 0.40 and 0.58 percentage points.

Another interesting result relates to the coefficient of the 10-year government bond yield. As this variable represents the long-term funding cost, it can also be considered as a proxy of a credit rationing effect for a debtor country. The lower is the rating of a specific country (i.e. the higher its riskiness) the higher will be the price that this country needs to pay in the financial markets in order to raise money. Our results provide suggestive evidence for a credit rationing effect in the EU, in particular when country fixed effects and year dummies are taken into account. More specifically, a 1 standard deviation increase in the 10-year government bond yield is associated with a decrease in public investment by 0.14 percentage points.

[26] For example, when the government decides to invest a certain amount in the year 2010, information on variables such as trade openness or private investment for that year is not yet available. Hence, if the government incorporates information on these variables in its investment decision, it will be based on data from 2009.
[27] Descriptive statistics for the subsamples used in subsequent regressions do not alter materially. Hence, we do not report them.

Table 4: Baseline regression results for 26 EU countries: POLS and fixed effects

Explanatory variables	(1)	(2)	(3)	(4)
$Public\ debt_{t-1}$	-0.014*	-0.015**	-0.019***	-0.013*
	(0.007)	(0.007)	(0.006)	(0.006)
$Business\ cycle_t$	0.002	0.052**	0.013	0.060**
	(0.014)	(0.025)	(0.014)	(0.022)
$Income_t$	-0.528**	-0.453**	1.050*	2.222***
	(0.216)	(0.200)	(0.600)	(0.760)
$Private\ investment_{t-1}$	0.030	0.028	0.060***	0.030
	(0.034)	(0.035)	(0.020)	(0.021)
$Public\ expenditure_{t-1}$	0.041	0.043	0.070***	0.066***
	(0.025)	(0.025)	(0.020)	(0.023)
$Borrowing\ rate_{t-1}$	0.016	0.056	-0.020	-0.066**
	(0.030)	(0.036)	(0.033)	(0.028)
$Trade\ openness_{t-1}$	0.001	0.000	-0.006	-0.008
	(0.002)	(0.002)	(0.005)	(0.005)
$Production\ expectations_{t+1}$	0.003	0.010	0.006*	0.013
	(0.009)	(0.016)	(0.003)	(0.008)
$Constant$	3.478**	2.718	-1.935	-3.676
	(1.343)	(1.712)	(2.276)	(2.698)
N	404	404	404	404
Time FE	NO	YES	NO	YES
Country FE	NO	NO	YES	YES
R^2	0.259	0.310	0.269	0.379

Dependent variable: Public investment. Heteroscedasticity–robust standard errors clustered at country level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively. In the POLS, Year FE are significant in 2009 and 2010, in the FE they are significant in 1997, 1999, 2000, from 2002 to 2007 and from 2010 to 2014.

In addition, the coefficient of GNDI is positive and significant in the estimation where country fixed effects are included. This might indicate that more 'mature' countries (i.e. countries with higher GNDI per capita), prefer a larger role for the government, which results in a higher level of public investments[28]. Regarding public expenditure, we do not find evidence that, between 1995 and 2015, more government expenditure implied a reduction in the level of public investment. In contrast, there is a positive relationship between public expenditure and public investment when country fixed effects are included. Put differently, when government expenditure rose, this was not compensated for by lower public investment. Finally, we also find that the business cycle measure is significant with a positive sign in both specifications with year dummies, providing suggestive evidence for pro-cyclicality of public investment[29].

4.5 Model specification: GMM and dynamic estimation

The estimation described in the previous section presents two important drawbacks. The first one is related to the problem of endogeneity in terms of reverse causality. In the previous paragraphs, we

[28] The results are the opposite compared to the estimation which excludes country fixed effects (i.e. the coefficient is significant but with a negative sign), which suggest these country fixed effects have an important role and country-specific factors do matter.
[29] This finding is in line with Guerguil, Mandon & Tapsoba (2017) and Hallerberg & Strauch (2002).

claimed that in order to mitigate the potential reverse causality of some variables we considered their lagged values. Although it is common practise in applied econometrics to replace a suspected endogenous variable with its lagged values (e.g. Green, Malpezzi & Mayo, 2005; Vergara, 2010; Stiebale, 2011), lagging an endogenous variable does not enable one to escape simultaneity bias[30]. These problems are even more pronounced when the potentially endogenous variable is characterised by serial correlation.

In order to solve this problem, we use an instrumental variable approach (GMM). A positive feature of this GMM approach is that it allows to deal with the endogeneity problem we mentioned before. A GMM technique is in fact based on a set of orthogonality restrictions (i.e. the moment conditions) and it finds estimates of the parameters in order to come as close as possible to achieve these orthogonality properties. In particular, we follow Antonakakis (2014) Checherita-Westphal & Rother (2012) and instrument the lagged value of public debt for each country through the average of the debt levels of the other countries in the sample[31]. Results are presented in columns 1 (without year dummies) and 2 (with year dummies) of Table 5.

A second important drawback of the previously used estimations, is that they do not capture the potential persistence in the public investment data. It might very well be the case that public investment today is in part determined by public investment in the past. In order to address this shortcoming we use a dynamic estimation, i.e. we include the lagged value of the dependent variable (public investment) in our specification. The addition of the lagged dependent variable as a regressor of the current level of public investment is aimed to capture its path dependence.

However, this addition produces the so-called 'dynamic panel bias' (Nickell, 1981). Since the fixed effects contained in the error term are by construction correlated with the lagged dependent variable, the predictive power belonging to a country's fixed effects might instead be attributed to the lagged dependent variable. In order to overcome this problem, we will use a difference-GMM approach that first transforms all the regressors taking their first differences[32] and then applies a Generalized Method of Moments (see Roodman, 2009). More specifically, we will use the Arellano-Bond estimator with clustered standard errors[33]. Moreover, as we did in our initial estimation (i.e. the POLS and the FE model), we take the lags of most other explanatory as the decision to invest in year t is based on information for most variables from year t-1[34].

Since the difference-GMM generates a large number of instruments and this would weaken the power of the endogeneity's test of the instruments, we follow the approach suggested by Roodman (2009) to limit the number of instruments. In particular, we use a collapsed instruments set based on a limited number of lags of the endogenous variables[35]. According to the difference-in-Sargan test, we

[30] See Reed (2015) for a detailed discussion on why the associated estimates are still distorted by simultaneity bias, and hypothesis testing is invalid.
[31] This can be considered as a good instrument if debt spillovers between EU countries are absent.
[32] All country fixed effects will then be removed since they do not vary over time.
[33] In all the specifications that follow, all control variables except for $Income_t$ and $Production\ expectations_{t+1}$, are considered to be endogenous.
[34] Again, we take 1-year lagged values for all explanatory variables, except for *Income*, *Business cycle* and *Production expectations*.
[35] Conversely, using all available instruments, their number would increase quickly with the time dimension of the panel. Using just a reduced number of instruments, we can also mitigate the problem related to the fact that too many instruments can create an overfitting for the endogenous variables (Roodman, 2009).

can assume that the instruments used in this estimation can be considered as exogenous[36]. Results are presented in column 3 of Table 5.

4.6 GMM and dynamic model: estimation results

We again find support for the debt overhang hypothesis in all three estimations. A 1 standard deviation increase in public debt results in a decrease in public investment of 0.37 to 0.92 percentage points. Equivalently, if public debt increases by 1 percentage point, public investment decreases by around 1.85 billion euro in the dynamic estimation with year dummies[37].

Table 5: GMM regression results for EU countries

Explanatory variables	**(1)**	**(2)**	**(3)**
$Public\ investment_{t-1}$	-	-	0.544***
			(0.112)
$Public\ debt_{t-1}$	-0.017***	-0.012*	-0.030***
	(0.006)	(0.007)	(0.009)
$Business\ cycle_t$	0.014	0.042**	0.072***
	(0.014)	(0.020)	(0.025)
$Income_t$	0.957*	2.039***	0.693
	(0.528)	(0.724)	(0.494)
$Private\ investment_{t-1}$	0.066***	0.031	0.012
	(0.018)	(0.020)	(0.026)
$Public\ expenditure_{t-1}$	0.057***	0.091***	0.019
	(0.022)	(0.020)	(0.045)
$Borrowing\ rate_{t-1}$	-0.040	-0.091***	-0.033
	(0.028)	(0.029)	(0.049)
$Trade\ openness_{t-1}$	-0.006	-0.007	-0.015***
	(0.005)	(0.005)	(0.006)
$Production\ expectations_{t+1}$	0.007*	0.013*	0.011*
	(0.004)	(0.007)	(0.006)
N	390	390	378
Country FE	YES	YES	-
Time FE	NO	YES	YES
Hansen J (p-value)	0.496	0.444	-
Difference-in-Sargan	-	-	0.362
R^2	0.281	0.376	-

Dependent variable: Public investment. Heteroscedasticity–robust standard errors clustered at country level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively. In the second specification, Year FE are positive and significant from 1997 to 2003, in 2008 and 2009; in the third specification, Year FE are negative and significant in 2000 and from 2004 to 2007.

[36] Additional confirmation for the validity of the GMM instruments comes from the serial correlation tests. According to the Arellano-Bond test for autocorrelation, we can reject at a 1% level of significance the null hypothesis of no autocorrelation of order 1 in first differenced-errors and we cannot reject the hypothesis of no autocorrelation of order 2.

[37] According to the literature on dynamic models, we can also compute the long-run effect of public debt on investments applying the following approximation: $\frac{\beta}{1-\delta}$ where $(1-\delta)$ represents the rate of convergence. If debt permanently increases by one percentage point, public investment will be reduced by 0.066 percentage points in the long run.

Moreover, as expected, our results show that public investment in the current year is significantly and positively influenced by GFCF in the previous year. Hence, there is a certain degree of persistence in public investment that should be taken into account and this justifies the use of a dynamic estimation (column 3).

Although the coefficients of the other control variables are not consistently significant across all three estimations, the results suggest that: public investment is rather pro-cyclical; there is a positive relationship between the maturity of an economy (measured by GDNI per capita) and public investment; public investment and private investment act as complements; public expenditure does not crowd out public investment; higher borrowing costs reduce public investment; countries more open to trade have less public investment; and a positive economic outlook is associated with higher public investment.

4.6.1 Robustness check: common shock

In this section, we check the robustness of our results to potential bias coming from omitted variables. In particular, we test for the presence of a common shock that could have simultaneously affected both public investment and the regressors described above (i.e. the determinants of public investment), and as a consequence the link between both. Following Erce (2015), we take the CBOE Volatility Index (VIX)[38], which is generally considered as a barometer of volatility and uncertainty in financial markets, as a proxy for global shocks. As we can see from the results presented in Appendix 4, even if a common shock is taken into account, the negative link between public investment and public debt still exists and is significant.

4.6.2 Extension: high vs. low debt countries

As an additional exercise, we divide the sample into three groups, according to their average debt level over the period 1995 and 2015 (high debt, medium debt, low debt), to test whether the debt overhang effect is stronger in the high debt group. As we can see from Figure 6 below, the patterns of both variables are indeed quite different in the high debt group than in the low debt group. The estimation results are presented in Appendix 5.

These results indicate that the impact of public debt on public investment is indeed stronger for high debt countries than for low debt countries where the coefficient is even positive (but not significant)[39]. For high debt countries, a 1 standard deviation increase in public debt reduces public investment by 0.318 percentage points. Equivalently, for an average country in the high debt group, a 1 percentage point rise in public debt is associated with a decline in public investment of €286 million (given the public investment levels prevalent in 2015). This provides some credence to the

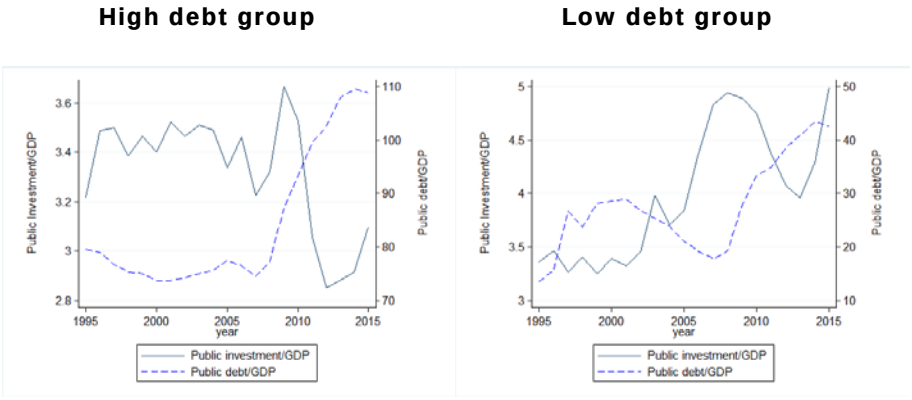
[38] This index is computed from the S&P 500 stock index option prices. Data come from Haver Analytics.

[39] To test the robustness of these findings, we included interaction terms between $Public\ debt_{t-1}$ and dummy variables for the different country groups in our main specification. Although the coefficient for the high debt group is negative, it is not significant. In addition, the results of the Wald test do not reject the null hypothesis of equality between the coefficients of the debt variables in the different country groups.

claim that excessive debt levels should be avoided and, if necessary, need to be addressed by fiscal consolidation measures.

For countries with medium levels of debt, we do not find evidence of a debt overhang effect but only of credit rationing in, which suggests that for this group of countries, the cost of servicing debt is more important, with respect to determining the level of public investment, than the level of public debt is.

Figure 6: Public investment and public debt as a percentage of GDP for 26 EU countries, 1995-2015



Three other results require further discussion. Firstly, public investment is quite pro-cyclical in countries with large and medium levels of debt. This is not the case for countries with low levels of debt, where production expectations play a more important role. Secondly, the maturity of the economy has a significant (positive) impact on public investment in countries with medium and low levels of debt, not so when countries are characterized by high levels of debt. Thirdly, trade openness of countries with high debt results in more public investment whereas the opposite is true for countries with medium levels of debt.

4.6.3 Extension: pre vs. crisis period

In this section, we want to test whether the sovereign debt crisis had a significant impact on public investment. As shown in Section 2, sovereign debt increased markedly in nearly all EU countries over the period 2009-2015. We study whether the debt overhang effect is more pronounced after the crisis of 2007-2009. In order to do that, we add a crisis dummy for the period 2009-2015 and we again run the dynamic regression.

As can be seen from the results in Appendix 6, public debt still has a negative impact on investment and the crisis dummy is not significant[40]. The most likely reason for this is that there is a lot of

[40] We also tested whether the impact of debt on investment differed in crisis years vs. non-crisis years by interacting $Public\ debt_{t-1}$ and the crisis dummy, but we again did not find a significant impact.

heterogeneity with regards to the period that the crisis affected a particular country. Some countries (e.g. Ireland) experienced an early crisis whereas other countries were affected by the crisis later. Moreover, public investment has been characterized by large volatility in a substantial amount of European countries (see Appendix 2)[41] and this makes it difficult to find a specific effect during the years of the crisis over our entire sample.

4.6.4 Extension: threshold effect

In Section 4.6.2, we tested whether the negative impact of debt on investment differed between countries when we group these countries according to their average level of public debt. Put differently, we investigated whether the debt overhang effect is stronger in countries which, on average, have high debt levels than in countries which have low average debt levels. In this section, we test for the presence of a threshold effect in the relation between public debt and public investment. More specifically, we want to see whether public investment is considerably lower if the ratio of public debt-to-GDP ratio exceeds a specific threshold.

In contrast to Section 4.6.2, where we divide our sample into different country-groups according to their average level of debt, in this section, we pool all country-year observations and create a dummy variable *Debt90* that assumes a value of 1 when the level of public debt exceeds 90% (following Reinhart & Rogoff, 2010) and 0 otherwise. We follow the related literature on this topic (described in Section 3.2.) which generally focuses on the relation between debt and growth, and which provides tentative evidence that debt levels larger than a specific threshold indeed reduce economic performance (see Égert (2015) for an overview).

As we can see from the results in Appendix 7, the coefficient of the debt threshold (i.e. $Public\ debt_{t-1}{*}Debt90)$ is negative but not significantly different from zero[42]. Moreover, the results of the Wald test do not reject the null hypothesis of equality between the coefficients of the debt variables in the country-years where debt exceeds 90% vs. the country-years where debt does not exceed this threshold. Thus, our results do not provide evidence for the hypothesis that there is one common debt threshold for all countries and across all years, after which economic performance, in this case measured by public investment, is dramatically compromised.

4.6.5 Extension: focus on the EZ

In this section, we focus only on the countries which are part of the **Eurozone** (EZ) in order to see if the adoption of a common currency has had a different impact on the relationship between debt and investment. In other words, we want to see whether the institutional arrangements of the EZ have had a specific impact on how debt-burdened countries allocate resources to public investment. For example, one of the euro convergence criteria stipulates that the annual government budget

[41] We tried all the combinations starting in 2007/2008/2009/2010/2011 and ending in 2012/2013/2014/2015 and also for shorter periods 2007/2008/2009 – 2008/2009/2010/2011 but none of them comes out to be significant.
[42] We tried also using 60% as a threshold (following the Maastricht's criteria) but this yields similar results.

deficit must not exceed 3%. If a crisis hits, and government revenues fall and/or its expenditures rise, the government might have no other option than to cut spending on public investment, simply to adhere to the deficit requirement. Moreover, since the adoption of a single common currency implies respecting the Maastricht convergence criteria, this can be considered as a way to group countries that are more (economically) similar to each other. Therefore, we focus on the 19 EZ member countries.

According to the regression results (Appendix 8) from the dynamic estimation, we once again find evidence of the **debt overhang** hypothesis. Interestingly, the negative effect of debt on investment is larger[43] in the EU as a whole than in the Eurozone which might suggest that the institutional framework of the EZ actually does not act as a 'straightjacket' for countries that experience high debt levels. The results for the other variables are in line with our previous analysis.

4.6.6 Extension: stocks vs. flows

In this last section, we test another hypothesis: is it only a matter of the stock of outstanding debt negatively impacting investment or does the flow of debt also play a role? Put differently, does rapid debt accumulation lead to lower investment? In debt sustainability analysis (DSA), the speed at which debt accumulates is an important parameter and is generally evaluated in conjunction with the growth rate of a country and its real interest rate (Guzman & Heymann, 2015). Gabriele, Erce, Athanasopoulou & Rojas (2017) show that considering both stock and flow[44] measures of debt, such as the ratio of gross general government debt-to-GDP and the gross financing needs (GFN), gives a more accurate picture of debt sustainability risks for a specific country.

In order to consider a flow-approach, we add the first difference of the public debt variable in order to see how its change can explain the change in public investment. Since the change in debt cannot be considered as an exogenous variable (because public investment is usually financed through government debt issuances), we instrument the change in debt with the GFN-to-GDP ratio[45,46]. This variable represents the summation of interest expenses, the primary balance and debt maturing in less than one year. Then, we run an instrumental variable approach (GMM) as explained in Section 4.5 using standard errors clustered at country level.

As shown in Appendix 9, the link between the change in public debt and public investment is negative and significant, as expected. A 1 standard deviation increase in the flow of debt produces a 0.157 decrease in public investment. Thus, this suggests that both the stock and flow of public debt matter in reducing the public investment. The results for the other determinants are in line with our initial analysis.

[43] The average coefficient is 0.0258 for the EZ and 0.0226 for the EU.
[44] They focus on gross financing needs as flow variable that adds up interest payments, principal repayments, and primary deficit.
[45] GFN data for 26 countries (UK and LU are missing) are downloaded from the ECB Data Warehouse.
[46] More specifically, we use its second and third lagged values as instruments. The second and third lagged values of this variable can be considered correlated with the change in debt but uncorrelated with the amount of investment today, which makes it a suitable instrument.

5. Conclusions

Identifying the determinants of public investments in EU countries is a topical subject given the downward trend showed by government investments in the past decade. Moreover, the recent sovereign debt crisis that affected the whole EU, but especially the southern European countries, caused public debt to rise significantly in nearly every EU country. We test whether the slump in investment was caused by the increase in public debt.

Surprisingly, the literature on which variables might have an impact on public investment in Europe is rather limited. Our paper furthers this literature, analysing a wide array of potential determinants of public investment and considering nearly the entire European Union. In particular, we focus on the link between public debt and public investment in order to study the debt overhang hypothesis, according to which high public debt results in low public investment. In order to perform this exercise, we tackle the potential issue of reverse causality between debt and investment by using a GMM model, exploiting the instrumental variable approach based on the linear GMM estimator of Arellano & Bond (1991).

The results of our empirical analysis show a significant negative link in the EU between general government consolidated gross debt and gross fixed capital formation[47]. The results of the dynamic GMM estimation, for example, indicate that a 1 standard deviation increase in public debt results in a decrease in public investment of 0.92 percentage points. Equivalently, if public debt increases by one percentage point, public investment is reduces by €1.85 billion, given the level of public investment prevalent in 2015. As our results show that high debt can negatively affect public investments, fiscal consolidation measures might be justified from a policy perspective[48].

Two other interesting results can be derived from our analysis. Firstly, it is quite difficult to explain the behaviour of public investment focusing only on macroeconomic variables. The explanatory power of the models used is indeed quite low which might suggest other factors play an important role in driving public investment, such as politics and the electoral cycle. Secondly, we find tentative evidence that the credit rationing channel has a significant impact on public investment. The consequent policy implication might be that a measure focused on debt reduction alone would be less effective than one which includes an additional lending strategy - for example with a 'concessional' interest rate - in order to restore public investments and subsequently growth. Since the evidence is not robust across all the estimations used, the impact of credit rationing warrants further analysis.

In our research, we focus on the average relation between debt an growth. According to part of the related literature (e.g. Eberhardt & Presbitero, 2015; Reinhart et al., 2012), this is potentially misleading. The impact of a high level of debt on growth might in fact be influenced by country-specific characteristics such as past crisis episodes, the institutional framework (Manasse & Roubini,

[47] This paper shows clear evidence that governments are inclined to reduce public investment when debt is high. A possible policy instrument to counter this inclination could be to increase EU funds available for investment in times of crises. See Carnot (2017) for the recent literature on the establishment of a European Stabilization Fund.
[48] This paper does not offer a definitive answer to this discussion as a wide variety of issues needs to be considered, such as the extent to which these measures (i.e. fiscal consolidation) could negatively affect growth in the short-run.

2009) and debt composition (i.e. short-term versus long-term debt), domestic versus external debt, the currency denomination, (Dell'Erba, Hausmann & Panizza, 2013), etc. Nevertheless, since we focus on countries that are members of the European Union and are hence characterized by a common EU policy - which leaves little room for large differences between countries - we believe that studying the average relation between public investments and public debt is an appropriate approach.

In conclusion, this paper offers an interesting contribution to the literature in various ways. We analyze the debt overhang effect through a broad variety of estimations, incorporating a rich set of explanatory variables. Moreover, we study the link between public debt and public investment using different econometric approaches (i.e. (P)OLS, FE and GMM) and comparing high vs. low debt countries, pre vs. post crisis period, EU countries vs. EZ countries and stock vs. flow measures. More specifically, we find that the debt overhang effect (i) is observed only in high debt countries, (ii) is not significantly stronger during and after the crisis (2009-2015), (iii) is slightly less strong inside the EZ than in the entire EU, (iv) there is no threshold effect; and (v) both the flow and stock of debt have a negative effect on investment.

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Appendices

Appendix 1: Country-specific descriptive statistics for the ratio of public debt-to-GDP and public investment-to-GDP

Mean (standard deviation)

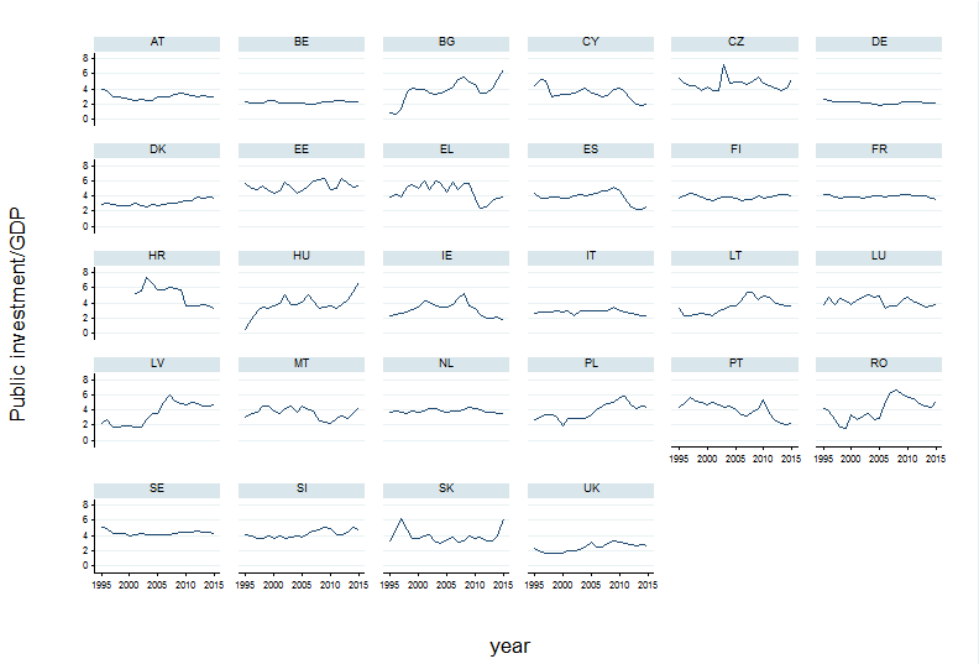
Country	Public debt	Public investment
Austria (AT)	71.78 (8.07)	2.99 (0.38)
Belgium (BE)	105.83 (11.66)	2.24 (0.15)
Bulgaria (BG)	37.79 (26.13)	3.79 (1.46)
Cyprus (CY)	64.18 (18.8)	3.95 (0.94)
Czechia (CZ)	27.86 (11.04)	4.64 (0.81)
Germany (DE)	66.31 (8.27)	2.21 (0.18)
Denmark (DK)	41.96 (6.78)	3.08 (0.37)
Estonia (EE)	6.62 (2.09)	5.27 (0.61)
Greece (EL)	122.86 (31.02)	4.57 (1.08)
Spain (ES)	61.5 (19.43)	3.78 (0.82)
Finland (FI)	46.63 (8.45)	3.82 (0.27)
France (FR)	70.77 (13.51)	3.92 (0.18)
Croatia (HR)	55.09 (19.53)	4.99 (1.33)
Hungary (HU)	67.72 (10.06)	3.80 (1.24)
Ireland (IE)	60.13 (32.78)	3.16 (0.94)
Italy (IT)	111.77 (10.50)	2.78 (0.29)

Appendix 1 (cont.): Country-specific descriptive statistics for the ratio of public debt-to-GDP and public investment-to-GDP

Mean (standard deviation)

Country	Public debt	Public investment
Lithuania (LT)	24.57 (10.24)	3.57 (1.00)
Luxembourg (LU)	12.19 (6.45)	4.17 (0.54)
Latvia (LV)	21.87 (13.90)	3.54 (0.98)
Malta (MT)	61.48 (10.23)	3.54 (0.73)
Netherlands (NL)	58.00 (9.16)	3.85 (0.22)
Poland (PL)	46.09 (5.70)	3.79 (1.06)
Portugal (PT)	78.05 (29.35)	4.00 (1.08)
Romania (RO)	22.71 (10.05)	4.12 (1.46)
Sweden (SE)	49.55 (11.22)	4.36 (0.28)
Slovenia (SI)	35.56 (19.94)	4.20 (0.48)
Slovakia (SK)	40.34 (9.52)	3.93 (0.91)
United Kingdom (UK)	54.32 (20.57)	2.42 (0.53)
European Union (EU)	54.48 (9.86)	3.70 (0.27)

Appendix 2: Public investment-to-GDP ratios for EU28, 1995-2015



Appendix 3: Correlation table

Country	Public investment and public debt
AT	0.26
BE	0.31
BG	-0.58*
CY	-0.72*
CZ	0.01
DE	-0.24
DK	0.01
EE	0.20
EL	-0.70*
ES	-0.88*
FI	0.66*
FR	-0.10
HR	-0.88*
HU	-0.20
IE	-0.77*
IT	-0.66*
LT	0.24
LU	-0.37
LV	0.58*
MT	-0.04
NL	-0.51*
PL	0.75*
PT	-0.83*
RO	0.15
SE	0.40
SI	0.53*
SK	0.05
UK	0.61*
EU	-0.15

* indicates significance at the 5% level

Appendix 4: Regressions results for analysis of a common shock: GMM

Explanatory variables	**(1)**
$Public\ investment_{t-1}$	0.544***
	(0.112)
$Public\ debt_{t-1}$	-0.030***
	(0.009)
$Business\ cycle_t$	0.072***
	(0.025)
$Income_t$	0.693
	(0.494)
$Private\ investment_{t-1}$	0.012
	(0.026)
$Public\ expenditure_{t-1}$	0.019
	(0.045)
$Borrowing\ rate_{t-1}$	-0.033
	(0.049)
$Trade\ openness_{t-1}$	-0.015***
	(0.006)
$Production\ expectations_{t+1}$	0.011*
	(0.006)
VIX_{t-1}	-0.030*
	(0.017)
N	378
Time FE	YES
Difference-in-Sargan	0.362

Dependent variable: Public investment. Heteroscedasticity–robust standard errors clustered at country level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively. Year FE are significant and negative in 2000 and from 2004 to 2011.

Appendix 5: Regressions results for country groups: GMM

Explanatory variables	High debt (1)	Medium debt (2)	Low debt (3)
$Public\ investment_{t-1}$	0.214*	0.678***	0.167
	(0.111)	(0.090)	(0.141)
$Public\ debt_{t-1}$	-0.012**	-0.000	0.019
	(0.006)	(0.008)	(0.013)
$Business\ cycle_t$	-0.514	2.088***	3.174***
	(0.873)	(0.680)	(0.977)
$Income_t$	0.149***	0.085**	0.045
	(0.029)	(0.034)	(0.030)
$Private\ investment_{t-1}$	0.052*	-0.007	0.088**
	(0.028)	(0.046)	(0.039)
$Public\ expenditure_{t-1}$	-0.043	-0.011	-0.010
	(0.036)	(0.040)	(0.048)
$Borrowing\ rate_{t-1}$	-0.057*	-0.163**	0.145**
	(0.033)	(0.076)	(0.073)
$Trade\ openness_{t-1}$	0.017***	-0.009*	-0.007
	(0.007)	(0.005)	(0.010)
$Production\ expectations_{t+1}$	-0.005	-0.008	0.019*
	(0.008)	(0.007)	(0.011)
N	150	133	95
Time FE	YES	YES	YES
Difference-in-Sargan	0.685	0.096	0.408

Dependent variable: Public investment. Heteroscedasticity–robust standard errors clustered at country level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively. The thresholds for the debt averages (expressed as percentage of GDP), used to identify the three groups are: 40.3381 and 61.47619. The group of high debt countries includes: AT, BE, CY, DE, EL, FR, HU, IT, PT; the group of medium debt countries includes: DK, FI, ES, HR, MT, NL, PL, SE, UK; the group of low debt countries includes: BG, CZ, , LT, LU, LV, RO, SI, SK. Year FE are negative and significant in the high debt from 1997 to 2008, in 2011 and 2014; in medium debt group they are positive and significant in from 1996 to 1999, from 2001 to 2003, in 2005 and 2009; in the low debt group they are never significant.

Appendix 6: Regressions results for analysis of the impact of the crisis: GMM

Explanatory variables	**(1)**
$Public\ investment_{t-1}$	0.545***
	(0.127)
$Public\ debt_{t-1}$	-0.014*
	(0.008)
$Business\ cycle_t$	0.009
	(0.023)
$Income_t$	0.178
	(0.420)
$Private\ investment_{t-1}$	0.034
	(0.028)
$Public\ expenditure_{t-1}$	0.003
	(0.047)
$Borrowing\ rate_{t-1}$	-0.049
	(0.039)
$Trade\ openness_{t-1}$	-0.002
	(0.004)
$Production\ expectations_{t+1}$	0.008*
	(0.004)
$Crisis$	0.076
	(0.220)
N	378
Difference-in-Sargan	0.516

Dependent variable: Public investment. Heteroscedasticity–robust standard errors clustered at country level are in parentheses.

*, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

Appendix 7: Regressions results for analysis of a debt treshold: GMM

Explanatory variables	**(1)**
$Public\ investment_{t-1}$	0.476***
	(0.102)
$Public\ debt_{t-1}$	-0.021**
	(0.010)
$Business\ cycle_t$	0.070***
	(0.023)
$Income_t$	0.733
	(0.470)
$Private\ investment_{t-1}$	0.039
	(0.027)
$Public\ expenditure_{t-1}$	0.038
	(0.039)
$Borrowing\ rate_{t-1}$	-0.019
	(0.041)
$Trade\ openness_{t-1}$	-0.015**
	(0.006)
$Production\ expectations_{t+1}$	0.008
	(0.006)
$Public\ debt_{t-1} * Debt90$	-0.016
	(0.011)
N	378
Time FE	YES
Difference-in-Sargan	0.311

Dependent variable: Public investment. Heteroscedasticity–robust standard errors clustered at country level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively. Year FE are significant and negative in 1999, 2000, from 2003 to 2008 and from 2010 to 2012.

Appendix 8: Regressions results for the EZ countries: GMM

Explanatory variables	**(1)**
$Public\ investment_{t-1}$	0.543***
	(0.112)
$Public\ debt_{t-1}$	-0.018**
	(0.007)
$Business\ cycle_t$	0.038**
	(0.019)
$Income_t$	1.543***
	(0.520)
$Private\ investment_{t-1}$	0.001
	(0.022)
$Public\ expenditure_{t-1}$	-0.038
	(0.041)
$Borrowing\ rate_{t-1}$	0.005
	(0.039)
$Trade\ openness_{t-1}$	-0.008**
	(0.004)
$Production\ expectations_{t+1}$	0.013**
	(0.006)
N	269
Time FE	YES
Difference-in-Sargan	0.101

Dependent variable: Public investment. Heteroscedasticity–robust standard errors clustered at country level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively. Year FE are significant and negative starting from 1999 to 2008 and from 2010 to 2012.

Appendix 9: Regressions results for analysis of the impact of stocks vs. flows: GMM

Explanatory variables	**(1)**
$\Delta Public\ debt_{t-1}$	-0.029*
	(0.017)
$Public\ debt_{t-1}$	-0.018**
	(0.007)
$Busines\ cycle_t$	0.009
	(0.013)
$Income_t$	1.896***
	(0.630)
$Private\ investment_{t-1}$	0.050*
	(0.026)
$Public\ expenditure_{t-1}$	0.077***
	(0.024)
$Borrowing\ rate_{t-1}$	0.002
	(0.029)
$Trade\ openness_{t-1}$	-0.011*
	(0.006)
$Production\ expectations_{t+1}$	0.009**
	(0.003)
N	314
R^2	0.314
Country FE	YES
Hansen J (p-value)	0.98

Dependent variable: Public investment. Heteroscedasticity–robust standard errors clustered at country level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.