HELSINGIN YLIOPISTO

The crowding out effect of government investments in Finland during the euro

An empirical study on firm investments

Master's Programme in Economics
General Track
Faculty of Social Sciences
Master's Thesis

Author:
Jaakko Eemeli Rahko

Supervisor(s):
Professor Jani Luoto

13.06.2023
Helsinki

Tiivistelmä

Tiedekunta: Valtiotieteellinen Tiedekunta

Koulutusohjelma: Taloustieteen maisteriohjelma

Opintosuunta: Taloustiede

Tekijä: Jaakko Eemeli Rahko

Työn nimi: Valtion investointien syrjäytysvaikutus Suomessa euroaikana, empiirinen tutkimus yritysten investoinneista

Työn laji: Maisterin tutkielma

Kuukausi ja vuosi: 06/2023

Sivumäärä: 61 +8

Avainsanat: syrjäytysvaikutus, investoinnit, valtion finanssipolitiikka

Ohjaaja tai ohjaajat: Jani Luoto

Säilytyspaikka: Helsingin Yliopisto

Tiivistelmä:

Julkinen sektori suomessa on kasvanut jo pitkään. Suuri hyvinvointivaltio ja laajat valtion investoinnit sekä muut ohjelmat ovat laajentuneet talouden myötä. Laajentumisen johdosta valtio on keskeinen markkinatoimija Suomessa. Valtion investointien vaikutusta taloudelle onkin tutkittava, jotta markkinat pysyvät tehokkaina.

Tässä tutkielmassa tarkastelen kuinka valtion investoinnit vaikuttavat yksityisten yritysten investointeihin Suomessa. Valtion investoinnit voivat joko vähentää (syrjäyttää), tai lisätä yritysten investointeja. Syrjäytysvaikutusta on tutkittu paljon kansainvälisesti, mutta Suomesta on vain muutamia tutkimuksia. Tutkielmani täyttää tätä tutkimuksellista aukkoa tarkastelemalla syrjäytysvaikutusta eri investointikategorioissa.

Tutkielman data koostuu valtion-, sekä yksityisistä investoinneista euroajan alusta 1999 viimeisimpään vuoteen 2022. Yksityiset investoinnit on jaettu neljään pääkategoriaan, kokonaisinvestoinnit, rakennusinvestoinnit, laiteinvestoinnit ja vara -investoinnit. Tutkin valtion investointien vaikutusta rakenteellisella VAR mallilla (SVAR) etumerkkirajoitteiden kanssa. Mallin identifioimiseen käytän tilastollista identifikaatiota.

Tulokset ovat linjassa aiemman kirjallisuuden kanssa. Yritysten kokonaisinvestoinnit laskevat valtion investointishokin myötä, mutta investointikategorioiden välillä on merkittäviä eroja. Syrjäytysvaikutus on suurinta laiteinvestoinneissa ja hieman pienempää rakennusinvestoinneissa. Uutena tuloksena on, että vara -investoinnit eivät syrjäydy, vaan päin vastoin kasvavat valtion investointien myötä.

Summary
Faculty: Faculty of Social Sciences
Degree Program: Master's Programme in Economics
Study Track: General Track
Author: Jaakko Eemeli Rahko
Title: The crowding out effect of government investments in Finland during the euro, an empirical study on firm investments
Level: MSc
Month and Year: June 2023
Pages: 61 + 8
Keywords: crowding out, crowding in, investment, fiscal policy, firm investments
Supervisor(s): Jani Luoto
Archived in: University of Helsinki
Summary:
The public sector in Finland is large and has been growing over the years. This has been because of the large welfare state and government programs that have expanded with economic growth. Large central government matters because it has a big market impact. It is worthwhile to consider how government investments affect the private sector.

In this master's thesis, I study how government investments affects the private sector firm investments in Finland. Government investments can either crowd out (reduce) or crowd in (increase) private investments. There has been much international interest in studying the crowding out phenomena but in Finland, the research is scarce. My thesis adds to this by focusing on different private investment categories enabling a more detailed understanding of the crowding out effect.

The data for the thesis consist of government and private firm investment statistics in Finland from the start of the euro in 1999 to the most recent available data in 2022. The private investments can be divided into four main categories, overall, construction, equipment, and assets. The impact of government investment is studied with a SVAR(8) model with sign restrictions. For the model identification, I have used statistical identification.

I find that the overall private investments are crowded out by government investments, but that there are differences between investment categories. Equipment investments experience the most crowding out, whereas construction investments are less affected. Notably the private asset investments are crowded in.

Contents

1 Introduction

The public sector in Finland is large and has been growing over the years. In 2020 public expenditure was as high as 59.8% of GDP[1]. Although the public expenditure has been rising in absolute terms, it has remained relatively stable relative to GDP[2]. This has been because of the large welfare state and government programs that have expanded with economic growth. Large central government matters because it has a big market impact. Fiscal policies can affect how recessions are felt in firms and how firms use their resources. Therefore, it is worthwhile to consider how government investments affect the private sector. In this master's thesis, I study how government investments affects the private sector investments in Finland. Government investments can either crowd out (reduce) or crowd in (increase) private investments. A third option is that private investments are unaffected by government investments. I find that the overall private investments are crowded out by government investments, but that there are differences between investment categories. Notably the private asset investments (including R&D investments) are crowded in.

Previous studies (*Salotti and Trecroci (2016), Kuismanen and Kämppi (2010), Afonso and Aubyn (2010)*) have found that increases in government expenditure or debt can decrease private investments over the short and long term. Expenditure increases also have a negative effect on growth and productivity. The effects can be non-linear and depend on the level of debt to GDP and the structure of the economy. On medium term public spending can actually increase private investments (*Puonti (2022)*) resulting in crowding in effect. Depending on how strong this effect is, it can mitigate the negative effects of crowding out. The overall effect of public spending is thus unclear. The effect of spending on investments is different depending on the economic situation. In a downturn credit availability drops and firms face restrictions, making some investments non feasible. In recessions the government can smooth out the decrease in demand and investments by increasing their spending. This can help the economy to rebound later (*Cerra, Panizza, and Saxena (2012)*).

This intervention increases the balance sheet of the government and possibly debt, depending on how the spending was financed. *Salotti and Trecroci (2016)* found that at a certain level the government debt can amplify the negative effects of crowding out. The threshold of debt to GDP in their study seemed to be 85–90%. It is therefore important to note that while providing temporary economic relief, public spending can hurt future growth. Budget balances

[1] A publication of EK on the public economy*EK (2023)*
[2] Statistics Finland, General government expenditure by function

are a constant topic of debate in Finland for a good reason. If there is no credible path to stabilising future budgets after an increase in spending, it could create unwanted externalities, one being crowding out.

The effects of crowding out depend on many factors, such as business cycle and debt level as mentioned above. In section 3 I present some papers, which discuss about the structure of the economy, and why it matters. Economic reforms can change crowding out effect to crowding in of investment (*Bahal, Raissi, and Tulin (2018)*). Government spending has different effects depending on where the investments are used. Investments in infrastructure has social benefits but usually generates poor returns on investment (*Puonti (2022)*). This means that the government has to raise more debt, making the crowding out effect stronger. When comparing public and private investments, it is good to keep in mind that they are driven by different factors. Private investments are (or at least should be) evaluated based on their ability to generate returns. Public investments can have social uses on top of revenue generation. The social benefits are important but when there are concerns of balancing the government budget and maintaining stable debt level, inefficient or unnecessary investments should be cut. My results can inform government policies on when the investments are useful.

To understand the effects of crowding out, I first need to explain the theoretical background. There is a more thorough look at the theory of crowding out in section 4. Starting with the government spending. When the government invests or spends money into anything, it needs to acquire capital. The government can either loan capital from credit markets, increasing debt, or increase taxation. If the government decides to take on debt and run a deficit in order to finance the investments, it increases the demand for loans and credit. Because the government is a large market agent, this increased demand drives up interest rates, given that on the short term loan supply remains fixed. Increased interest rates make it expensive for firms to get loans from the private sector. When investing, the government also increases the demand for all of the production factors, such as equipment and personnel. The overall effect is that firms face higher prices, limiting their investments. The other financing option for the government are taxes. In this case, taxes need to be increased in order to accommodate the increase in expenditure. This decreases the savings of firms and households. According to New Keynesian theory the savings are used to finance future investments. Increasing taxes thus decrease investments in the future (*Modigliani (1961), Friedman (1978)*).

My thesis extends the existing literature on crowding out by focusing on investments in Finland. Because crowding out is affected by a multitude of factors, the results of the international or domestic papers cannot be generalised. *Puonti (2022)* and *Kuismanen and Kämppi*

(2010) offer some guidance on how to approach this topic in Finland and what kind of results to expect. Their papers will provide a base for my analysis but I will make a few important deviations. More on these in section 3.1 and on the results in section 7. The main addition in this thesis is to study the effects on all of the investment sub categories.

The rest of the paper is constructed as follows. In the next section 2 I present my research question in detail and consider possible caveats of my approach. Section 3 has a literature review that covers the most important papers for my thesis. In this section I will contrast my study to previous research done on the crowding out effect and highlight what my approach adds to the field. Then in section 4 the general theoretical background for the crowding out is explored. This section covers two possible mechanism by which the government investments can affect private investments. The theoretical outlook helps to contextualise the results. Section 5 presents the data and all of the variables used in my models. In section 6 the SVAR model, its statistical identification, and the sign restrictions are explained. Then in section 7 the results of the model are presented. I create four main models, each of which are covered in this section. The robustness of the results is tested in section 8, and the last section 9 concludes the main result of this thesis.

2 Research Question

My research question is how central government investments crowd out private firm investments in Finland during the Euro era (from 1999 to 2022). I want to quantify this effect, how much does the government intervention affect the private investments and does this effect differ between investments. In my analysis there are three main investment categories, in addition to the overall private investments. These are construction investments, equipment, machinery and transport investments, and asset investments. Construction investments includes all of the building constructions as well as infrastructure investments. Equipment investments include all of the machinery investments and transportation investments. And last the asset investments include growth assets, R%D, and human capital investments. Previous literature (*Cerra, Panizza, and Saxena (2012)*) has established that crowding out effect depends on the business cycle. Structural changes in the economy, and recessions might mitigate the crowding out effects of government investments. If there is a recession, the credit availability on the market decreases, and there are more resources available. The government investments can in a recession increase private investments. The crowding out effect can also be different depending on the investment use. This is because investments differ in their capital intensity, exposure to the capital markets, overall resources, and collateral requirements. Construction, and equipment investments are usually large and funded with credit, making them more prone to changes in the economy. The effect on asset investments is less clear as these encompass many different kinds of investments from IT to human capital. I create a separate SVAR models for each of the three main investment categories and the overall private investments. The effects of crowding out are thus a non-linear. My model cannot account for the non-linear effect of crowding out, which manifest in larger confidence intervals of the results. However, these results should still reflect the overall effect of government investments on private firm investments.

In the introduction I brought up studies like *Salotti and Trecroci (2016)* and *Puonti (2022)* who studied the effect of overall government spending but I am interested in studying specifically central government investments. A natural question arises on the causal effect of government investments to the credit market and subsequently to private investments. Because government investments are part of overall spending, which according to *Modigliani (1961)* affect the credit markets, then investments should have a similar but smaller effect. Spending and investments in Finland are mainly funded by debt, which can be seen from consistent deficits of both the central and general governments [3]. During my time frame from 1999 to 2022, the credit markets in Finland are integrated to the European markets. Government spending or investments do not have a sizeable effect on these markets in theory. Even though the credit markets are integrated, they are imperfect. From the total amount of firm loans in Finland, around 40% are from abroad [4]. Because the majority of loans are domestic, and there are frictions in the credit markets, the government investments can have some effect through this channel. Other channel is the demand for production factors. Increases in government investments raises prices and leads to crowding out.

The central government investments in my analysis are a macro shock. This means that I do not separate different government investments into sub categories. This is because I am interested in crowding out effect that comes from an increase in demand in both credit and goods markets, called portfolio crowding out (explained more thoroughly in section 4). Studying how government construction investments affect private construction investments falls more closely to transaction crowding out, where firms compare the government investment project directly to private projects. The overall government investments have a larger market impact, and on each of the private investment categories. There are international papers (*Ahmed and Miller (2007), Pereira (2001)*) which have separated the different government investments. To keep

[3] Statistics Finland, General government EDP deficit and debt, annually.

[4] Statistics Finland reports the Foreign Direct Investments as 8 billion euros*StatisticsFinland (2023b).* Bank of Finland reports the total amount of loans taken by firms to be around 20 billion euros*BankOfFinland (2023).*

my analysis more focused and more comparable to the previous studies in Finland, I opted to only study the overall government investments.

3 Literature

Crowding out has a significant effect on economic growth, and market functioning, changing how fiscal policies are transferred to the economy. Because of this, there has been interest in studying crowding out in different settings. The research on crowding out can be divided into two categories; panel studies and country specific studies. The majority of the papers in both categories use either vector autoregressive (VAR), or vector error correction (VECM) models. A few papers have employed DSGE models, but these have focused on theoretical research. Some older papers also utilised OLS regressions but I will focus on the more recent research, which uses VAR models. Following previous research, especially *Puonti (2022),* I will use structural VAR (SVAR) model to study the crowding out effect in Finland. This enables me to compare my model and results with previous empirical studies and models.

Previous literature has studied the crowding out effect of both government spending (*Puonti (2022)* and *Kuismanen and Kämppi (2010), Traum and Yang (2015)*) and government investments (*Afonso and Aubyn (2010), Bahal, Raissi, and Tulin (2018), Hatano (2010), Pereira (2001), Xiaoming and Yanyang (2014)*). I use central government spending in my model, and thus my thesis is closer to research done by the latter papers. Investments represent a more narrow look at crowding out as public spending includes everything from infrastructure to defence. Focusing on investment offers interesting viewpoints. As I mentioned in section 2 private investments differ in terms of their capital and credit intensities, resulting in varying effects from crowding out. This is because as *Puonti (2022)* points out, some investments can generate revenue, which changes the need for credit and thus how crowding out affects them. The results of different papers using spending and investments are relatively similar, but there are some key differences which I will explore in the next subsections 3.1 and 3.2.

Though there are many international studies on crowding out, Finland has only been studied in a few papers. There are several panel studies that focus on European or industrialised countries, including on Finland (*Afonso and Aubyn (2010)*). There are less studies focusing on crowding out specifically in Finland. *Puonti (2022)* and *Kuismanen and Kämppi (2010)* study the effect of government spending on private investments. My thesis adds to the existing literature by offering a more detailed description of the crowding out effect in Finland. I compare the different private investment categories. *Puonti (2022)* focuses on the overall government spending, whereas I study the effects of government investments, which brings a new approach to analysing crowding out in Finland. I base my model on *Puonti (2022)* to enable a better comparison of the results, and to connect my results to her paper. Many international papers on crowding out use government investments rather than spending. These include *Sousa and Afonso (2011)* and *Pereira (2001),* and to a lesser extent **Bahal**. Many of the papers focus on larger economies, but they can be useful in their methodological approach. In the next sections I will first present the papers concerning Finland (*Puonti (2022), Kuismanen and Kämppi (2010)*) in section 3.1. In this section I also present other papers which have studied crowding out in Finland as a part of a panel of countries (*Afonso and Aubyn (2010)*). In section 3.2 I present other international papers on crowding out. These do not focus on Finland but they offer methodological considerations and enable comparing my results to other European countries.

3.1 Crowding out in Finland

The two papers studying crowding out in Finland are *Puonti (2022)* and *Kuismanen and Kämppi (2010).* The main paper I am focusing on is *Puonti (2022)* (and the previous paper *Puonti (2019)*). She studied the effect of government deficit spending, proxied by public debt, on productivity growth and private investments in Finland between 1999 and 2021. Puonti used quarterly data. The time frame and data frequency of my model are the same as in her paper, making the results relatively comparable. The difference between the analysis in my paper and that of Puonti comes from the model. Puonti uses SVAR(1) and SVAR(2) models to study crowding out whereas I use a SVAR(8) model. Based on previous international studies government spending or investments can have a lagged effect on private investments. Because of this it is better to use more lags. In my model there are 8 lags, covering a medium term of 2 years. As the crowding out mechanism is complex, including longer lags can capture some of the more nuanced effects. Puonti also has slightly different variables. In both of her models there are five variables; public debt, private financial position, real GDP growth, overall private investments, and firm/public sector share of the value add. In my main model there are four variables, central government investment, private firm investments, interest rate on 12 month government bonds, and the GDP growth rate. The identification method follows *Lanne and Luoto (2020)* and uses the statistical properties of the data to identify the shocks.

According to *Puonti (2022)* an increase in public debt crowds out private investment and decrease GDP growth rate on the short term. In her SVAR(1) model a one standard deviation shock decreased private investments by around 0.08 standard deviations after 10 periods (2.5 years) before the effect of the shock fades. The real GDP growth in the model decrease by around 0.3 standard deviations on impact and return quickly to the normal level. Increasing the lags to two changes the results. In the SVAR(2) model of Puonti private investments decrease at first by around 0.05 standard deviations after 5 periods (1.5 years), after which they start to increase. After 20 periods (5 years) the private investments have increased by 0.07 standard deviations. Real GDP growth follows the same pattern as in the SVAR(1) model, decreasing on impact but resuming to zero quickly after. In SVAR(2) model GDP growth turns positive by 0.1 standard deviations after 10 periods (2.5 years). According to Puonti public debt shock temporarily decreases private investments and GDP growth. However, growth rate increases in the long run because the increase in public debt increases public share of the value add. The larger public sector compensates for some of the crowding out effects. There is short term crowding out in private investments and medium to long term crowding in.

The other study on crowding out in Finland is *Kuismanen and Kämppi (2010).* Their paper is methodologically close to *Puonti (2022),* but use different time frame. In their paper *Kuismanen and Kämppi (2010)* study how fiscal policy affects economic activity in Finland. The fiscal policy, measured as public expenditure, is not equal to the public debt spending in *Puonti (2022).* This leads to different results. *Kuismanen and Kämppi (2010)* use quarterly data as did *Puonti (2022),* but they have a different time frame, running from 1990 to 2007. *Kuismanen and Kämppi (2010)* use two fiscal policy shocks, a positive tax shock, and a government expenditure shock. To study the crowding out effect of these two policies, *Kuismanen and Kämppi (2010)* utilise a Vector Stochastic Process with Dummy Variables (VSPD) method. They also estimated a SVAR model to compare the results from the VSPD method to. *Kuismanen and Kämppi (2010)* use two lags in their SVAR model, making it similar to *Puonti (2022).* The variables in both the SVAR and the VSPD models are private consumption, investments, GDP, government spending, and public revenues. The use of different variables from *Puonti (2022)* is due to the research question. *Puonti (2022)* was interested in how private investments and especially growth were affected by public debt spending whereas *Kuismanen and Kämppi (2010)* study the broader effect of expenditure shock on the economy. This is why they also used GDP and not GDP growth.

The results from the SVAR(2) model in *Kuismanen and Kämppi (2010)* indicate that increase in government expenditure crowds out all private sector activities, including investments. The positive tax shock (a revenue shock) unexpectedly increases private investments in their SVAR model. *Kuismanen and Kämppi (2010)* hypothesise that this counter intuitive result is because increase in government tax revenue increases with economic boom, which simultaneously boosts private sector investments and consumption. The 95% confidence intervals of impulse responses of private investments and consumption on public expenditure shock include zero. This means that they are are not statistically significant on the 5% level. However, *Kuismanen and Kämppi (2010)* note that the shape of the impulse responses is downward trending for both variables. This leads to a conclusion that the public expenditure shock decreases the private investments in the medium term. The initial effect of the shock on private investments is slightly positive, after 2 to 4 periods (0.5 to 1 year) private investments might be crowded in. On medium term, from period 5 forward, the private investments decrease. Private consumption does not have the initial slight increase, but rather starts to decrease after period 3.

There are also international papers, which study the crowding out effect in Finland as a part of a panel of countries. *Afonso and Aubyn (2010)* study the effect of public investments on private investments in 14 European and certain other western countries such as the US and Canada. Results from Finland can be compared to other European countries such as Denmark, Sweden, Portugal, and Germany. *Afonso and Aubyn (2010)* use a four variable VAR model for estimation and identified the model with Cholensky decomposition. The variables in the model were growth rate of real public investment, real private investment, real output, and total economy employment. This was also the ordering of the variables in the model. For each country they used a yearly time series from 1960 to 2005. This created 45 datapoints for each variable, somewhat small considering their model size.

Afonso and Aubyn (2010) find that public investments cause both crowding out and crowding in depending on the country. They observed crowding in Finland and eight other countries. This would mean that increasing public spending would induce private investments. In Finland the a one unit increase in public investments increase private investments by 0.38 units. Other countries where there was crowding in are Austria, Denmark, Portugal, Germany, Japan, Greece, and the US. In Denmark the change in private investments was 0.37, and in Portugal 0.23, quite close to the results from Finland.

The results of *Puonti (2022)* are in line with those of *Afonso and Aubyn (2010),* even thought they use different shocks in their models. Both find evidence of crowding in of private investments in Finland. The results cannot be compared directly due to different models and units. Because *Afonso and Aubyn (2010)* use public investments as the shock, a better comparison for their results might be those of *Kuismanen and Kämppi (2010),* who use public expenditure. The expenditure is not equal to investments, but they are closer than general debt spending. Surprisingly the results of *Kuismanen and Kämppi (2010)* are contradictory to *Afonso and Aubyn (2010). Kuismanen and Kämppi (2010)* found the public expenditure shock to crowd out private investments over the medium term. Due to different model specifications, the results are not directly comparable, but the contradictory results are noteworthy.

There can be multiple reasons for the different results. *Afonso and Aubyn (2010)* use yearly data that that covers a long time frame. The Finnish economy was very different in the 1960s than it was after 1991 and more so in the 2000s. As the papers in the next section (3.2) stress, the structure of the economy matters for crowding out effect (*Bahal, Raissi, and Tulin (2018)* and *AmirKhalkhali, Dar, and AmirKhalkhali (2003)*). The changes after 1991 are particularly important in Finland, because the whole banking system and credit markets changed. Yearly time series also lacks important variation within the year. Another reason for the different result could be that *Afonso and Aubyn (2010)* used the same four variables for all of the countries in their panel. These might not capture all of the central variables when it comes to private investments in Finland. Relatively small model and the fact that *Afonso and Aubyn (2010)* do not focus on any particular country could yield imprecise results. Lastly is the identification. Cholensky decomposition might not suite the data and some expectations about the economic model behind it could be misleading. Because of the more precise data and shorter time frame, I expect the results of *Kuismanen and Kämppi (2010)* to reflect better the effects of public expenditure or investment shocks in Finland.

Results of *Kuismanen and Kämppi (2010)* contrast also to those of *Puonti (2022).* These results can be compared more due to their similar time frame, though the models are different. As *Puonti (2022)* note in her paper, public expenditure increases with public debt, making the impulse variables correlated. The effect of public expenditure shock in *Kuismanen and Kämppi (2010)* seems to be completely opposite to the public debt shock in *Puonti (2022). Kuismanen and Kämppi (2010)* found slight crowding in before a medium term crowding out effect, whereas *Puonti (2022)* observed crowding out over the short term and crowding in over the medium term. Even thought the models have different variables, the difference between the impulse responses to the shocks indicates that there are some components in the public debt, which have a crowding in effect. That is public expenditure is not directly equal to debt, but rather a part of it. In overall public debt spending, there is the expenditure component, but also other variables. The results of studies of *Kuismanen and Kämppi (2010)* and *Puonti (2022)* show that aggregate variables of public debt or overall expenditure do not capture all of the nuances of crowding out effect in Finland. Focusing on government investments, which are a part of both public expenditure and debt, gives a more detailed understanding on crowding out.

The papers on Finland study the effect on overall private investments, but not all of the private investments are similar. *Puonti (2022)* makes an important note that the effect of public debt spending can vary between investment categories, for example R&D or infrastructure. Because crowding out is driven by a decrease in credit due to an increase in demand, or in the other case a decline in the savings of people, some investments are not affected by crowding out. If an investment creates revenue, then the need for credit can be lower. In these cases demand for credit does not change as much on the market. *Puonti (2022)* notices that R&D investments do not increase together with debt, concluding that debt is not used for R&D. This can be because R&D investments create long term revenue, decreasing credit demand. She did not separate the investment uses in her analysis, having only a brief consideration on the matter.

Because investment use is important to the crowding out effect, it has been studied in other contexts. *Pereira (2001)* studies how public investments affect private investments in the US. Importantly he disaggregates private and public investments into sub categories. There are seven categories for private investments and five for public investments. The private investment categories are 1. ICT and related equipment, 2. industrial equipment, 3. transportation, 4. other equipment, 5. non-residential buildings, 6. utility buildings, and 7. farms, mining structures. *Pereira (2001)* uses VAR for the analysis. Overall there are eight models, each with a different private investment category. There are also models which include all of the private investment categories, such that all of the possible combinations are modelled. The only other variable in the models is the GDP. The annual data runs from 1956 to 1997. Because I am studying how overall government investments affect private investments, I will focus on the results from a similar set up from *Pereira (2001).*

Pereira (2001) finds that the effect of public investments is heterogeneous between private investment sub categories. Public investments decreased private investments in ICT-, non residential building-, and farm and mining structure investments. Other investment categories increased as a result of public investments. The overall equipment investments, which includes all of the equipment sub categories, increased as well. The effects were calculated in dollars. A one collar increase in public investments increased the overall equipment investments by 1.42 dollars. The crowding out effects were relatively small, for ICT -0.28 dollars, non residential building -0.02 dollars, and farm and mining structures -0.03 dollars. The crowding in effects for industrial equipment, and transportation investments were 1.12 and 2.19 dollars respectively. I do not expect the results for Finland to follow these results. The US economy cannot be compared to Finland, but the study by *Pereira (2001)* illustrates that the effect of public investments depend on which private investments are included in the model. This conclusion follows the remarks made by *Puonti (2022).*

On top of investment use, time horizon matters. As the results of *Puonti (2022)* prove, crowding out has different short, medium and long term effects. *Puonti (2022)* says that the medium term effect can depend on the business cycle. I expect that in a recession, government investments boost demand and thus helps private investments to grow. To guarantee long term growth, government needs to invest in R&D (*Puonti (2022)*). The GDP controls for some of the business cycle changes, which is why it is included in all of the models in the papers I have discussed. Time horizon is important also because the effects of public investments is not immediate. It takes a few quarters for the effect to materialise in private investments. The findings of *Kuismanen and Kämppi (2010)* suggest that it can take a year before the shock affects investments.

Domestic interest for studying the effect has remained quite low. The papers of *Puonti (2022)* and *Kuismanen and Kämppi (2010)* are the few academic papers published on the subject in Finland. There are interest from ministries and government branches for more specific areas of crowding out such as R&D investments[5]. Crowding out has also been mentioned in some economic overview reports[6], but has not been at the centre for research. My thesis extends this literature. In the next section, section 3.2, I present international papers that have used SVAR to study crowding out. They offer new approaches and some international comparisons for the results of *Puonti (2022)* and *Kuismanen and Kämppi (2010)* as well as for my results later in section 7.

3.2 International literature

Internationally there is a larger body of literature on crowding out. Many country level studies have been done on larger economies such as China (*Xiaoming and Yanyang (2014)*), India (*AmirKhalkhali, Dar, and AmirKhalkhali (2003)*), Japan (*Hatano (2010)*), and the United States(*Pereira (2001), Ahmed and Miller (2007)*). There is also interest for smaller economies, which can be used to compare the Finnish results to. The papers in this section explore different approaches on studying the crowding out effect. These include focusing on government investments rather than the overall spending, analysing the effects on different investment types, and considering the structure of the economy.

[5]Valtioneuvoston selvitys, Yritysten t&k-toiminta ja t&k-investointien kasvattamisen edellytykset
[6]Ministry of Economic Affairs, Taloudellinen katsaus, syksy 2019

Starting with other research on smaller economies similar to *Puonti (2022)* and *Kuismanen and Kämppi (2010). Sousa and Afonso (2011)* studied the effects of government spending, and government revenue shocks in Portugal. In the early 2000s Portugal used large fiscal measures to keep budget deficit down. This prompted research into the effects of the policies and the crowding out effect. *Sousa and Afonso (2011)* use a Bayesian SVAR(2) model with five variables to study the effects of government spending. The variables in the model were government primary expenditures (or debt, depending on the model), government revenue, GDP, the GDP deflator, and the average cost of debt refinancing. Their data was quarterly and ran from 1978 to 2007, making the five variable SVAR model feasible.

Sousa and Afonso (2011) found that a government spending shock decreased investments. The effect lasted around 10 periods (2.5 years). The private investments fell by 1% after six periods, when government spending increased 6%. Private consumption fell slightly less, by 0.6%. *Sousa and Afonso (2011)* find crowding out of private investments in Portugal. The government revenue shock had a different effect. Private investments initially increased before turning negative in period 8 (2 years). The effect of the shock lasts 20 periods (10 years). A 5% government revenue shock initially increases private investments by 0.7% and private consumption by 0.2%. The long term crowding out effect outweighs the crowding in effect in the first few periods. To test the robustness of their results *Sousa and Afonso (2011)* used a fully simultaneous system approach. The results remained robust. Compared to the results of *Kuismanen and Kämppi (2010),* the government spending (expenditure), and government revenue shocks have an opposite shape. Spending shock crowded in investments in Finland over the short term and crowded out over the medium term (*Kuismanen and Kämppi (2010)*). A revenue shock on the other hand caused long term crowding in in Finland (*Kuismanen and Kämppi (2010)*). The length of the shocks are similar to *Puonti (2022)* and *Kuismanen and Kämppi (2010).* The short term effects in *Sousa and Afonso (2011)* last around 2 to 3 years and the medium term effects around 4 to 8 years. Because the model used by *Sousa and Afonso (2011)* is similar to the Finnish studies, the difference in the results can be due to the time frames and the differing economic structures, even though Portugal and Finland are similar in scope of the GDP per capita. Interestingly the results of *Sousa and Afonso (2011)* contradict *Afonso and Aubyn (2010)* paper, where Portugal was found to experience crowding in. The reason for this discrepancy is most likely in the different model and the higher frequency of data in *Sousa and Afonso (2011).*

The importance of the structure of the economy is highlighted by *Bahal, Raissi, and Tulin (2018)* who studied how public investment crowds out private investments in India. Data is yearly and runs from 1950 to 2012. *Bahal, Raissi, and Tulin (2018)* use SVECM to study the crowding out effect. They found that public investments caused crowding out in India. However, when *Bahal, Raissi, and Tulin (2018)* restricted the data to start from 1980, the effect was reversed, and public investment actually caused crowding in. They explain this with major structural changes that happened in the Indian economy. There were reforms to the banking sector and the government investment strategy. *Bahal, Raissi, and Tulin (2018)* say that a move away from infrastructure investments to production enhancing investments played a major role. This is in line with *Puonti (2022)* and *Pereira (2001),* investments into areas that generate revenue cause crowding in rather than out. Structural changes are important for crowding out. I have chosen to start my analysis from 1999 specifically to avoid the large structural changes of the Finnish economy in the early 1990s. The joining the common markets of the EU and the currency Euro, brought stability to the economy. There are economic crises during my dataset, the financial and the euro crisis. However, these do not represent major changes to the structure of the Finnish economy or the financial sector.

Major changes in Finland were the banking sector liberalisation in the 1990s and joining a currency union in the 2000s. More on this later in section 6. *Puonti (2022)* and *Kuismanen and Kämppi (2010)* avoided these structural changes as their analyses starts from 1990s. Finland joining the eurozone changed drastically how currency flows from and to abroad. The importance of the structural changes is highlighted by *AmirKhalkhali, Dar, and AmirKhalkhali (2003)* who studied how the degree of capital mobility changes crowding out. Importantly they included Finland in their analysis of 19 OECD countries. The countries are grouped based on their government size[7]. In the paper they use OLS regression with random coefficients model to study how government deficit and private savings affect private investments. *AmirKhalkhali, Dar, and AmirKhalkhali (2003)* use three time periods of 1970-1979, 1980-1989 and 1990-1999. They find that crowding out effect decreases from the 1970s to the 1990s at the same time as capital mobility increases. The results for Finland indicate that there is no strong correlation of government deficit on private investments, indicating that there might not be crowding out effect. However I question the use of OLS in studying crowding out effect, especially with a small model like *AmirKhalkhali, Dar, and AmirKhalkhali (2003)* have in their paper. The important result from this paper is that there seems to be some evidence of capital mobility affecting crowding out. Joining currency union expands the credit markets in Finland, which I expect to decrease the crowding out effect. For this *AmirKhalkhali, Dar, and AmirKhalkhali (2003)* study lends support.

[7] Finland is grouped with Ireland, Canada, UK and Germany

Some of the investment categories have been studied more closely. *Marino et al. (2016)* study R&D investments in France. They use a different approach from other papers and study the effect of R&D subsidy policy. Contrary to *Pereira (2001)* and *Afonso and Aubyn (2010),* the R&D investments in France decreased during the tax subsidies. The government program caused crowding out of private R&D investments. *Marino et al. (2016)* argue that there was substitution between small, medium and larger firms. Because the credit scheme benefited certain sized companies more than others, the distribution of R&D investments was changed. This change resulted in an overall decrease in private R&D investments, rather than the more usual crowding in.

Larger economies have been studied more. *Xiaoming and Yanyang (2014)* focuses on government investments in crowding out in China from 1980 to 2011. Even thought Chinese and Finnish economies are very different, the paper can provide some methodological insight as they use SVAR to study the effects. *Xiaoming and Yanyang (2014)* divide the government investments into two types, public goods and infrastructure, and private industry. In their VAR model, there are only three variables, the aforementioned government investments and private investments. They identify the model with Cholensky decomposition. *Xiaoming and Yanyang (2014)* find that public goods investments crowds in and industry investments crowd out private investments. The paper supports *Puonti (2022)* and *Sousa and Afonso (2011)* that investment use matters.

In addition to *Pereira (2001),* there has been interest in studying the disaggregated effects of government expenditure on private investments. *Ahmed and Miller (2007)* study how government debt financed expenditure affects different sub categories of investments in a panel of 39 countries. They divide these countries into developing and developed countries. *Ahmed and Miller (2007)* use a random effects OLS rather than SVAR used by many other papers. They find that there are significant differences between the expenditure sub categories in developing and developed countries. Transportation and ICT spending crowded in investments in developing countries only. These results are in line with *Pereira (2001)* who found that the transportation investments were crowded out in the US, a developed country.

Similar to *Bahal, Raissi, and Tulin (2018), Hatano (2010)* studied the effects of public investments on private investments in Japan. As in other studies *Hatano (2010)* acknowledges that the previous studies have been inconsistent, some supporting the crowding out and others crowding in arguments. His data runs from 1955 to 2004 and like *Bahal, Raissi, and Tulin (2018),* he used SVECM. The paper finds there to be a long run crowding in effect. *Hatano (2010)* concedes that there are some caveats in his approach. The reverse causality bias is present and that more weight should be put on the possible effects of Keynesian fiscal policies i.e. governments spending programs.

My thesis combines a SVAR analysis like in *Puonti (2022)* and *Kuismanen and Kämppi (2010)* but uses government investments, like *Pereira (2001)* and *Hatano (2010),* as the shock. I take a closer look at how investment categories are affected by the shock. Including more lags into my model than either of the papers on Finland, increases the understanding of long term effects of crowding out. Results from the other papers indicate that the need to consider the economic structure of Finland throughout the time series. Overall government spending and investments seem to have very different consequences depending on the country specific criteria. My approach uses examples from international research that focus on investments, while integrating it to the special case of Finland, where *Puonti (2022)* established a solid research to which I can add methodological backing from papers such as *Sousa and Afonso (2011)* and *Traum and Yang (2015).* I can contrast my results to their conclusions and compare how the crowding out effect looks when taking the impulse from an increase in public investments rather than increase in debt.

4 Theoretical background

In this section I present a more detailed theoretical outlook on crowding out. I presented the general theory of crowding out in section 1 with the paper *Modigliani (1961).* Because crowding out is complex phenomena, more theoretical studies have been done after *Modigliani (1961).* These include *Friedman (1978)* and *Buiter (1977).* Crowding out depends on the structure of the capital markets as well as economic situation and overall demand. The traditional explanation of crowding out mechanism functions through credit markets. The credit market effects are presented in an IS-LM model in the aforementioned papers. This theoretical framework is suited best for closed economies, which Finland is not. The IS-LM framework works in Finland to some extend due to imperfections in the credit markets even during the Euro era. Another approach to crowding out suited for open economies is the demand and supply balance. In the following sections I first present the general model based on capital markets, and second the model with demand and supply dynamics.

4.1 IS-LM model

The theoretical literature distinguishes between transaction crowding out and portfolio crowding out. *Buiter (1977)* describes transaction (direct) crowding out, as government competes from the same resources as the private firms. In this case the government directly competes with firms on personnel and equipment. The direct crowding out happens through the demand and supply mechanic covered in the next section 4.2. Portfolio (indirect) crowding out, on the other hand happens when government actions indirectly affect the firms decisions (*Buiter (1977)*). This can happen through interest rate markets. This distinction to these two crowding out channels is shared by all of the theoretical literature.

To study both the transaction and portfolio effects *Buiter (1977)* and *Friedman (1978)* use the standard Keynesian IS-LM model with wealth effects. The IS-LM model has been widely used in the theoretical literature on crowding out because it captures the short-run effects. In order to understand crowding out in this model, let us start with the curves of the IS-LM framework. *Friedman (1978)* defines his model with three main equations, which determine how the IS and LM curves move, and how the bond markets react to government policies. Starting with the IS curve, *Friedman (1978)* defines it as

$$Y = y_0 + y_1 G + (1 - y_1)T + y_2 r + y_3 W \tag{1}$$

where Y is income (total spending), G is government spending, T is taxes assumed in this model to be a lump sum tax, r_k is interest rate for capital, and W total private wealth, y_0 to y_3 are coefficients. The wealth W is defined as

$$W = M + B + K \tag{2}$$

The wealth consists of money stock M, outstanding stock of interest bearing government bonds B, and outstanding stock of real capital K. In general the public holds all three of these assets and each has a expected yields r_m, r_b, and r_k respectively. The key variation of wealth in this model comes from the government budget constraint $G - T = dM + dB$. Assuming that at period 0 the budget is balanced and $G = T$, any spending increase or decrease in the next period equals $dM + dB$ (*Friedman (1978)*). This is also the same for private wealth W changes, as on the short-run the capital is assumed to be fixed (*Friedman (1978)*). The government does not control the money stock but by issuing bonds, the government increases the wealth of households. *Friedman (1978)* states that he implicitly assumes that the public regards increase in government bonds as increase in wealth. This means that the government bonds are expected to be relatively liquid. In my model this assumption holds well as the Finnish government bonds during the euro era have been relatively liquid[8]. Compared to German bonds they have been more volatile but due to the good rating of Finnish bonds, they can be considered wealth as they are easy to exchange to either cash or capital.

The money demand, LM, curve depends on wealth W, income Y, and the interest rate for bonds and capital(*Buiter (1977)*). *Friedman (1978)* expresses the money market function as

$$M = m_0 + m_2 r_b + m_3 r_k + m_4 Y + m_5 W \tag{3}$$

where the money markets M are dependent on the yields/interest rate on bonds r_b and capital r_k, the total income Y, and the wealth W. The interest rate for money r_m is fixed at zero in the model by *Friedman (1978).* The coefficients $m_0, ..., m_5$ determine the relative weights of how much each variable affects the money market balance. They are comparable to y_i coefficients in equation 1. The coefficients for m_2 and m_3 are negative (*Friedman (1978)*), indicating that the demand for money decreases when the interest rates for capital and bonds increase. This is because people are more willing to hold capital and bonds when their yields increase.

In the last equation *Friedman (1978)* defines how interest bearing government bonds are priced,

$$B = b_0 - (m_2 + b_3) r_b 0 b_3 r_k + b_4 Y + b_5 W \tag{4}$$

The bond markets B are dependent on the interest rate for bonds r_b and the interest rate for capital r_k, the income Y, and the wealth. The coefficients $b_1, ..., b_5$ again determine the relative weights. The last coefficient b_5 defines how much of the increased wealth people are willing to hold as bonds. If the increase in wealth increases the demand for money, $m_5 > 0$ in equation 3, then $b_5 < 1$, implying that the people divide the increase in wealth to bonds and money (*Friedman (1978)*). The demand for bonds depend positively on r_b and negatively on r_k, the increase in capital yield decreases the demand for bonds.

These three equations, 1, 3, 4 define the model for crowding out. In this IS-LM model the IS curve is conditional on G, M, K, B, and T and the LM curve on M, K, B, and r_b. The IS-LM curves are usually drawn in a interest rate-income figure. Since the interest rate effect

[8]The bond liquidity can be measured on a multiple indicators. The number of transactions of Finnish government bonds has remained stable during the euro (Bank of Finland)

in the goods market depends on the interest rate for capital r_k, it is used as the other axis. The interest rate for bonds r_b is more informative on the financial conditions of the economy than the monetary policy. *Friedman (1978)* solves the equations 1 and 3 for r_k and Y, the r_b is solved from equation 4. As r_b is part of equation 3, it affects the position and intersection of the IS and LM curves. In addition, the both r_k and Y are arguments of equation 4. This results in jointly determined variables of r_k, Y, and r_b (*Friedman (1978)*).

The two crowding out channels affect the different curves. Transaction crowding out effect moves the IS curve, and portfolio effect moves the LM curve (*Friedman (1978)*). It is worthwhile to consider how both of these channels work, as they can compliment each other, or work in opposite directions. The overall movement of these curves defines whether government investments crowds out or crowds in private investments.

Transaction crowding out affects the IS curve by changing the income Y of people. Under deficit spending, the income Y increase as it is dependent on G. If m_4 from equation 3 is positive, then this increases the demand for money M. If the money market remains balanced, M is fixed, the interest rate r_b, r_k, or both of them has to rise. If both the money markets M and the bond markets B are fixed, then both r_b and r_k need to increase in order for the markets to clear. The increase in interest for capital and bonds decreases the willingness of people to hold money, hence decreasing the demand for money.(*Friedman (1978)*)

Portfolio crowding out under government bond financing increases the wealth W (recall that $W = M + B + K$). The money markets M are again fixed, such that the increase in wealth has to be offset by a change in interest rates. An important difference to the transaction crowding out is that the bonds are assumed relatively liquid as I noted before. This creates a wealth effect and it is not clear if r_b or r_k will rise (*Friedman (1978)*). Capital remains fixed on a short-run, meaning that the capital markets are balanced by an increase in r_b, or a decrease in r_k. Because the increase in r_b can help balance the capital and money markets, and the bond markets, it unambiguously rises with bond financed government spending (*Friedman (1978)*). In contrast, an increase in r_k can clear the money markets but a decrease can clear bond and capital markets (*Friedman (1978)*). Therefore it is impossible to know prior if r_k rises or falls and if the portfolio or transaction effect dominates.

The effect of r_k on increased bond financed government spending can be studied with the partial derivatives of equations 3 and 4 (*Friedman (1978)*). Solving for r_k and r_b and taking the partial derivative with respect to G (*Friedman (1978)*), we can see how the two interest rates react,

$$\frac{\partial r_b}{\partial G} = -\frac{b_3 m_5 + m_3(1-b_5)}{m_2 m_3 + m_2 b_3 + m_3 b_3} \tag{5}$$

$$\frac{\partial r_k}{\partial G} = \frac{m_2(1-b_5) - m_2 m_5 - b_3 m_5}{m_2 m_3 + m_2 b_3 + m_3 b_3} \tag{6}$$

The partial derivative for r_b is always negative, meaning that the interest rate for bonds always decrease when government spending increases. As Friedman noted, the reaction of r_k cannot be observed from the partial derivative without additional assumptions. The denominator for both partial derivatives is the cross-product of the three key substitution coefficients (*Friedman (1978)*). If these three are substitutes to at least some decree, the denominator is strictly positive (*Friedman (1978)*). The nominator in equation 6 indicates how r_k reacts to government spending. When people are willing to hold at least some of the new wealth from increased government bonds as money (i.e. $m_5 > 0$), then the sign of the numerator for equation 6 depends on m_2 and b_3. The relation of these coefficients determines if the portfolio effect causes the interest rate for capital r_k to rise or fall. In other words, the crowding out or crowding in is determined by m_2 and b_3. *Friedman (1978)* defines the relative substitutability index as

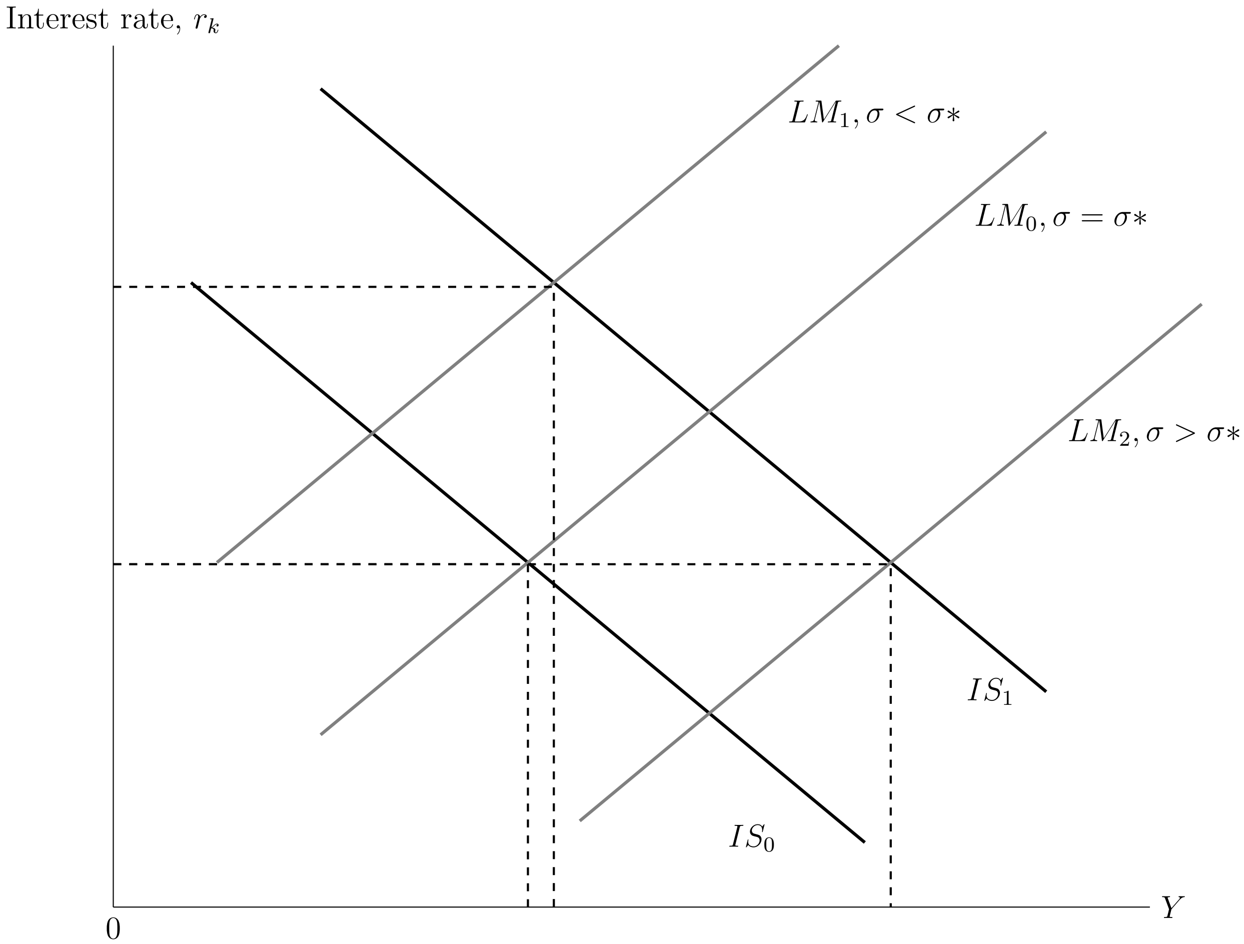
$$\sigma \equiv \frac{m_2}{b_3}, (= \frac{b_1}{k_2}) \tag{7}$$

where m_2/b_3 is the ratio of substitution between bonds for money and b_1/k_2 is the substitution of bonds for capital, k_2 is the coefficient for r_b in capital markets. If bonds are close substitutes for money but not for capital, then σ is large and if the bonds are closer substitutes for capital than money, then σ is small. *Friedman (1978)* defines a critical value $\sigma*$, which defines if there is a crowding out or crowding in effect. It is defined as

$$\sigma* = \frac{m_5}{1 - b_5 - m_5} \tag{8}$$

This critical value can be compared to the value of σ from equation 7. There is a crowding out effect if $\sigma < \sigma*$. This means that bonds are a better substitute for capital than money (*Friedman (1978)*). The portfolio and transaction effects both work in the same direction. If $\sigma > \sigma*$, then there is crowding in, the bonds are a better substitute for money, i.e. they are more liquid. This reinforces the income effect of government spending (*Friedman (1978)*). Bonds can be equal substitutes for money and capital ($\sigma = \sigma*$), in which case there is no portfolio crowding out as the bond markets balances with the money market.

The figure 4.1 visualises the effects of increased government deficit spending. As mentioned at the beginning of this section, the IS curve is conditional on G, M, K, B, and T and the LM curve on M, K, B, and r_b. When government increases their spending, they issue bonds B that increase wealth in equation 2. The increase of bonds shifts the IS curve right from IS_0 to IS_1. The movement of the LM curve depends on the substitution index σ and its relation to the critical value σ. When bonds are equal substitutes for money and capital ($\sigma = \sigma*$), then the LM curve does not move and remains at LM_0. The new intersection of IS_1 and LM_0 increases the income Y and also the interest rate r_k, resulting in crowding out. Notably the crowding out effect stems entirely from the shift in the IS curve.



When bonds are better substitute for capital than money, $\sigma < \sigma*$, both the IS and the LM curves shift. The IS curve shifts to the right to IS_1 as before but the LM curve shifts to the left to LM_1. When bonds are a better substitute for capital, then the return from assets has to grow in order to balance the money markets from equation 3 (*Friedman (1978)*). The interest rate for capital r_k has to increase, which also shifts the LM curve. The new equilibrium is at a higher interest rate, resulting in crowding out.

The last possibility is that bonds are better substitutes for money than capital, $\sigma > \sigma*$. The increase in government bonds decreases the expected return on capital (*Friedman (1978)*). Now both the IS and the LM curves shift to the right. The new equilibrium is at the intersection of IS_1 and LM_2. Depending on how much the IS and the LM curves shift, the interest rate r_k remains at the original level, or decreases. The decrease in r_k reduces the cost of capital, inducing firms to invest more. The investments of a firm are expected to be negatively dependent on interest rate r_k. When the cost of capital is high, then firms can be credit constrained and not be able to loan as much as they would have liked. Decrease in credit reduces the firm output and investments

4.2 Demand and Supply

The supply and demand framework is more straightforward than the IS-LM model presented in the previous subsection. It relies more on the direct crowding out channel studied by *Buiter (1977).* In free markets the prices for all of the goods, including labour, are determined by demand and supply. The price of any good is such that there are no firms willing to sell it for less. There are also no firms that would buy the good for more than the set price. The prices are at an equilibrium. When a government decides to increase investments, they increase the demand for goods and labour needed for the investments. For example construction investments require workers, materials, and machinery. The increase in demand from government investments drives the prices higher for all of the production factors. The result is that the new equilibrium price is at a higher level such that the demand and supply are in balance again. The increased prices faced by firms decreases their investment possibilities, and investments fall.

There is an important feature in the demand and supply framework, it depends on the business cycle. As *Bahal, Raissi, and Tulin (2018)* noted in their study, economic changes affect crowding out. Prices balance demand with supply when there are scarce resources. However, if the output gap is open, i.e. there is unused capacity in the economy, government investments (or spending in general) can cause crowding out. During recessions, when the output gap is open, there is more production capacity in the economy than is being used. The demand does not match supply. When the government increases investments in a recession, the increase in demand does not increase prices or reduce resources (labour, materials, and machinery) for the private sector. The output gap only gets smaller. The result is crowding in effect of government investments.

In the demand and supply framework there is no difference between government investments and general spending, as both affect demand. The difference is the magnitude of change in demand. Similar to the IS-LM model, investments are a part of the overall government spending. Thus they have a smaller effect on private firm investments. Unfortunately, my SVAR(8) model does not capture the non-linear effects of business cycles. This creates more uncertainty in the model, which manifests in larger confidence intervals. Both the demand and supply dynamic, and the IS-LM dynamic affect the firm investments in Finland. It is not possible to separate these effects from the results in section 7. These theoretical frameworks offer explanation for why the government investments crowd out private investments.

5 Data Description

This section describes the data in my analysis. The data is quarterly time series covering the time period from 1999 quarter 1 to 2022 quarter 2. There are 96 observations per variable. I limit my analysis to the euro era in Finland, staring from 1999. Focusing on this time period makes the results more robust, because there are no major structural changes to the capital markets, and the relation of government fiscal policy to monetary policy remains the same as there is no independent monetary policy in Finland after 1999. Because crowding out depends on how government deficit financed spending interacts with bond- and money markets as illustrated in section 4, the euro creates a natural time frame. This also makes the results comparable with *Puonti (2022). Kuismanen and Kämppi (2010)* start their analysis from 1990, but they control for structural changes, making the results comparable.

The four variables I use are central government investments, private investments, interest rate on 10-year government bonds, and the GDP. The data is obtained from Statistics Finland and the Bank of Finland. All of the variables are seasonally adjusted and indexed to the price level of 2015. Private investments are divided by their use. The main categories are construction, equipment, and assets. There are also the overall private investments. I include interest rate and GDP into my model to control for changes in the economic growth and general economic situation. The variables in previous studies used were dependent on the research question, so there are slight variations.

The papers of *Puonti (2022)* and *Kuismanen and Kämppi (2010)* focusing on Finland studied how public spending affected the economic activity, private investments among them. Due to the different research question they used alternate variables. *Puonti (2022)* included real GDP growth, share of public sector to the value added, and the public financial position. The shock in her model came from an increase in public debt. *Kuismanen and Kämppi (2010)*i studied more broadly on how economic activity reacted to a shock in government expenditure and public revenue. The expenditure shock is similar to *Puonti (2022)* as the expenditure can be financed with debt. *Kuismanen and Kämppi (2010)* note that the increased expenditure can also be due to increased tax revenue. *Afonso and Aubyn (2010)* studied the crowding out effect of public investments. Notably their analysis compared multiple countries and the data started from 1960. Due to the long time frame their model needed to account for many structural changes. The interest rate *Afonso and Aubyn (2010)* used the interest rate on 10-year government bonds to control for economic changes.

My model focuses on investments, which limits the need for additional variable such as private consumption or taxes. Following *Afonso and Aubyn (2010),* the central endogenous factors affecting private investments are public investments, real GDP growth, and interest rates. I use government investments and not the whole public sector investments because they are more focused and based on fiscal policies, enabling evaluation of government policies. The private investments obtained from Statistics Finland were not originally seasonally adjusted. To remove the seasonal variation, I used Tramo/Seats method employed by the Statistics Finland and the European Statistical Systems in their calculations. The government investments and the GDP were already seasonally adjusted.

All of the positive variables are in logarithms. These include government-, and private investments. The interest rate and GDP growth are not log transformed, as they can take negative values. In the following subsections I present each of the variables, starting with the central government investments in section 5.1, private investments in section 5.2, interest rates in section 5.3, and GDP growth in section 5.4.

5.1 Government investments

The central Government investments are depicted in figure 1. The time series is seasonally adjusted by Statistics Finland and the investments are in real terms (millions of euros). Investments in Statistics Finland are counted as the gross capital formation in expenditure. I have used the same definition for private investments as well, such that the investment data is comparable. Statistics Finland defines the gross fixed capital formation as the Finnish producers (firms) acquisitions, less disposals of fixed assets. Fixed assets are tangible or intangible assets produced as outputs from processes of production that are themselves used repeatedly, or continuously, in processes of production for more than one year (**Statistics Finland 1**).

There is a positive trend in central government investments. The adjusted investments

Figure 1: Government investments

have risen from 704 million euros at the start of the series, to 1134 million at the end of 2022. Even with the seasonal adjustments of the series, investments vary from quarter to quarter. There are four notable drops throughout the time series. After the first quarter of 2000 the investments decreased significantly to a little over 600 million. The next drop is in 2005 quarter 4. The largest decrease of government investments during the euro happened at the end of 2014. However, the investments bounced back quickly to the 2013-2014 level. The last drop is after fourth quarter of 2020, which comes after the most recent upswing in government investments in fourth quarter of 2019.

Comparing the central government investment statistic to central government debt figures [9] reveals that they have very different trends. The government debt remained stable with a slightly negative trend from the start of 2000 to the end of 2007. After the financial crisis the both the general and the central government debts have started to increase. Even when accounting for the increase in GDP the general government debt has increased. This is one reason for my focus on government investments. Because central government investments are more policy oriented, they make for a better case to study how it affects the private sector.

[9]Statistics Finland reports central government debt in their quarterly national accounting statistics, **Statistics Finland 2**

Construction	Equipment	Asset
1. Residential building construction 2. General construction 3. Building construction 4. Other general construction 5. Other building construction 6. Ground- and water constructions (general infrastructure)	1. Equipment and machinery 2. Transportation	1. Growth assets 2. Human capital

Table 1: Investment categories

5.2 Private investments

Private investment data has been chained and is measured real prices, like with the government investments. Different years and quarters are comparable in chained data and real prices enables removes the effect of inflation. The original data was not seasonally adjusted, which can be seen from the large variation of different investments in figure 2. Without seasonal adjustment the time series are too volatile to yield accurate results. For the seasonal adjustment I used Tramo/Seats method employed by Statistics Finland for all of their datasets. The seasonal adjustment makes the private investment statistics comparable to central government investments.

Statistics Finland divides private investment based on investment use. There are 12 categories in total; 1. Residential building construction, 2. General construction, 3. Building construction, 4. Other general construction, 5. Other building construction, 6. Ground- and water constructions, 7. Equipment, machinery and transportation, 8. Transportation, 9. Equipment and machinery, 10. Growth assets, 11. Assets and human capital, 12. Human capital.

The investment subcategories can be grouped into three main categories, presented in table 1. The three categories are 1. construction investments, 2. equipment investments, and asset investments. These main investment categories include some but not all of the other 12 subcategories. Table 1 details what subcategories are included in each main category. I have run a separate model using each of the 12 categories which are in the appendix, but for the results section (section 7) I focus on the three main categories. Statistics Finland details what these three categories include. Construction investments includes all of construction from infrastruc-

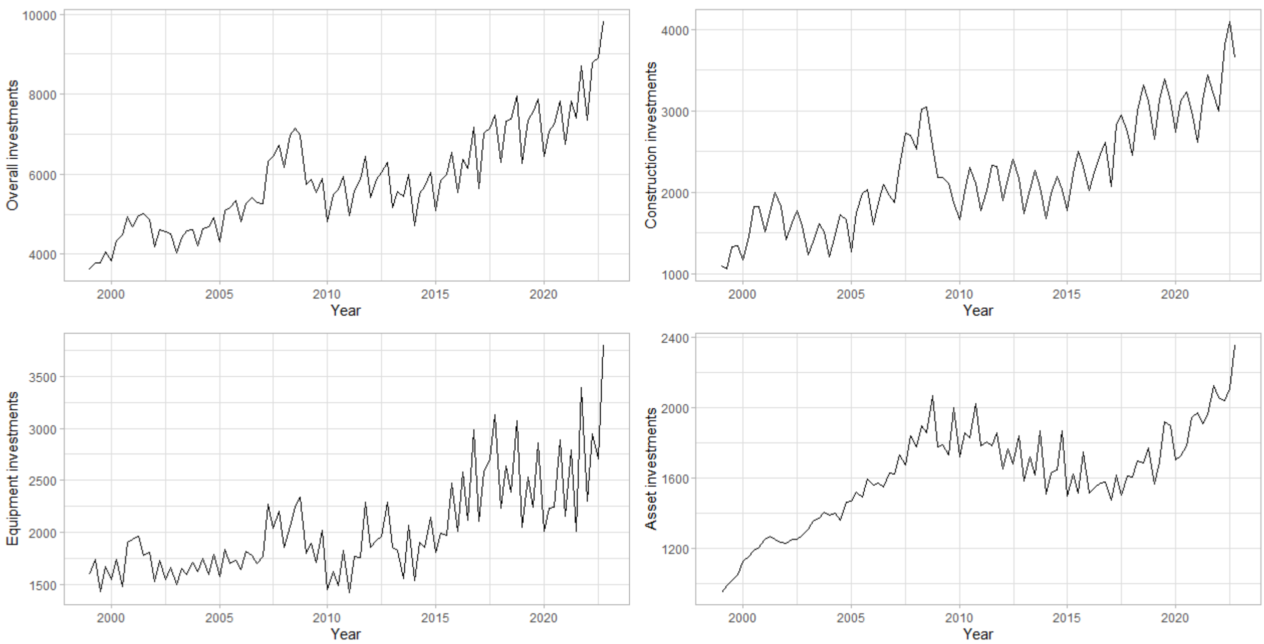


Figure 2: Non adjusted private investments

ture to building construction investments. It should reflect the general economic situation [10]. Equipment investments include ICT- and computer investments, all of the other machinery investments, and transportation investments. The last main category, asset investments includes human capital investments such as R&D and software as well as growth assets. These three categories represent the general distinction of investments in crowding out literature. Separating infrastructure investments from R&D investments has been highlighted by *Pereira (2001), Salotti and Trecroci (2016)* and *Marino et al. (2016).* This is because these investments have different returns and dependence on credit markets.

On top of the specific sub categories I study how the overall private investments react to government investments. The non-adjusted investment of the main categories are depicted in 2. All of the time series are volatile and depict clear seasonal variation. Overall private investments have a large variance and clearly follow some seasonal variation. Construction investments increase in the second and third quarters and are low in the first quarter of the year, reflecting the seasonal nature of construction in Finland. The equipment, machinery, and transportation investments are also seasonal. There is a level shift in 2015. The variance also increases. Asset and human capital investments follow the business cycle, rising before the financial crisis of 2007, then decreasing from 2007 to 2015, and increasing again with an economic upturn after 2016.

However, the non-adjusted data is not useful in analysis because the difference between

[10] rakennusalaa pidetään yleensä hyvänä mittarina

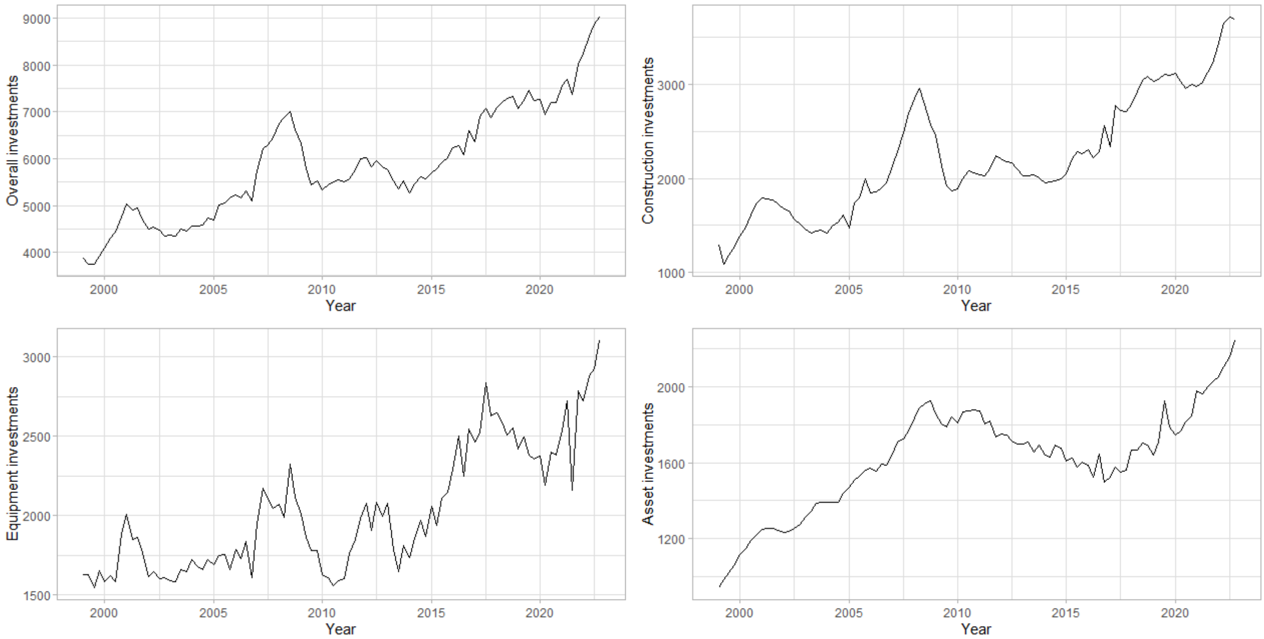


Figure 3: Seasonally adjusted private investments

any observations is non meaningful. Time series of investments can be behave predictably from year to year. Construction investments seem to increase during spring and summer and slow down in winter months. Equipment, machinery, and transportation followed a similar variation. Variance of asset and human capital investments was smaller but still exhibited regular variation. Time series can be thought to have three components, trend cycle, seasonal variation, and the random variation. By estimating the seasonal variation, it can be eliminated from the time series, resulting in seasonally adjusted data. The Tramo/Seats method used by Statistics Finland as well as the Eurostat, can be used to separate the seasonal variation from the trend series. It can also adjust to the different number of working days from year to year. The seasonal adjustment of the central government investments in the previous subsection 5.1 has been done using the same method, keeping the time series consistent.

The seasonally adjusted time series of the three investment uses and the overall investment are depicted in figure 3. The overall shape is similar to the non-adjusted series but the figures are smoother. The changes in investments now reflect the trend changes that depend on a variety of structural and policy changes. The time series of overall investments is similar to the construction investments, which can lead to construction investments driving the results. Because the overall results might be driven by certain investments uses, the differences between the time series in figure 3 highlights the importance of separating the investments categories. As the time series on construction investments follow overall investments quite closely, I expect the regression results to be similar between them.

5.3 Interest rate

The interest rate, measured as the interest rate on 10-year government bonds, is in figure 4. The interest rate of bonds captures the changes in economic situation, which in turn affects firms. The interest rate for 10-year government bonds has been widely used in previous studies (*Puonti (2022), Sousa and Afonso (2011), Kuismanen and Kämppi (2010), Afonso and Aubyn (2010)*) as the indicator of long term interest rates [11]. The bond interest rates reflect the variable r_b from equations in section 4. The interest rate on bonds r_b and interest rate on capital r_k define how the crowding out effect affects firms. Because the interest rate on government bonds follow the economic situation, they capture part of the movements in the capital market rates r_k. In the Euro area the corporate loans are usually tied to the 12 month Euribor rate. This can be used as a proxy for interest rate on capital r_k. The figure 4 displays both the interest rate on bonds and the 12 month Euribor rate.

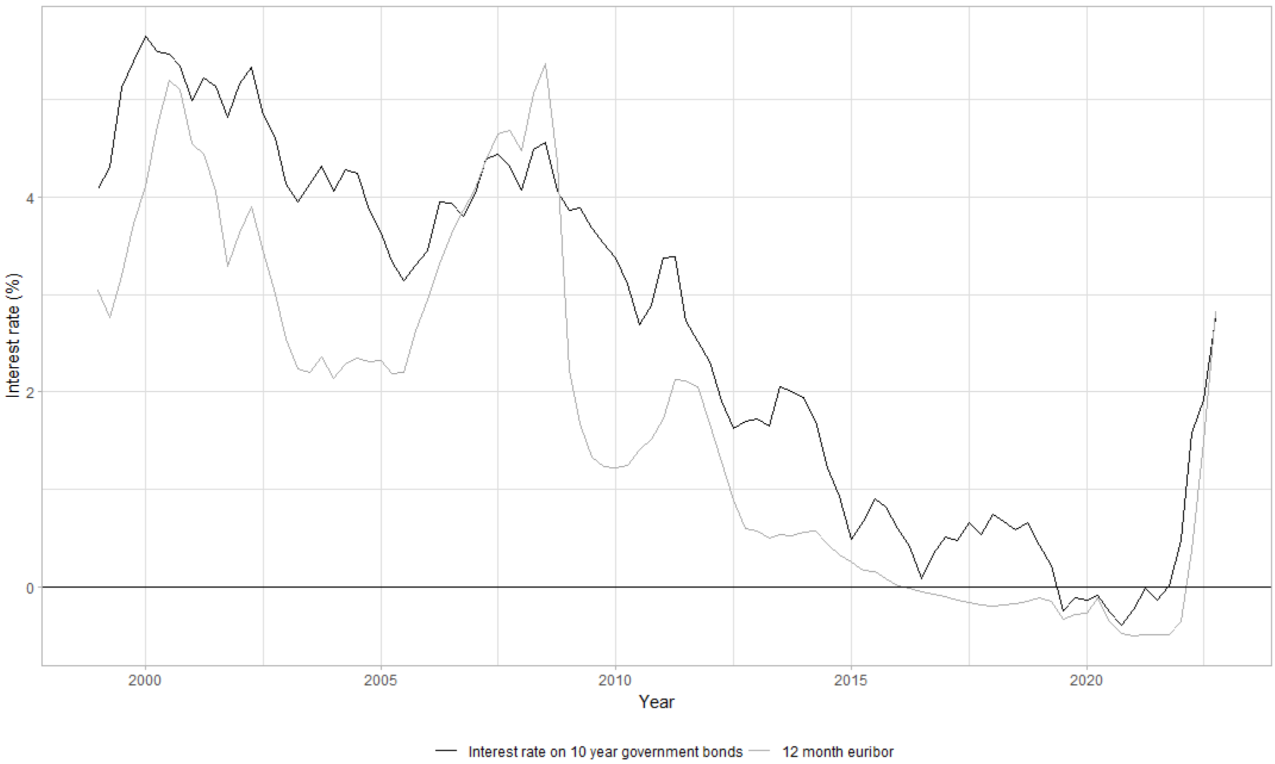


Figure 4: Interest rates for 10-year government bonds and the 12 month Euribor

There is a downward trend from the beginning of 2000. The interest rate of bonds starts at over 5% and declines. There are some upswings, in 2005 the interest rate increases from around 3% to 4.5% in the third quarter of 2007. When the key ECB interest rates were at zero lower bound from 2012 to the start of 2022, the interest rate for Finnish government bonds decreased

[11]In addition the OECD defines the long term interest rates as the interest rate on 10-year government bonds

from around 2% to near 0%. There was a dip to the negative in 2020 before the inflation in the Euro area started to rise, followed by ECB rates. The high inflation and rapid rise of the ECB rates pushed the interest rate on Finnish government bonds to 2.8% at the end of 2022.

5.4 GDP growth

Gross domestic product (GDP) growth is in figure 5. Statistics Finland produces quarterly GDP growth series. Previous crowding out studies have use either real GDP figures GDP growth in their models. Crowding out effect is not sensitive between these two variables, as long as there is a measure of economic development in the model. To make my model comparable to that of *Puonti (2022),* I chose to use the GDP growth series. The difference to a model using real GDP is the set sign restrictions. Government investments affect the growth rate but not the real GDP over the medium term. The GDP growth is measured as a percentage change from the quarter of the previous year.

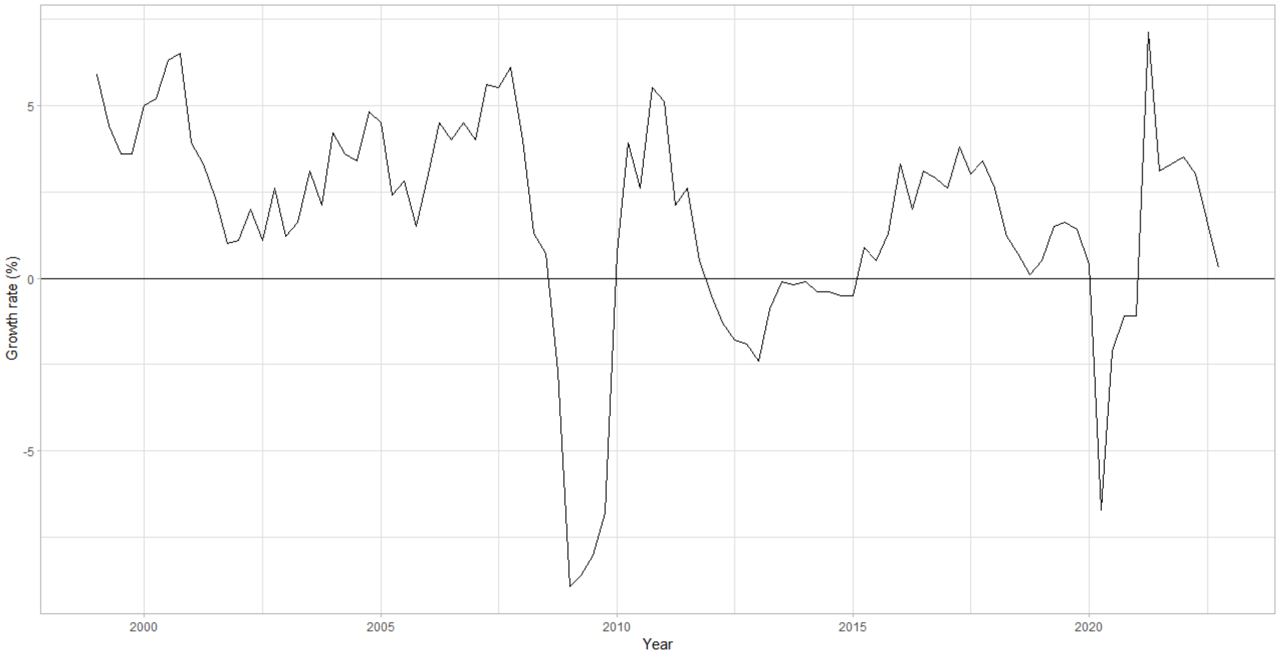


Figure 5: GDP growth

There is large variation in the growth rate of Finland. At the beginning of the currency union in the early 2000s there is consistent growth of around 2.8%. After the financial crisis of 2007, the growth plummets to -8.2%. It takes a few years for Finland to resume growth in 2010. The Euro crisis hampers growth again after 2012, and the recent pandemic in 2020. Large stimulus measures for the economy prompted the GDP to resume growth in 2021 and 2022, but there is still the most recent downward swing. The crises have had a larger effect on the growth, affecting the economy and the firms. These variations in the economic situation are important to include in the model.

6 Econometric Method

To study the crowding out effect I am using a Bayesian SVAR model with sign restrictions and statistical identification. The identification method relies on *Lanne and Luoto (2016)* and *Lanne and Luoto (2020).* Previous research papers on crowding out have used a variety of methods, the most commonly SVAR and SVEC models. My approach follows studies by *Puonti (2022)* and *Kuismanen and Kämppi (2010),* which enables me to compare my results to these previous papers. These papers focus on Finland and use similar variables and time frame. The paper by *Puonti (2022)* is especially comparable, as she also used statistical identification.

The problem when using SVAR models is to credibly identify the shocks in order to give them economic meaning. In SVAR models the identification can be achieved in a few different ways. Most of the previous literature on crowding out identifies the shocks based on theory, using sign restrictions on variables, and ordering them accordingly in the model. This approach relies on the economic theory, that might not always reflect the data. The Finnish economy is not fully comparable to other EU countries, and thus identification based on theory in previous research can yield false results. This is evident when comparing the results of the previous research. Papers in section 3 were divided on the effects of crowding out, even when studying the same countries. This was because crowding out is affected by multiple structural factors. Because there is no consensus on how government investments affect the private investments, it is better to use an alternate identification and test if the theoretical sign restrictions reflect the crowding out in Finland.

Statistical identification developed by Large stimulus measures for the economy prompted the GDP to resume growth in 2021 and 2022. *Lanne and Luoto (2016)* [12] use the statistical properties of the data to identify unique shocks. This approach assumes genuinely uninformative priors for the variables such that minimal external information affects results. Instead of theory, data can be used to learn about the impulse responses. Using the statistical identification, different impulse responses can be computed but they carry no economic interpretation. In order to label these shocks sign restrictions need to be used. The restrictions can be based on theories of crowding out or previous research. Crucially, the plausibility of these restric-

[12] Multiple papers contribute and expand this approach, see *Lanne and Luoto (2016)* and *Lanne and Luoto (2020), Lanne, Luoto, and Anttonen (2022)*

tions in the data can be assessed using the methods of *Lanne and Luoto (2020).* The set sign restrictions are tested against the impulse responses obtained from the data. If an impulse response matches the sign restrictions with a high probability, then the shock is identified. It could be that there is no match, then the restrictions should be changed. The theory might not reflect the shocks in the data hence the impulse responses drawn from the data might not match the expectations. If the sign restrictions I set do not hold in Finland, then there might be some interesting differences in how crowding out manifests in Finland versus in other European countries. The same sign restrictions might not hold for all of the investment categories either.

In the next subsections I present my SVAR model and the error distribution in 6.1, then the set of sign restrictions I intend to use in the model in 6.4, estimation of the posterior distribution and the likelihood function in 6.2. In subsection 6.3 is the algorithm for estimating the posterior distribution.

6.1 SVAR model

The SVAR model I am using is an n-variate standard structural VAR(p) model akin to *Lanne and Luoto (2020),*

$$y_t = a + A_1 y_{t-1} + ... + A_p y_{t-p} + B\epsilon_t, \tag{9}$$

where y_t is the vector of variables of $n \times 1$ dimension, y_{t-1} up to y_{t-p} the lags of the variables, $A_1, ..., A_p$ are $n \times n$ coefficient matrices, and B is a matrix with the structural effects of the error vector ϵ_t. The error vector $\epsilon_t = (\epsilon_{1t}, ..., \epsilon_{nt})'$ consists of independent non-Gaussian components. Following *Lanne and Luoto (2020)* I will assume the error process is a sequence of identically distributed random vectors. Each of the components of the error vector ϵ_{it} to have zero mean and unit scale σ_i. The components of the error vector are also assumed to be mutually independent. *Lanne and Luoto (2020)* make improvements from previous econometric research to the assumption on the distribution of the error components. If the errors are assumed to follow a skewed generalised t-distribution (SGT distribution) it enables more information to be obtained and also decreases the risk of distributional misspecification. This is because the SGT distribution nests most other general distributions (*Lanne and Luoto (2020)*).

To get the impulse responses I need the moving average representation of the SVAR(p) model,

$$y_t = \mu + \sum_{j=0}^{\infty} \psi_j B\epsilon_{t-j}, \tag{10}$$

where μ is the unconditional expectation of y_t, ψ_0 is the identity matrix, and $\psi_j, j = 1, 2, ...$

are obtained recursively from $\psi_j = \sum_{l=1}^{j} \psi_{l-j} A_j$.*Lanne and Luoto (2020)*

The problem is that y_t can have multiple moving average representations and structural shocks cannot be uniquely identified. If ϵ_t is assumed to be normally distributed, then the matrix B from equation 10 cannot be uniquely identified because any matrix C that is non singular can replace B with BC and error term with $C^{-1}\epsilon_t$. Assuming a diagonal covariance matrix of ϵ_t means that the transformation matrix C has to be of the form $C = DO$ where O orthogonal and D diagonal. Assuming non-Gaussainity of the structural error term ϵ_t the orthogonal matrix O in DO can be restricted such that B is uniquely identified up to permutation and signs of its columns. For the unique identification at least one of the $n-1$ components need to be non-Gaussian. (*Lanne and Luoto (2020)*)

6.2 Likelihood function and prior distribution

SVAR parameters are estimated with Bayes methods. Using this approach I need the probability density function for the posterior, and the prior densities. The posterior probability density function can be obtained by multiplying the likelihood function with the prior density $p(\theta)$. The calculation of posterior distribution requires the prior density. Using Bayesian methods means that there needs to be some assumption on the distribution of θ (*Kilian and Lutkepohl (2016)*). The prior distribution of θ should ideally be uninformative such that they do not affect the parameter estimates. Truly uninformative priors do not exist (*Kilian and Lutkepohl (2016)*). However, *Lanne and Luoto (2020)* show that the selection of informative versus uninformative prior for the matrix B does not alter the results. *Kilian and Lutkepohl (2016)* note that because priors are always somewhat informative in at least one dimension, they can be set to have desirable properties based on the VAR model at hand.

Following *Lanne and Luoto (2020)* I operate on the inverse of the matrix B, $(B^{-}1) \equiv b$, and set a Gaussian prior, $b \sim N(b, V_b)$. This results in an uninformative prior. In a point-identified SVAR model this results in a well-defined posterior distribution for B (*Lanne and Luoto (2016)*). The deterministic terms and matrices of 9 are in matrix $A = [a, A_1', ..., A_p']'$. The prior for the vector A follows from *Lanne and Luoto (2016), vec*$(A) \equiv c$, where $c \sim N(\underline{a}, \underline{V_a})$. The $\underline{a}$ is set to zero and $\underline{V_a}$ to $10000^2 I_{pn^2+n}$. Matrix A_1 is set to identity matrix I_n and the other matrices $A_2, ..., A_p$ to zero.

Next the likelihood function, i.e. the distribution of the data, is needed for the posterior distribution. The likelihood function is from *Lanne and Luoto (2020),*

$$p(y|\theta) = |det(B)|^{-T} \prod_{i=1}^{n} \prod_{t=1}^{T} f_i(x_i' B^{-1} u_t(\pi); \lambda_i, p_i, q_i) \tag{11}$$

where $\theta = (\pi', \beta', \gamma')'$, $\pi = vec([a, A_1' : ... : A_p']')$, $\beta = vec(B)$, x_i is the ith unit vector, and $u_t(\pi) = y_t - a - A_1 y_{t-1} - ... - A_p y_{t-p}$. With the likelihood function (11) and the prior densities $p(\theta_i$ for parameter vectors θ_i the posterior distribution can be calculated as,

$$p(\theta|y) = \frac{p(y|\theta)p(\theta)}{p(y)} \propto p(\theta)|det(B)|^{-T} \prod_{i=1}^{n} \prod_{t=1}^{T} f_i(x_i' B^{-1} u_t(\pi); \lambda_i, p_i, q_i) \tag{12}$$

This posterior distribution is used later in equation 14 to obtain the posterior probabilities of sign restrictions. Calculating the equation 12 is computationally time consuming. Because of this *Lanne and Luoto (2020)* use a modified Metropolis-Hastings Markov chain Monte Carlo algorithm to estimate the posterior, presented next.

6.3 Algorithm for posterior

The complexity of the likelihood function makes the distribution of blocks of parameters π, β, γ unknown (*Lanne and Luoto (2020)*). This is why in the most recent paper *Lanne and Luoto (2020)* uses a differential evolution Markov Chain, DE-MC, algorithm from *Ter Braak and Vrugt (2008)* to estimate the posterior distribution. Major advantage of the DE-MC algorithm is that it is not sensitive to the initial approximation of the target distribution (*Lanne and Luoto (2020)*). The algorithm generates N chains that are long sample of the parameter vector. To get a precise inference, long samples are need to be drawn, when the posterior is computed from a dependent rather than random sample (*Kilian and Lutkepohl (2016)*). The chains are then run in parallel and updated through a Metropolis step, where the scaled differences of the N chains are compared(*Lanne and Luoto (2020)*). The chains do converge when using this simulation, but the convergence is faster when the initial conditions are closer to the target posterior distribution.

The number of chains should be larger than one (*Ter Braak and Vrugt (2008)*). Like *Lanne and Luoto (2020),* I will use $N = 2$. The algorithm of *Lanne and Luoto (2020)* works as follows; after the number of chains has been chosen, the DE-MC algorithm selects from each chain at random two row vectors $x_{\tau 1'}$ and $x_{\tau 2'}$ from the matrix X, which consists of the current and past states of the chain. Then a proposal $\theta^* = \theta_i + \phi(x_{\tau 1} - x_{\tau 2}) + \epsilon$, where ϕ is a tuning constant and $\epsilon \sim N(0, bI_d)$. *Lanne and Luoto (2020)* use an arbitrary small b and set $\phi = 2.38/\sqrt{2d}$, where d is the number of elements in θ. The value of ϕ follows from *Ter Braak and Vrugt (2008)* who found that this value is optimal for Gaussian target distributions as well as working with other target distributions. The proposal θ^* is accepted with the probability $min(1, \frac{p(y|\theta^*)p(\theta^*)}{p(y|\theta_i)p(\theta_i)})$. If the proposal is rejected, then the previous proposal θ_i is left unchanged.

The whole population $\theta_1, ..., \theta_N$ is updated K times(*Lanne, Luoto, and Anttonen (2022)*). The K is also the thinning rate. The results are stored in X The steps in the algorithm described above are repeated until the population $\theta_1, ..., \theta_N$ has converged. To ensure a close approximation of the posterior distribution, a number of initial sample values are discarded, called the burn-in period. *Lanne and Luoto (2020)* discard $M/2$ rows of X and the remaining rows form a posterior distribution for θ. The result is the estimate for equation 12, and is then used in equation 14 to calculate the posterior probability of sign restrictions.

As I mentioned at the start of this subsection, the chains do not necessarily converge. Adequate convergence of the chains can be assessed using the $\hat{R}$ statistics(*Lanne and Luoto (2020)*). *Lanne and Luoto (2020)* set the limit at 1.1, such that if $\hat{R} < 1.1$, then the chains have converged. Otherwise longer chains N should be drawn, the thinning rate K could be increased or different initial X and $\theta_1, ..., \theta_N$ chosen.

6.4 Sign restrictions

The identified impulse responses from the matrix B have no economic meaning. To interpret the results, sign restrictions can be used. The restrictions are placed on the shocks of the variables, for example a positive GDP growth shock can be set to have a positive effect on all of the other variables. This assumption might not match any of the shocks found in the data, or it might match multiple shocks. The idea in statistical identification proposed by *Lanne and Luoto (2016)* is to estimate the probability of these types of restrictions appearing in the data based on posterior distribution. The sign restrictions in my model are based on previous research and the theory of crowding out presented in section 4.

Lanne and Luoto (2016) estimate the probability of set sign restrictions using restricted SVAR model. They restrict the impact matrix B with another matrix R, which includes the sign restrictions. Then they define a set Q such that it consists of the columns of B that satisfy the restrictions in R. This is a $J \times n$ matrix, where J is the number of variables that the shock affects. The set Q is thus defined as

$$Q = \{\theta_{0k} : R\theta_{0k} >= 0_{J\times 1}\} \tag{13}$$

The θ_{0k} is the kth column of the impact matrix B. Using this set the plausibility of structural shocks satisfying the sign restrictions embodied in R can be calculated. The conditional probability of each shock ϵ_{kt} is computed by

$$Pr(\theta_{0k} \in Q, \theta_{0,m\neq k} \in Q^c|y) \tag{14}$$

This equation can be interpreted as the posterior probability of the restricted SVAR model (*Lanne and Luoto (2016)*). Using posterior distribution of impulse response matrices ψ_j this probability can be calculated for all $k \in 1,...,n$. The sum of these probabilities gives the likelihood of the SVAR model satisfying the sign restrictions set in R (*Lanne and Luoto (2016)*). If the probability is close to zero, then the probability that there are no shocks in the data that satisfy the sign restrictions is high. When none of the impulse responses match the sign restrictions, either the model or the sign restrictions have to be changed. *Lanne and Luoto (2016)* note that there could be alternating signs for different lags of the shocks. These can be included in the model by redefining the set Q as $Q = \{\theta_{0k} : (I_{q+1} \otimes R)\theta_{0k} >= 0_{J(q+1)\times 1}\}$. It could also be that there are multiple impulse responses that satisfy the sign restrictions. In this case *Lanne and Luoto (2020)* calculate the Bayesian factor from the posterior probabilities of each impulse response. The Bayes factor is a ratio of marginal likelihoods of two statistical models (*Kilian and Lutkepohl (2016)*), in this case the unconstrained and sign restricted models. After transforming the posterior probability into the Bayes factors, it can be used to weight the posterior evidence of constrained model to unconstrained (no sign restrictions) (*Lanne and Luoto (2020)*). The relative likelihoods tell how probable the sign restrictions are in a given model. Following previous literature *Lanne and Luoto (2020)* state that if the Bayesian factor for one of the impulse responses in a model is greater than 3.2, then it is the most probable to be the shock of interest and it is labeled as the identified shock.

In the case of crowding out, I assume the effect of a government investment shock to be the same for all of the lags. I include 8 lags into my model, capturing more of the variation in crowding out. As my data is quarterly, this constitutes for 2 years. I am only interested in identifying the government investment shock, though the statistical identification of *Lanne and Luoto (2016)* facilitates identifying multiple shocks at the same time. The equation 14 can be generalised to include $g > 1$ structural shocks with unique sign restrictions. Each shock has its own matrix R_i that includes the sign restrictions. The calculation of posterior probability requires posterior distribution as mentioned above. The posterior distribution can be calculated from the likelihood function and prior densities (*Lanne and Luoto (2020)*). The probability of identifying these shocks is naturally lower than in the case of one identified shock, as the impulse

Sign restrictions				
Variable	Government investment	Industry investment	Interest rate	GDP growth
Government Investment	1	-1	0	-1

Table 2: Sign restrictions

responses from the data need to be matched to multiple sign restrictions. I am interested in studying specifically the impact of government investments, but identifying multiple shocks in future research could make the results more robust if they coincide with economic theory.

The sign restrictions in my model are based on *Puonti (2022)* and the theory from *Modigliani (1961)*. Table 2 depicts the sign restrictions for government investments. A positive shock is assumed to have a non-positive effect for investments in all of the sub categories. Effect on interest rate is assumed to be non-existent. For the GDP growth the shock is negative according to *Puonti (2022)*.

There are four main models I am using in the following estimations. In the first model, model 1, there are the overall private investments. In model 2, are the private construction investments. Model 3 has the equipment, machinery, and transport investments. Last model, model 4, has the asset investments. The other variables in all of the models are central government investments, interest rate on 10-year government bonds, and the GDP growth.

7 Results

The parameters of the four variable SVAR(8) model presented in section 6 are estimated with the algorithm from section 6.3. There are four main models, each using a different measure of private investments. In model 1 there are the overall investments in section 7.1, model 2 the construction investments in section 7.2.1, model 3 the equipment investments in section 7.2.2, and in model 4 the asset investments in section 7.2.3. Rest of the variables are the interest rate on 10-year government bonds, and the GDP growth. I follow *Lanne and Luoto (2020)* and use two chains drawn from the posterior distribution of θ. A suitable length for the chains is 100 000 for each model, after which the chains have converged. The convergence can be measured with the $\widehat{R}$ statistic. A threshold used by multiple papers (*Lanne and Luoto (2020), Gelman et al. (2013)*) for $\widehat{R}$ is 1.1, below which the chains have converged. The chains for model 1 are depicted in figure 6. Because I use 8 lags for all of the variables, the chains need to be sufficiently long. Though my model is relatively small, the length needs to be at least around

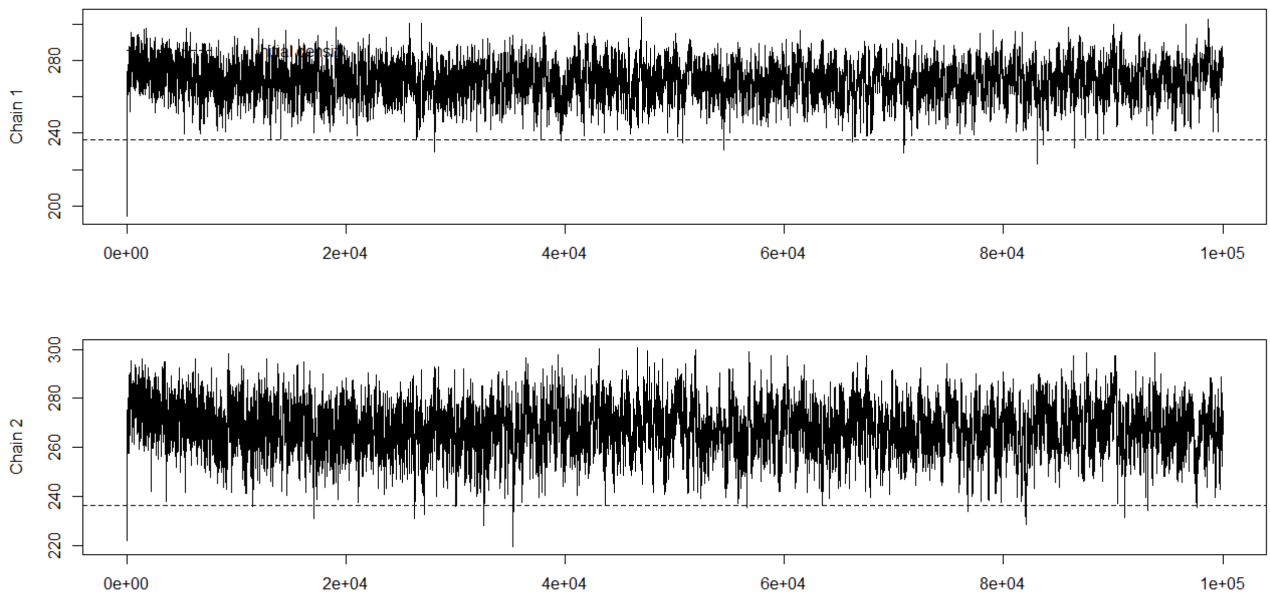


Figure 6: Chains of the model 1

70 000 for the chains to converge properly. I have rounded this up to 100 000, the results are not sensitive between these two lengths.

The positive variables in the SVAR models are log transformed. These include government and private investments. Log transformation changes the interpretation of the results. The changes in both the government and private investments are measured as percentage changes (*Kilian and Lutkepohl (2016)*). Following results are reported as the percentage change of private investments as a response to a percentage change in government investments. The other two variables, interest rate on government bonds and the GDP growth rate are not log transformed as they include negative values. The response of these variables is measured as standard deviations (*Kilian and Lutkepohl (2016)*).

There are 8 lags in my model, which is considerably longer than in *Puonti (2022)* or *Kuismanen and Kämppi (2010). Puonti (2022)* used a SVAR(1) and SVAR(2) models in her paper, and *Kuismanen and Kämppi (2010)* based their VSPD model on a VAR(2) model. The government investment shock does not immediately affect the private investments as noted in section 6.4. The sign restrictions are thus evaluated after 8 periods (2 years). According to the previous research in sections 3.1 and 3.2 crowding out effect is most prominent after two years. Because the investment data is quarterly, a larger model with 8 lags is able to capture more of the variation caused by the shock. This also affects the results from my analysis compared to the other papers. In the next subsections 7.1 I first present the results on overall private investments. Then in subsection 5.2 are the results from different investment subcategories.

7.1 Effect on overall investments

The impulse responses of the first model including overall private investments are shown in figure 7. The parameters are statistically identified but the shocks carry no economic meaning if they are not labelled. The identification of the shocks of interest is done using the sign restrictions set in section 6.4 and estimating the posterior probabilities of these shocks as described in section 6.2. In the first model none of the shocks match the set sign restrictions when the α is set at 3.2. There is still a clear shape in the impulse responses, indicating that the limit of 3.2 might not be suitable for this model. The government investments have a smaller effect than the overall government deficit spending analysed in previous studies. Because the effect is smaller and only a part of the overall spending shock, the identification of the shock is harder. Lowering the α to 3 such that 70% of the credible sets are reported, the government investment shock can be identified as the first shock. I consider the reduction of 0.2 in α to be reasonable.

A central government investment shock (shock 1 in figure 7) decreases the overall private investments over the medium term. The estimation horizon is set to 28 periods, or 7 years. The effect is not immediate and during the first few periods the government investment shock would seem to increase private investments, indicating a crowding in effect. Private investments increase by 0.012% on the first few periods. After 10 to 12 periods (or 2.5 to 3 years) there is a clear decrease in overall private investments of 0.014%. The effect of the shock disappears after 15 periods (3.5 to 4 years). Increasing the time horizon up to 40 periods (10 years) in figure 13 in the appendix, matching *Puonti (2022),* it is clear that the negative effect of the shock has a medium term effect on private investments. Crowding out effect of government investments on private investment is only contemporary, which follows the previous studies of *Pereira (2001), Ahmed and Miller (2007)* and *Sousa and Afonso (2011).*

Government investment shock does not have a large effect on interest rate of 10-year government bonds. The interest rate on bonds initially increases around 0.1 standard deviations, but then quickly declines to around zero after the first period. The initial increase of interest rate on bonds is in line with the theoretical framework from section 4. Interest rates on government bonds initially rise but then fall because if the bond financing is only temporary (one shock), then the interest rates do not rise beyond the impact period. GDP growth rate on the other hand decreases significantly and sharply after 3 periods (under a year). Growth decreases by 0.8 standard deviations. The effect of the shock fades relatively quickly after 10 periods (2.5 years). The shape of the impulse response of GDP growth is strikingly similar to the SVAR(2)

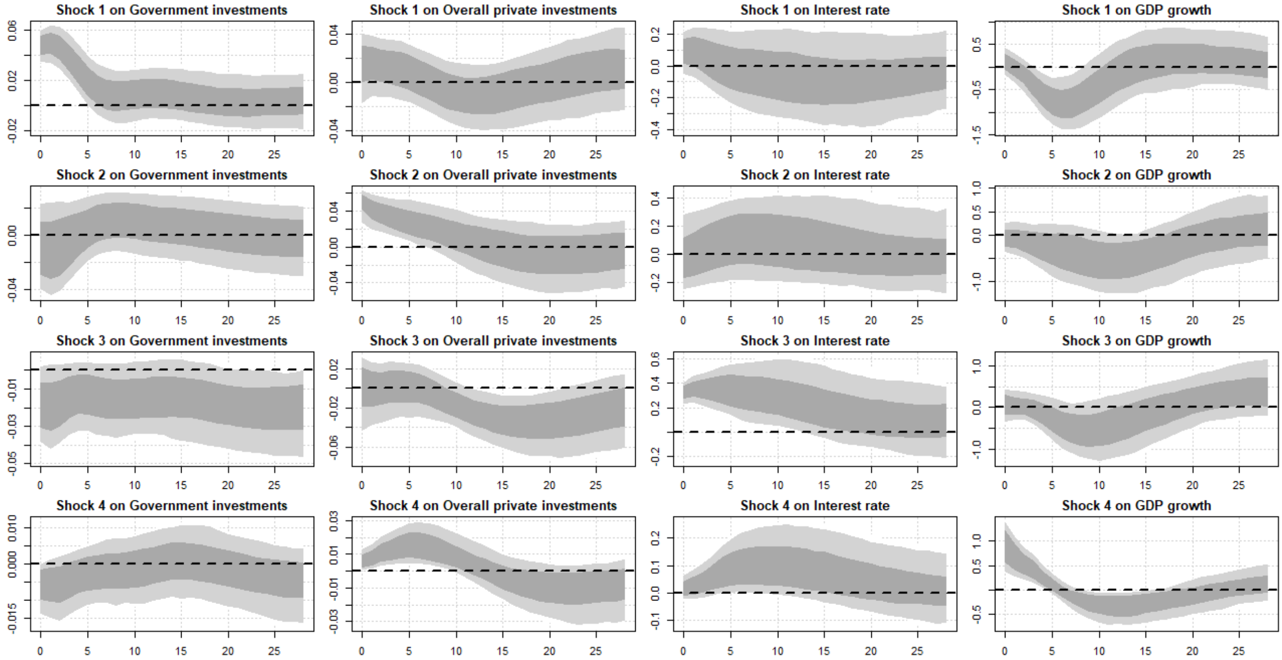


Figure 7: Impulse response functions of model 1, overall investments

model from *Puonti (2022)* who found that the GDP growth decreases after the public debt shock, but then rebounds and the growth increases after 10 periods (2.5 years) before the effect diminishes.

The results of my overall SVAR(8) model contrast interestingly to those of *Puonti (2022),* even though the identified shock is different in her paper. The public debt shock used by Puonti includes all of the governments debt spending, whereas my analysis focuses only on investments. Because investments are only a fraction of the total government spending, and thus the debt, it is expected that the effect of the shock in my model is weaker than in *Puonti (2022).* The shape of the impulse response of overall private investments is different in my SVAR(8) model than in the SVAR(2) model of *Puonti (2022).* In her model, the private investments initially decrease before period 10, but then start to increase and public debt spending induces crowding in over the medium to long term. The government investments shock affects private investments slower than the debt shock. The initial crowding in effect turns into crowding out over the medium term, and fades after that. The persistence of the debt shock in the model of *Puonti (2022)* can be because the overall debt spending has a larger effect on the economy. The debt spending also affect the interest rate markets more than just the government investments, which is why the effect on private investments in *Puonti (2022)* are immediate. The larger shock in her model also increases the duration of the shock. The medium term effect in the model of *Puonti (2022)* is an aggregate crowding in effect. This suggests that some variables in deficit spending have a positive effect on private investments over the medium to long term, which drive the investments up. The impact of government investments in my model are smaller, but the aggregate effect is negative. This leads to a conclusion that overall debt spending crowds in private investments, but government investments have crowding out effect.

The results from figure 7 are closer to the results of the SVAR(2) model of *Kuismanen and Kämppi (2010).* The shape of the impulse response function of private investments to a public expenditure shock in *Kuismanen and Kämppi (2010)* are very similar to my results. There is an initial crowding in effect before medium term crowding out. Similar to the figure 7, the results of *Kuismanen and Kämppi (2010)* are not statistically significant to the 5% level, but there is a clear shape to the impulse responses. The difference between the public expenditure shock of *Kuismanen and Kämppi (2010)* and the government investment shock in my model is in the length of the effects. The crowding in effect of public revenue shock is not in the first few periods, taking around 4 periods (1 year) to emerge. The crowding out effect on the other hand is longer lasting in *Kuismanen and Kämppi (2010).* There is a decrease in public investments even after 16 periods (4 years) of the shock. In my model, the government investment shock decreases private investments but the effect is limited to medium term. Comparing my results to *Puonti (2022)* and *Kuismanen and Kämppi (2010),* it is evident that the government investment shock is closer to the public expenditure shock of *Kuismanen and Kämppi (2010).* The effect in my model is limited in length compared to the revenue shock because, as with the debt shock, investments are a part of expenditure. The difference between the impulse response figures imply that some components of the expenditure decrease private investments also on the medium to long run.

The timing of crowding out effect of government investments differs from *Kuismanen and Kämppi (2010).* Government expenditure shock in their paper is evident after a year, whereas government investment shock in my model causes crowding out after two years. *Puonti (2022)* also found that the public debt spending shock materialises after 1.5 years, although she observed crowding in effect. The government investment shock takes longer to crowd out overall private investments than the more broad categories of expenditure, and debt shock.

The percentage changes of private investments can be converted into euros. Because both the government and private investments were in log form, the percentage changes can be compared directly. The ratio of these is the relative impact. A one unit change in government investments decreases private investments by 0.014 units seen from figure 7. In other words, increase in government investments decreases private investments in a ratio of 1 to 0.014. Converting this into euros, the result is that for every 1 euro of government investments, private investments decrease by 1.4 cents. This is not a large decrease, if a government invested 1 million euros, it would only decrease overall private investments by 14 000 euros. These can be compared to the results of *Pereira (2001),* who studied the dollar changes in investments in the US. In his paper the crowding out/in effects ranged from 2 cents to over 2 dollars based on investment category. The magnitude of the crowding out effect in Finland is similar. The small coefficient in Finland can be due to my model being linear and not accounting for business cycles. As noted in section 4.2, government investments can cause smaller crowding out, or even crowding in, if the is unused production capacity in the economy. After the financial crisis of 2008, which was followed by the euro crisis, there has been more unused capacity in the Finnish economy. The crowding out effect of government investments is dampened by this capacity, which results in relatively small effect in the impulse response function of overall private investments.

These results are in line with other European countries with similar economies. According to *Sousa and Afonso (2011),* in Portugal private investments decreased by 1% after 6 quarters (1.5 years) in response to a 6% increase in government spending. The crowding out effect is larger than in Finland, albeit the shock in *Sousa and Afonso (2011)* is government spending and not investments. The length of the shocks in the paper of *Sousa and Afonso (2011)* is similar to my findings. The crowding out effect appears after a year from the shock in both cases. Other European countries were studied by *Afonso and Aubyn (2010).* Crowding out of private investments appeared in Italy, the UK, Belgium, France, Ireland, Spain and the Netherlands. *Afonso and Aubyn (2010)* do not comment on the length of the effect. The effects of government investments in Finland follow well the European counterparts. This can be because most of the countries share the currency union and single market, where goods can travel freely. In theory, these should mitigate both the IS-LM framework and the demand-supply dynamics presented in 4. In practise however, there are frictions in both the credit markets (part of the currency union) and the single market. These frictions enable the non-Keynesian effects of government spending.

Comparing my results on Finland to larger countries outside Europe, there are more significant changes. As covered in the previous paragraphs, *Pereira (2001)* studied the crowding out effect in the US, where there was a large variation depending on investment category. Another paper on the US is by *Traum and Yang (2015),* who found similar results. Government debt spending shock decreased investments by 0.1% in their paper. China has been studied by *Xiaoming and Yanyang (2014),* who found that there overall crowding in. In Japan *Hatano (2010)* found that increase in public investments initially decreases private investments, but after 2 years, there is a clear crowding in. The crowding out effect changes in some of the countries depending on the structure of investments. When *Xiaoming and Yanyang (2014)* limited the analysis only to state owned enterprises, which invest and compete more directly with private sector, there was major crowding out effect. The was also differences between investments in the US. In the paper of *Pereira (2001)* the US experienced more overall crowding out than Finland, but some of the investment sub categories had a similar sized effect as my results. This can mean that the US economy has been running on close to full capacity in terms of resources. The additional increase in demand from the government projects can thus cause more crowding out. In China on the other hand there can be more unused resources on certain sectors, resulting in crowding in. The crowding in effect in Japan according to *Hatano (2010)* was also slightly larger than the crowding out effect in Finland. A 1% shock increased private investments by 0.2% in Japan.

The impulse response of GDP growth rate on government investment shock is almost identical to *Puonti (2022).* The initial decrease of growth is replaced by an increase in growth on the medium term. The time series on GDP growth in Finland are the same in my model and that of *Puonti (2022),* and they can be compared directly. The effect of government investments is larger than public debt spending, but the effects are otherwise similar. *Puonti (2022)* found that the growth decreases by 0.25 standard deviations, whereas they decrease by 0.8 standard deviations in my model. Changes in growth rate was also noted by *Afonso and Aubyn (2010).* From the European countries that experienced crowding out, Italy, the UK, and the Netherlands had a contraction in their output expansion, whereas Belgium, France, Ireland, and Spain had an increase in output. Based on my results, Finland falls closer to the latter countries. Government investments can be a vital part of growth, but the effect is country and business cycle specific.

As the previous literature underlined, the investment sub categories are different in their responses to government investment shock. The investments differ in terms of their capital intensity, which affects how they respond to changes in interest rate markets and hence how government investments affect them. The small effect of government investments on overall private investments does not hold for all of the investment sub categories. *Pereira (2001)* has focused on different investment categories in the US, and *Marino et al. (2016)* in France. In the next subsections, I analyse how the three main categories of private investments presented in section 5.2 are affected by the government investment shock. The model specifications remain the same as in the first model (model with overall private investments), enabling comparisons between the figures. The impulse response functions using all of the 13 investment sub categories are in the appendix.

7.2 Effects on investments subcategories

I have divided the three main categories of investments into separate models. This is done to keep the models concise. Because the different investment categories are unlikely to affect each other, they can be separated to different models. The models are as follows, model 1 was in the previous section 7, model 2 has the construction investments, model 3 the equipment and machinery investments, and model 4 the asset investments. Impulse response functions for each model are in figures 8, 9, and 10. The sign restrictions for each model are in table 2, and assumed to be the same as for all of the models. The same algorithm as in the previous section is used to evaluate the posterior probability of the shocks corresponding to the sign restrictions. The α is initially set at 3, meaning that 70% of the credible sets are reported.

7.2.1 Construction investments

Results for model 2 using private construction investments are presented in figure 8. Only one of the shocks match to the set sign restrictions in 2, the first shock. Shock 1 is labeled as the government investment shock. The Bayes factor for the shock is 3.27, meaning that it could have passed the conventional limit of $\alpha = 3.2$. Private construction investments have a similar shape as the overall private investments in figure 7, and the effect is around the same size. The initial increase in construction investments is 0.02% compared to the 0.012% in figure 7. Government investment shock increases the construction investments at the first period, after which they start to decrease. After 12 to 15 periods (3 to 4 years) the effect of the shock disappears. Government investments decrease construction investments by 0.017% after 12 periods (3 years). Construction investments have larger reaction to the shock than overall investments, one euro increase in government investments decreases the construction investments by 1.7 cents. Again, relatively small. The effect is not statistically significant with 95% confidence intervals. However the impulse response functions indicate that the construction investments do react to the shock.

The results from the figure 8 are similar to those in figure 7. Construction investments might drive the overall results because they make up an average of 37% of overall investments, leading to similar results. The effect of government investment shock is smaller for construction investments than the overall investments. The shape of the impulse response function is almost identical. Construction investments are usually quite large, the average amount of construction investments were 2 billion euros per year[13]. Large loans usually have long maturities, which

[13]Based on the data on private investments in the data section

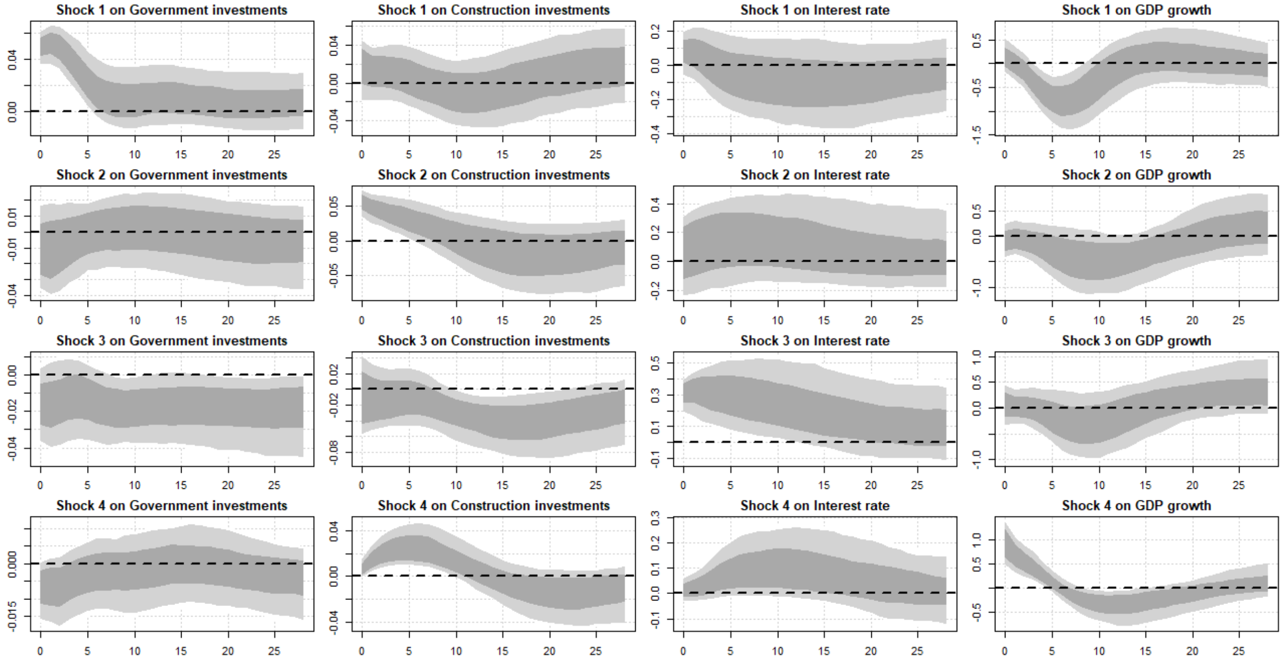


Figure 8: Impulse response functions of model 2, construction investments

can mitigate some of the effects of crowding out. This can happen if the interest rate on loans are fixed for a set number of years or if a firm uses credit default swaps. The changes in interest rate markets do not affect these firms immediately.

Construction investment category in my model can be compared to the non residential building investments in *Pereira (2001).* In my model construction investments include residential buildings, which makes my category larger than that of *Pereira (2001),* but the categories are close enough to compare the general effect of government investments shocks. *Pereira (2001)* finds that private building investments as well as farm and mining structure investments are crowded out by government investments. The coefficients were only estimated on medium term. My results are in line with these findings. Even though the economies of Finland and the US are vastly different, the construction sector is crowded out. This can be due to the fact that domestic demand dictates construction investments. *Pereira (2001)* found that that one dollar increase in public investments decrease non residential building investments by 2 cents. My estimate for construction investments in Finland is very close to this at 1.7 cents. Even though the investment categories are somewhat different between my model and that of *Pereira (2001),* the scale of the results is remarkably similar. This can be because construction is less dependent on international demand, making the small open economy of Finland more comparable to the 'closed' economy of the US.

Xiaoming and Yanyang (2014) include construction investments in their study on China. They note that because the government is heavily involved in this sector, it competes closely with the private sector. The large involvement of state actors on this sector decrease the resources for private sector (*Xiaoming and Yanyang (2014)*). This has lead to crowding out. In Finland large building projects usually also include government funding. Especially in infrastructure the state involvement is highlighted. The crowding out of private construction investments can be due to the same factors as in China, the increase in competition reduces resources.

The findings of *Xiaoming and Yanyang (2014)* are further confirmed to hold true in Finland when the construction investments are further divided. According to *Puonti (2022)* investments into infrastructure are crowded out more than R&D. The results in 8 support this finding of *Puonti (2022)* in that infrastructure investments are crowded out. The impulse response for model with infrastructure investments (ground- and water construction) is in the appendix in figure 19. Government investment shock (shock 1) reduces the infrastructure investments by 2.3 cents for every euro after 6 periods (1.5 years). After this, the private investments resume to their normal level. There can be a slight crowding in effect over the medium to long term. Compared to the overall building investments, infrastructure investments are much more crowded out. This is in line with the international paper of *Xiaoming and Yanyang (2014).*

Government investment shock on interest rate and GDP growth is the same as in the model with overall private investments in figure 7. This is not surprising as the only difference between the models are the private investments, which do not affect the interest rate on government bonds. Private investments can affect the GDP growth but as the construction investments account for the majority of the overall private investments, the effect remains unchanged. GDP growth decreases by 0.8 standard deviations after 6 periods (1.5 years) before the effect of the shock disappears. GDP growth in 8 follow the impulse response of *Puonti (2022).*

7.2.2 Equipment, machinery, and transport investments

The impulse responses for model 3 are in figure 9. Sign restrictions are the same as in previous models. Estimating the posterior probability of these restrictions with α set to 3 results in two matches, there are two shocks with a Bayes factor of more than 3. Shock 1 has a factor of 5.8 and shock 2 a factor of 3.4. When two shocks are identified to match the set sign restrictions *Lanne and Luoto (2020)* recommend to either tighten the restrictions (raising the α) or choose the shock with a higher Bayes factor. Both of these methods would yield the same result. Because shock 1 has a significantly larger factor, it is the most probable to be the shock of interest. The government investment shock is thus identified as the first shock in the model.

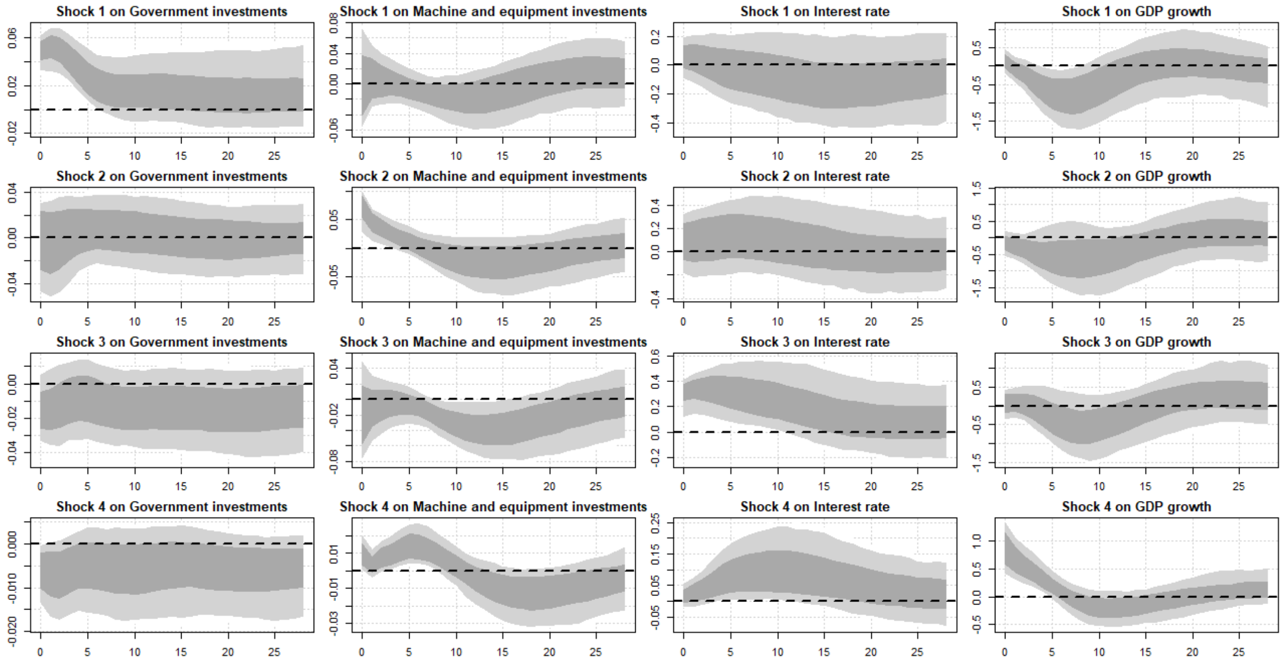


Figure 9: Impulse response functions of model 3, equipment, machinery, and transport investments

A shock in government investments decreases private investments in equipment, machinery, and transport. There is a crowding out effect similar to the results from models 1 in section 7 and model 2 in section 8. The difference in equipment, machinery, and transportation investments is that the government investment shock has a larger effect and the shape of the impulse response curve. Shock has a faster effect. Once 5 periods (1.5 years) have elapsed from the shock, there is a clear decrease in private equipment, machinery, and transport investments. The decrease is larger than in constructions investments. A one unit (100%) increase in government investments decrease equipment, machinery, and transportation investments by 0.025 units (2.5%) after 12 periods (3 years). One euro increase in government investments decrease private investments by 2.5 cents. The effect of the shock fades after around 15 periods (3 to 4 years). Unlike in construction investments, there is no initial crowding in effect in the first periods. The government investment shock takes five periods (a little over a year) to impact private investments. Compared to the construction investments, the effect of the shock is much more prompt and shorter.

The effect of government investment on equipment and machinery investments, and transportation investments are separated in tables 22 and 21 in the appendix. Interesting finding is that transportation investments are not affected by the government investments. There is neither short term nor medium to long term effects. It might be that transportation investments are usually co-projects with private sector and the government. Equipment and machinery investments on the other hand are crowded out by government investments, seen in figure 22. The shape of the impulse response is similar to the figure 9. Crowding out effect is emerges in 10 to 15 periods. Compared to the figure in 9, the confidence intervals in figure 22 are slightly tighter, yielding to more precise results. The effect of government investments on equipment and machinery investments remains statistically inaccurate. This can be credited to the uncertainty of the model, which cannot capture the non-linear effects of the business cycles.

The results on equipment, machinery, and transportation investments are opposite to the results of *Pereira (2001).* An equivalent category in his model is the overall equipment investments, which include industrial equipment and transportation. *Pereira (2001)* found that in the US overall equipment investments increased due to government investments. The effect was also large compared to the other investment subcategories in his model. A one dollar increase in government investments increased overall equipment investments by 1.12 dollars. The increase in transportation investments was even greater at 2.19 dollars. Private investments in *Pereira (2001)* increased by more than a 100%. My results were completely contrary to these results. Government investments in my model also caused crowding out, but the effect is smaller. One euro increase in government investments decreased private equipment investments by 2.5 cents. Compared to the construction investments in the previous section, section 7.2.1, the effect is significantly larger. As I noted in section 3.1, the results of *Pereira (2001)* are not fully comparable to Finland. Thought the scale of the crowding out effect in general is similar between his results and mine, as the changes in private investments are measured in cents in many categories.

Xiaoming and Yanyang (2014) noted in their study on China that if the government invests through state owned enterprises (SOE), there is a crowding out effect. This is because the SOEs compete directly with the private sector. When investing, they increase the demand for production factors and cause crowding out (*Xiaoming and Yanyang (2014)*). In Finland the construction investments and the equipment investments have similar differences. The equipment, machinery, and transportation markets are more competitive and the private demand is already high. There are less competitors in building construction than in machinery production. The larger crowding out effect in equipment, machinery, and transport investments can be caused by the same factor as in *Xiaoming and Yanyang (2014),* the direct competition of government investments with private sector increases prices. Government should consider more carefully the demand and supply structure of the private sector to understand how the investments affect the economy.

Equipment, machinery and transport investments can be crowded in in some cases. *Ahmed* *and Miller (2007)* concluded in their study that in developing countries government can increase private investments by investing in transportation and ICT. This is most likely because the transportation networks in developing countries suffer from the lack of investment. There are no other private actors filling the demand, and thus the government can step in without causing crowding out. In Finland the transportation and ICT networks and equipment are already well established, which explains why crowding out prevails.

The government investment shock effect on interest rates and GDP growth remains the same as in models 1 and 2. There are some slight variation in the effect of the shock on GDP growth. This can be due to how private investments affect growth. Part of the change in growth rate can be caused by private sector. Because construction accounts for a larger share in the investments and economy, it has a bigger effect on the GDP than machinery investments. The decrease in GDP growth is thus smaller in figure 9 than in figure 8.

7.2.3 Asset investments

Model 4 includes private assets. These encompass growth assets, and human capital. The impulse responses of the model are in figure 10. None of the shocks match the sign restrictions in table 2. The Bayes factors for all of the shocks is below 3. Even when decreasing α to 2.8 there are no matching shocks. This leads to a conclusion that the sign restrictions set in 6.4 do not hold for the private asset investments in the Finnish data. Government investments do not crowd out asset investments. Previous studies of *Puonti (2022), Salotti and Trecroci (2016),* and *Pereira (2001)* have suggested that some investment categories, notably R&D, are crowded in by government spending or investments. Conversely *Pereira (2001)* found that ICT investments are crowded out by government investments. *Puonti (2022)* noted that a spending shock affects R&D investments faster than infrastructure. To test the alternate hypothesis of government investments crowding in private asset investments I change the sign restrictions for the model 4 to

Variable	Government investment	Asset investment	Interest rate	GDP growth
Government Investment	1	1	0	-1

Table 3: Sign restrictions for model 4

I also set the impact horizon of the shock to a shorter 4 periods (1 year) in accordance to the previous findings of *Puonti (2022).* Now government investments are expected to have a positive effect on private asset investments. Using the sign restrictions of table 3 and estimating the posterior probability of the shocks results in two matches. Shock 1 with a Bayes factor of 6.1 and shock 2 with a factor of 4.5. Following *Lanne and Luoto (2020)* the shock with a larger Bayes factor is identified as the shock of interest. Shock 1 is labeled as the government investment shock.

Unlike with construction investments or equipment, machinery, and transport investments, government investment shock increases private asset investments. The effect is also faster. A one unit increase in government investments increases private asset investments by 0.017 units within a year from impact. The effect of the shock fades quickly after 6 periods (1.5 years). Government investments crowd in asset investments on short term, but there are no medium to long term effects. The crucial difference to the other investment sub categories in figures 8 and 9 is that there is no crowding out effect. The other sub categories were initially crowded in but on medium term crowded out. The crowding in effect of government expenditure on private asset or R&D investments is supported by previous literature.

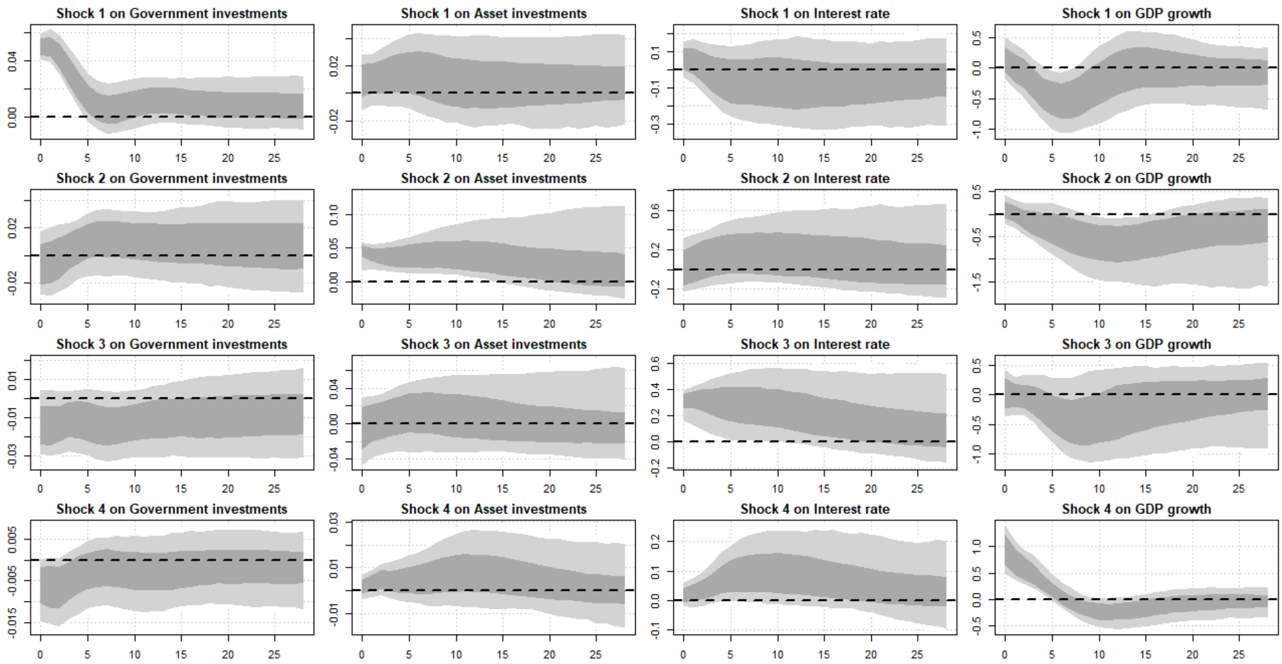


Figure 10: Impulse response functions of model 4, asset investments

The paper of *Puonti (2022)* stressed that the R&D investments create long term growth. Based on my results the government investments do increase these private investments for a short while, but for the effect to be long term, government investments should be persistent. Public debt spending in *Puonti (2022)* can have a longer lasting impact on both the private investments and GDP growth, as the shock has a larger effect on the whole economy. International studies of *Ahmed and Miller (2007)* and *Sousa and Afonso (2011)* agree that government investments generally increase the growth rate. The effect of R&D or asset investments on growth was not part of my analysis, but based on the previous research, government investments can increase asset investments, which induce growth.

The exception is *Marino et al. (2016).* They focused on R&D investments in France, and though their paper is an event study, it offers interesting contrast to my results. *Marino et al. (2016)* found that the R&D investments were crowded out due to substitution effect between firms of different sizes. Tax subsidies incentivised more firms to cut their R&D investments, rather than increasing them. Even though my findings indicate that in Finland the government investments can increase private R&D investments, the study of *Marino et al. (2016)* highlights that the effect depends on how the policies are implemented. The crowding out effect in *Marino et al. (2016)* can be described as transaction crowding out, presented in section 4.1. The incentives of government investments on private R&D investments should also be taken into consideration, as they are dependent on how the government investments are used.

Focusing on the GDP growth effect in the figure 24, the growth rate decreases initially as in the previous models. However the decrease in growth is smaller and rebounds is larger. The crowding in effect of private asset investments in model 4 mitigates the negative effects on GDP growth. This supports the conclusions of the previous studies on R&D investments helping growth.

Converting the my results in figure 10, the private asset investments, into euro amounts. The crowding in effect of one euro government investment is 1.7 cents. A relatively small effect in absolute terms. Compared to the construction investment coefficient, and the equipment and machinery investment coefficients it is consistent in magnitude. The crowding in effect of asset investments is around the same size as the crowding out effect of construction investments. Considering that the investment level is lower in assets than in construction, the government investments affect asset investments more readily. However, the crowding out effect of construction investments is longer lasting. It is possible that the effect of government investments is not linear for asset investments, meaning that the crowding in effect of government investments have diminishing returns. Comparing all of the three main investment sub categories it is clear that the government investments have the largest effect on equipment, machinery and transportation investments. Which is expected, these markets have a high competition as discussed in section 7.2.2.

Separating the components of asset investments into human capital investments, and growth asset investments in the figures 25 and 23 in the appendix, reveals peculiar features. Human capital investments in figure 25 are crowded in by government investments in the short run, and the effect fades after a bit over a year. The increase in these investments is 0.018 units, or 1.8

cents for every euro of government investment. The impulse response of overall asset investment figure in 10 and the human capital investments in 25 are closely aligned. The impulse response of growth assets in figure 23 is completely contrary. There is short term crowding out, and compared to the other impulse responses, the effect is very large. Growth assets decrease by 0.06 units on impact. The only similar feature of growth asset response to human capital is the length of the effect of the shock. Both disappear after a year. From these results it is clear that government investments exclusively crowd in human capital investments. The R&D investments are embedded in both of these investment categories. The net effect on R&D investments is the result from table 10. According to Statistics Finland, R&D investments make up the majority of the asset investment category.

Government investments have been noted to crowd in R&D investments in multiple studies both internationally and in Finland. The reason for this can be the demand and supply mechanic presented in section 4.2. Ministries and government organisations such as Business Finland have note that the R&D investments in Finland are low compared to other similar European countries[14]. With respect to GDP, the private R&D investments have declined in Finland, whereas they have risen in other analogue countries. The markets in Finland are not fully utilising the R&D resources. Because there is free capacity on the market, the increase in demand from government investments does not affect the price of the R&D resources. This results in crowding in effect. In addition to the demand and supply mechanism, the government of Finland actively encourages R&D investments. Ministry of Economic Affairs and Employment of Finland coordinates R&D investment grants together with other ministries and Business Finland. These are also projects aiming to increase other investment categories, such as energy- and production investments.

8 Robustness checks

The results are robust to a variety of specifications. Changing the prior for beta matrix β, does not change the impulse responses or output of the investment categories. *Lanne and Luoto (2020)* note that the assumptions on β do not have a large effect on the results.

In the models in section 7 I used four variable based on models in previous papers of *Puonti (2022)* and *Kuismanen and Kämppi (2010).* The major point in portfolio crowding out is the interest rate. The use of 10 year government bond rates is widely used in crowding out

[14]Business Finland has published a review of investments, focusing on the R&D investments, *BusinessFinland (2023)*

literature as presented in section 3. It does not reflect the interest rate on capital, which can affect firms. Individual interest rates for each credit application is hard to collect, but most of the corporate loans are based on the 12 month Euribor rate. To test the robustness of my results I ran additional five variable SVAR(8) models, where I included the 12 month Euribor rate. Because of the larger model the length of the chains needed to be increased to 300 000 in order for them to converge properly (seen in figure 11). The identification of the government investment shock was carried out as in models in section 7. The shock 1 was identified as the government investment shock in all of the models.

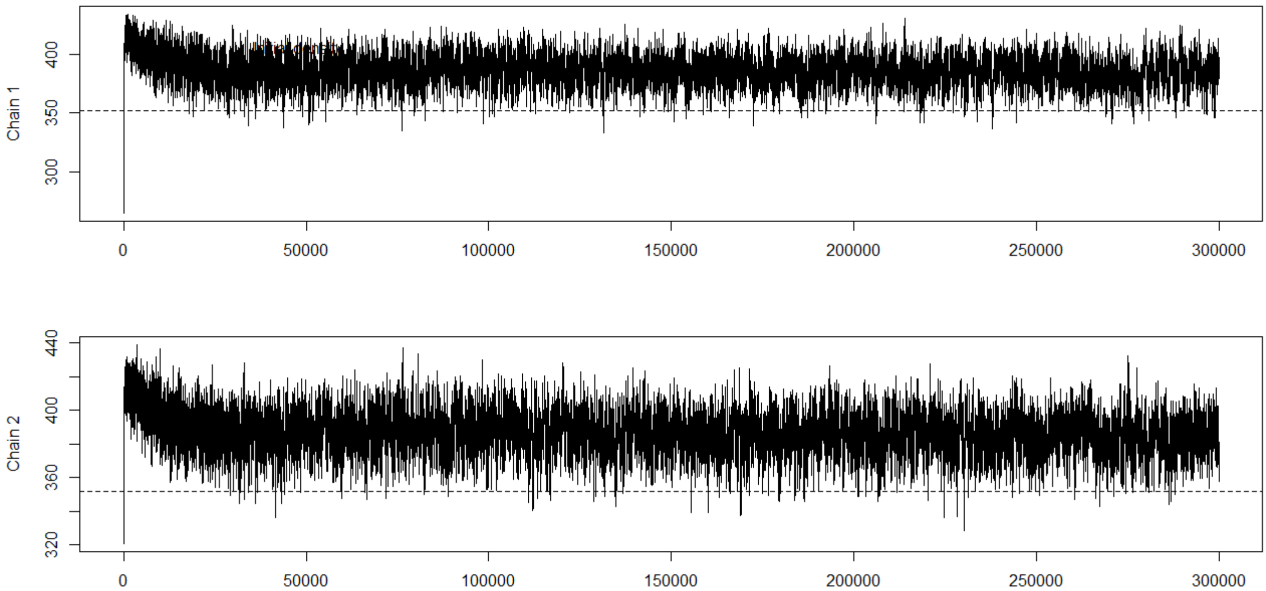


Figure 11: Chains for the extended model with Euribor

Figure 12 collects the results from the five variable SVAR(8) regressions. On the first row there are the overall private investments, on the second row are the construction investments, on the third are equipment, machinery and transportation investments, and on the last row is the model with asset investments. Sign restrictions for each model are the same as in the table 2, with the exception of asset investments. These follow the sign restrictions set in table 3, such that the results of table 12 are comparable to the results in section 7.2. The government investment shock is identified as the first shock in all of the models.

Comparing the impulse responses of the tables 12 to tables 7, 8, 9, and 10, there are no major differences in the impulse responses of the private investments categories. The addition of the 12 month Euribor rate increases the confidence intervals, because it increases the uncertainty in my model. The Euribor rates reflect the business cycles, but as my model is linear and does not accommodate the non-linear effects discussed in section 4.2, the confidence intervals are wider.

However, the overall shape of the impulse responses remains robust. Overall investments are crowded in on the short term, but the medium term crowding out is larger than this initial effect. Construction investments follow the overall results as they did in the previous results. The machinery, equipment, and transport investments remain the most affected by government investment shock. The crowding out effect is slightly faster in this model than in table 9, but only marginally. Crowding in effect on asset investments persists in the model with Euribor rate. The changes in private investments are of the same magnitude than in the other models, thought they are slightly smaller due to the increase in uncertainty of the models.

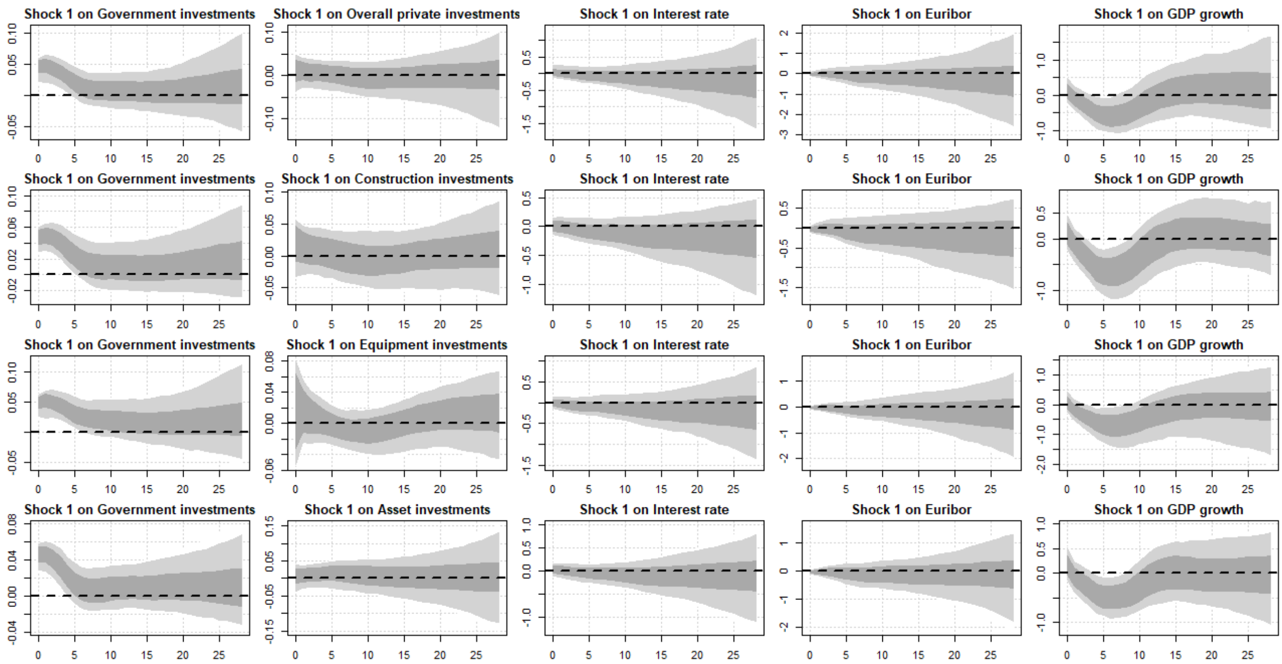


Figure 12: Impulse response functions of the extended model with Euribor

The results remain robust with changes to the thinning factor K. In the models presented in section 7 K was set to 0.2, but increasing it to 0.4 does not alter the shape of the impulse response functions of private investments. *Lanne and Luoto (2020)* noted that the thinning factor can be used to improve the results of the SVAR model if the chains are not converging quickly enough. This is not the case in any of the models in section 7.2 as the chains drawn were sufficiently long in order for them to converge. As a results, the thinning factor does not have a noticeable impact on the results.

9 Conclusions

In section 3.1 I presented two papers that looked at crowding out in Finland. They had contradictory results, *Puonti (2022)* concluded that public debt spending shock crowds in private investments over the medium term, whereas *Kuismanen and Kämppi (2010)* found that public expenditure shock has a crowding out effect on private investments. The differences between the results can be due to the shock in each model. *Puonti (2022)* used debt spending, whereas *Kuismanen and Kämppi (2010)* used a more narrow expenditure. These studies demonstrate that depending on the shock, the there can be either crowding out or crowding in. I focused on central government investments in this thesis to make a more concise model, which focuses on only one of the expenditure categories, namely the investments. The previous studies on Finland also have not studied the crowding out effect of different investment sub categories which, according to international literature (*Pereira (2001), Sousa and Afonso (2011), Ahmed and Miller (2007)*), have distinctive reactions to the government spending shocks. The aim of my thesis was to separate the investment sub categories and compare how they are affected by the government investment shock.

There is crowding out in Finland of overall private investments from an increase in government investments, which follows the results of *Kuismanen and Kämppi (2010).* There are very short term crowding in effects, but the long term effect is a decrease in private investments. The main result is how the three main investment categories of construction, equipment, and assets differ. The construction investments followed the overall results closely, which can result from the fact that the overall results are driven by this investment sub category. The equipment, machinery, and transport investments were the most crowded out private investments. The effect was also longer lasting than with construction investments. The odd one out was the asset investment category, which experienced crowding in, meaning that government investments increase them. It is noteworthy that R&D investments make up the majority of the asset investments*StatisticsFinland (2023a).* Unlike the construction or equipment investments, there was no crowding out effect at all. However, the crowding in effect of government investments on private asset investments was brief, lasting only around 1 year.

The scale of the crowding out and crowding in effects were relatively small. For every euro of government investments, construction investments decrease by 1.7 cents and equipment investments by 2.5 cents. Asset investments increase by 1.8 cents. Converting these changes into millions of euros, for every 1 million euros the Finnish government invests, the equipment investments decrease by 25 000 euros. The increase in asset investments is around 18 000 euros.

Even though my model is linear, and cannot take into account the changes in business cycles, the small estimates indicate that there is no major crowding out effect in Finland. There are important differences between the investment categories. The equipment, machinery, and transport investments are the most affected. Government should consider the implications when investing in these. The equipment, machinery, and transport markets have a large number of market players, and thus there is a high demand for production factors. On the contrary, the government should increase investments in assets, specifically R&D. These investments would help the private sector to increase their production on the long run. The R&D investments have a central role in creating long term economic growth, and my results confirm that there can be more government involvement.

Previous research both in Finland (*Puonti (2022), Kuismanen and Kämppi (2010)*) and internationally (*Sousa and Afonso (2011), Salotti and Trecroci (2016)*) have noted that the R&D investments are usually crowded in by government spending or investments. Most of the other investment sub categories are usually crowded out. This can be due to many countries and industries under investing in R&D, resulting in unused capacity. The other types of investments face more demand, such that the production factors are in almost full use.

The scale of my results is in line with *Puonti (2022).* She found that a one unit increase in public debt spending changes private investments from -0.05 to 0.1 units. The coefficients in my model are smaller, as I expected since the government investment shock is only a fraction of the public debt spending shock. Comparing the results to international paper, *Pereira (2001)* also used currency amounts in his study of crowding out in the US. Though the economies of Finland and the US differ vastly, the scale of the estimates are somewhat similar. According to *Pereira (2001),* a one dollar government investment decreases construction investments by 2 cents, remarkably close to my estimate in Finland of 1.7 cents. The equipment investment coefficient in *Pereira (2001)* was much larger at more than a dollar, meaning that there is a major crowding out effect in these investments in the US. Crowding out effect is not as prominent in Finland. This can be due to the common currency and credit markets within the EU, which mitigate the effects of the interest rate mechanism discussed in section 4.1.

Another reason for the smaller estimates in my results can be the linear model. The business cycle can affect the crowding out mechanism. When there is a downturn or a recession, production capacity is left vacant. In this scenario, government investment could replace some of the decreased demand, without increasing the prices. When the economy is growing, the additional demand from government would cause prices to rise, resulting in crowding out. The were no large structural changes in my model, as I limited the analysis in the Euro era. The largest changes in the Finnish economy happened in the early 1990s, when the credit markets were liberated. The business cycle variation still affects the crowding out mechanism. In the future, my model could be improved to include the changes in the business cycle, which would decrease the spread in confidence intervals in the impulse response figures and yield more precise results. The different government investment categories could also be separated into different models.

References

Afonso, A. and M. Aubyn (2010). "Public and private investment rates of return: evidence for industrialized countries". In: *Applied Economics Letters* 17.

Ahmed, H. and SM. Miller (2007). "Crowding-out and crowding-in effects of the components of government expenditure". In: *Contemporary Economic Policy* 18.

AmirKhalkhali, S., A. Dar, and S. AmirKhalkhali (2003). "Saving–investment correlations, capital mobility and crowding out: some further results". In: *Economic Modelling* 20.

Bahal, G., M. Raissi, and V. Tulin (2018). "Crowding-out or crowding-in? Public and private investment in India". In: *World Development* 109.

BankOfFinland (2023). *Statistics: Yrityslainoja on nostettu poikkeuksellisen paljon.* URL: https://www.suomenpankki.fi/fi/Tilastot/rahalaitosten-tase-lainat-ja-talletukset-ja-korot/tiedotehistoria/2022/yrityslainoja-on-nostettu-poikkeuksellisen-paljon/.

Buiter, W. (1977). "Crowding-Out and the Effectiveness of Fiscal Policy". In: *Journal of Public Economics* 7.

BusinessFinland (2023). *Yksityisen sektorin TKI-toiminnan tilannekuva 2022.* URL: https://www.businessfinland.fi/4aa841/globalassets/julkaisut/yksityisen-sektorin-tki-toiminnan-tilannekuva-2022-slided.pdf.

Cerra, V., U. Panizza, and C. Saxena (2012). "International evidence on recovery from recessions". In: *Contemporary Economic Policy* 31.

EK (2023). *Julkiseen talouteen on syntynyt vakava alijäämä, joka paisuttaa velkataakkaa.* URL: https://ek.fi/tutkittua-tietoa/tietoa-suomen-taloudesta/julkinen-talous/.

Friedman, B. (1978). "Crowding Out or Crowding In? Economic Consequences of Financing Government Deficits". In: *Brookings Papers on Economic Activity* 3.

Gelman et al. (2013). *Bayesian data analysis.* CRC press.

Hatano, T. (2010). "Crowding - in Effect of Public Investment on Private Investment". In: *Public policy review* 6.

Kilian, L. and H. Lutkepohl (2016). *Structural Vector Autoregressive Analysis, The Science of Microfabrication.* Cambridge University Press.

Kuismanen, M. and V. Kämppi (2010). "The effects of fiscal policy on economic activity in Finland". In: *Economic Modeling* 27.

Lanne, M. and J. Luoto (2016). "Data-Driven Inference on Sign Restrictions in Bayesian Structural Vector Autoregression". In: *CREATES Research Paper* 4.

Lanne, M. and J. Luoto (2020). “Identification of economic shocks by inequality constraints in Bayesian structural vector autoregression”. In: *Oxford Bulletin of Economics and Statistics* 82.

Lanne, M., J. Luoto, and J. Anttonen (2022). “Statistically identified SVAR model with potentially skewed and fat-tailed errors”. In: *University of Helsinki*.

Marino, M. et al. (2016). “Additionality or crowding-out? An overall valuation of public RD subsidy on private RD expenditure”. In: *Research Policy* 45.

Modigliani, F. (1961). “Long-run implications of alternative fiscal policies and the burden of the national debt”. In: *The Economic Journal* 71.

Pereira, A. (2001). “On the effects of public investment on private investment: what crowds in what?” In: *Public Finance Review* 29.

Puonti, P. (2019). “Data-driven structural BVAR analysis of unconventional monetary policy”. In: *Journal of Macroeconomics* 61.

— (2022). “Public Debt and Economic Growth from the Perspective of Private Investment”. In: *ETLA Report* 130.

Salotti, S. and C. Trecroci (2016). “The impact of Government Debt, Expenditure and Taxes on Aggregate Investment and Productivity Growth”. In: *Economica* 83.

Sousa, R. and A. Afonso (2011). “The macroeconomic effects of fiscal policy in Portugal: a Bayesian SVAR analysis”. In: *Portuguese Economic Journal* 10.

StatisticsFinland (2023a). *Consepts: Gross fixed capital formation*. URL: `https://www.stat.fi/meta/kas/paaoma_muodostu_en.html`.

— (2023b). *Statistic: 12gu – Foreign direct investment by immediate target and investor country, annually, 2013-2021*. URL: `https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__ssij/statfin_ssij_pxt_12gu.px/`.

Ter Braak, C. and J. Vrugt (2008). “Differential evolution Markov chain with snooker updater and fewer chains”. In: *Statistics and Computing* 18.

Traum, N. and S. Yang (2015). “When Does Government Debt Crowd Out Investment?” In: *Journal of Applied Econometrics* 30.

Xiaoming, X. and Y. Yanyang (2014). “Does government investment crowd out private investment in China?” In: *Journal of Economic Policy Reform* 17.

Appendix

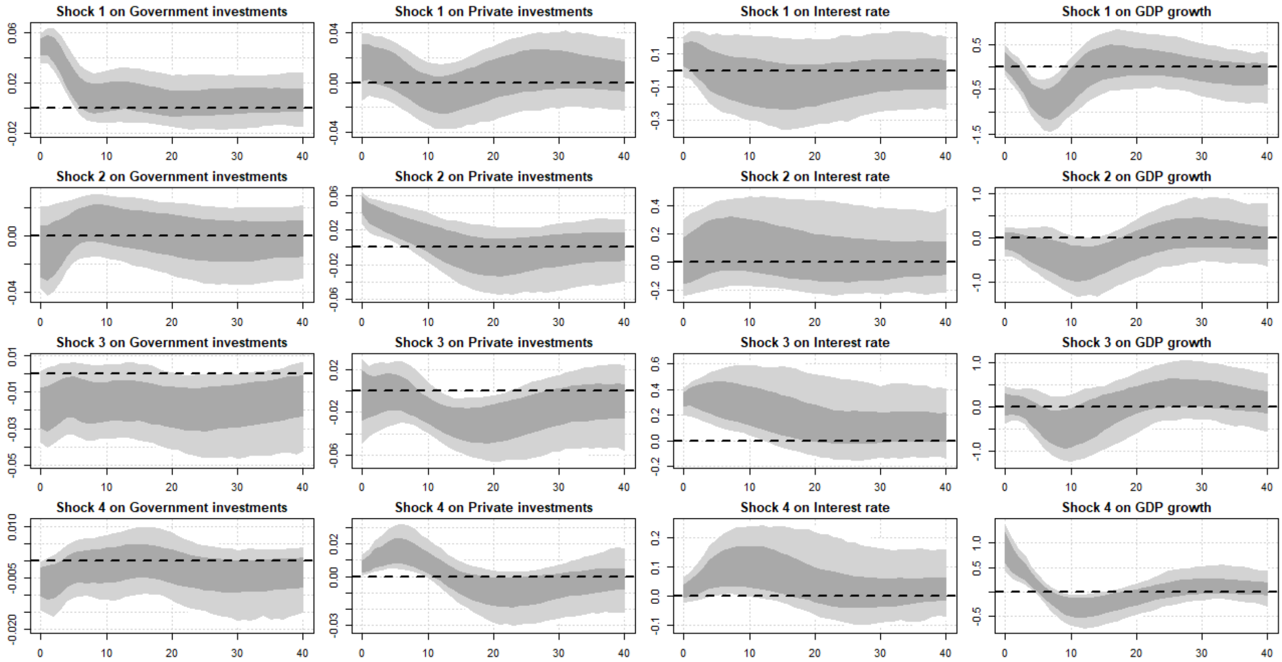


Figure 13: Overall investments with 40 period forecast horizon

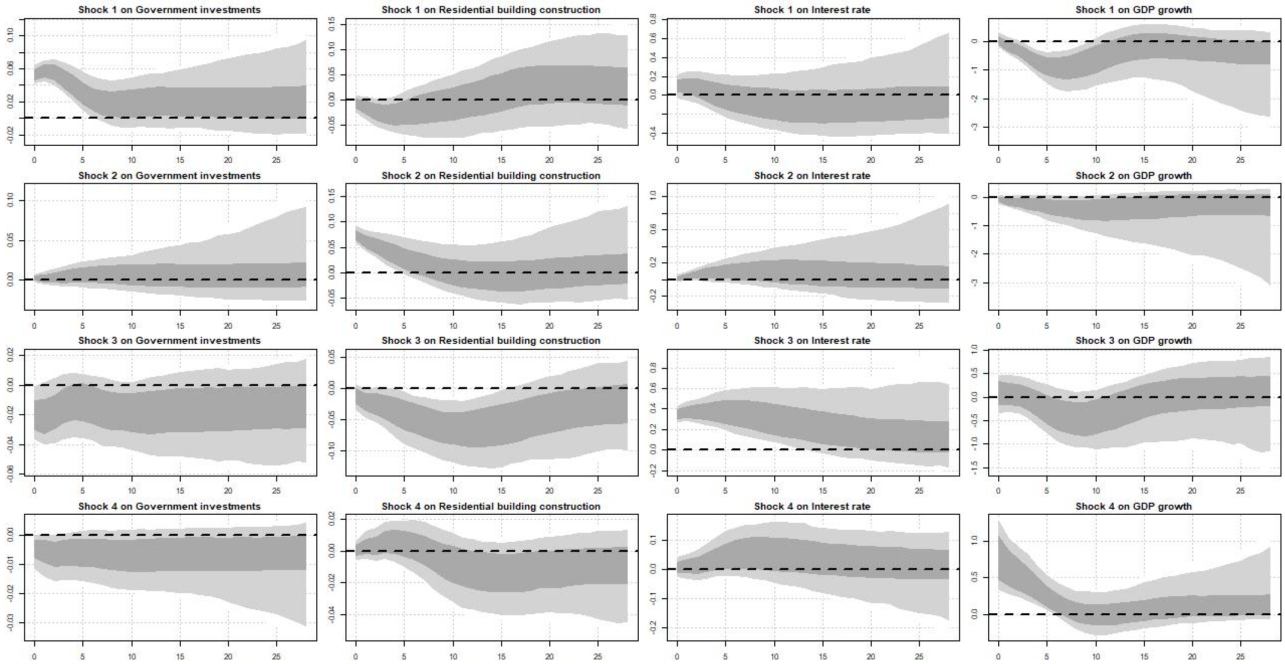


Figure 14: Residential building construction

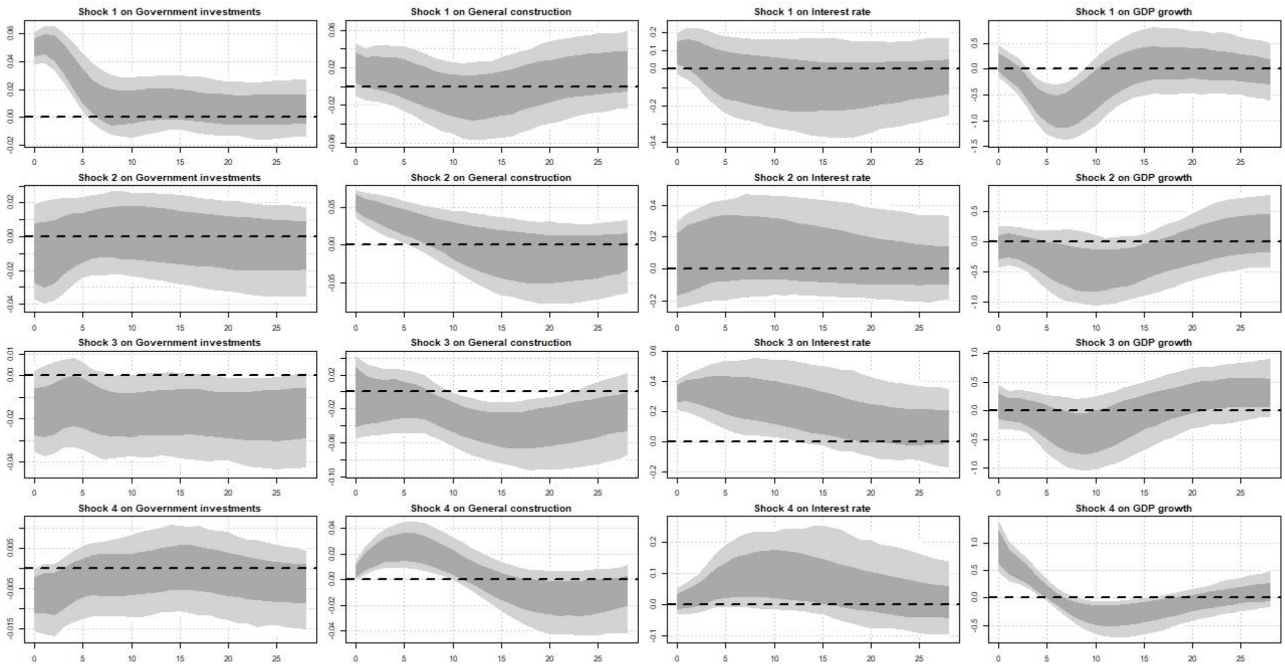


Figure 15: General construction

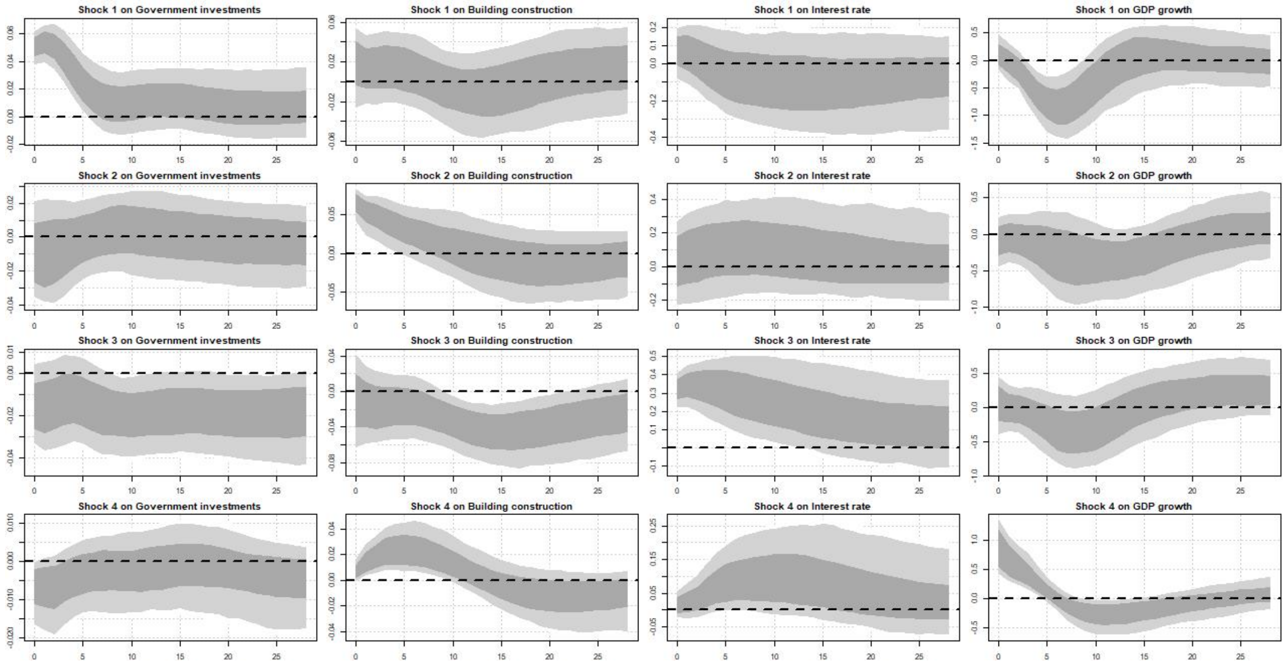


Figure 16: Building construction

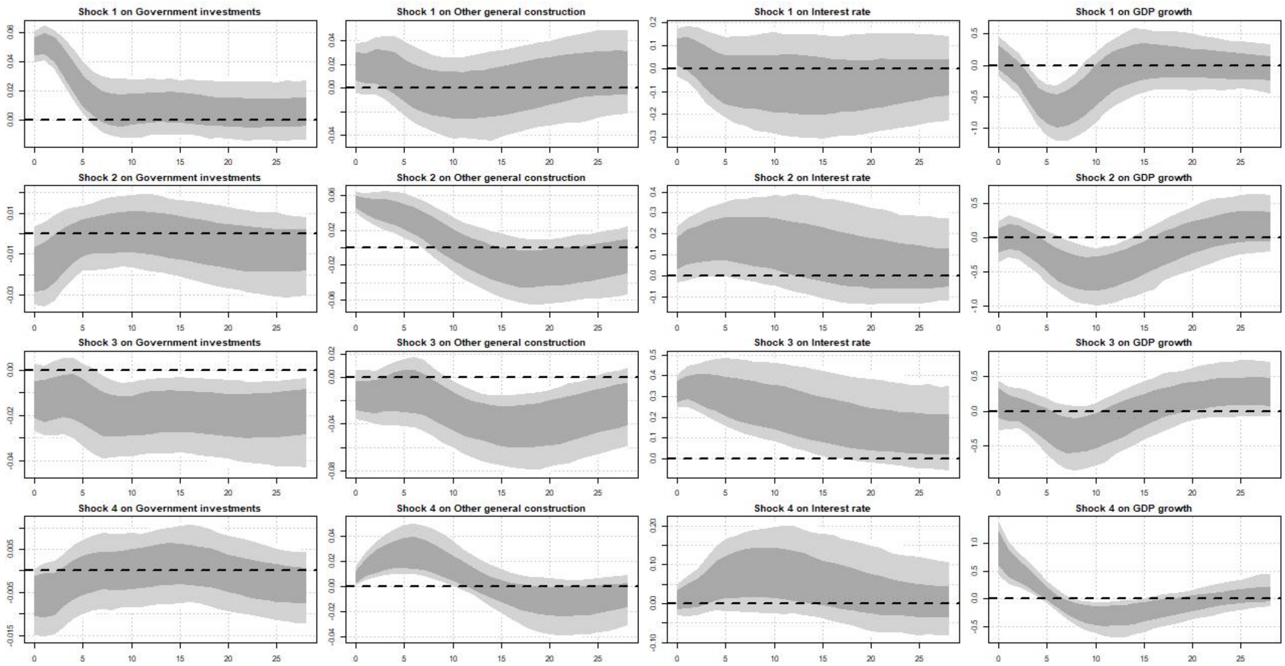


Figure 17: Other general construction

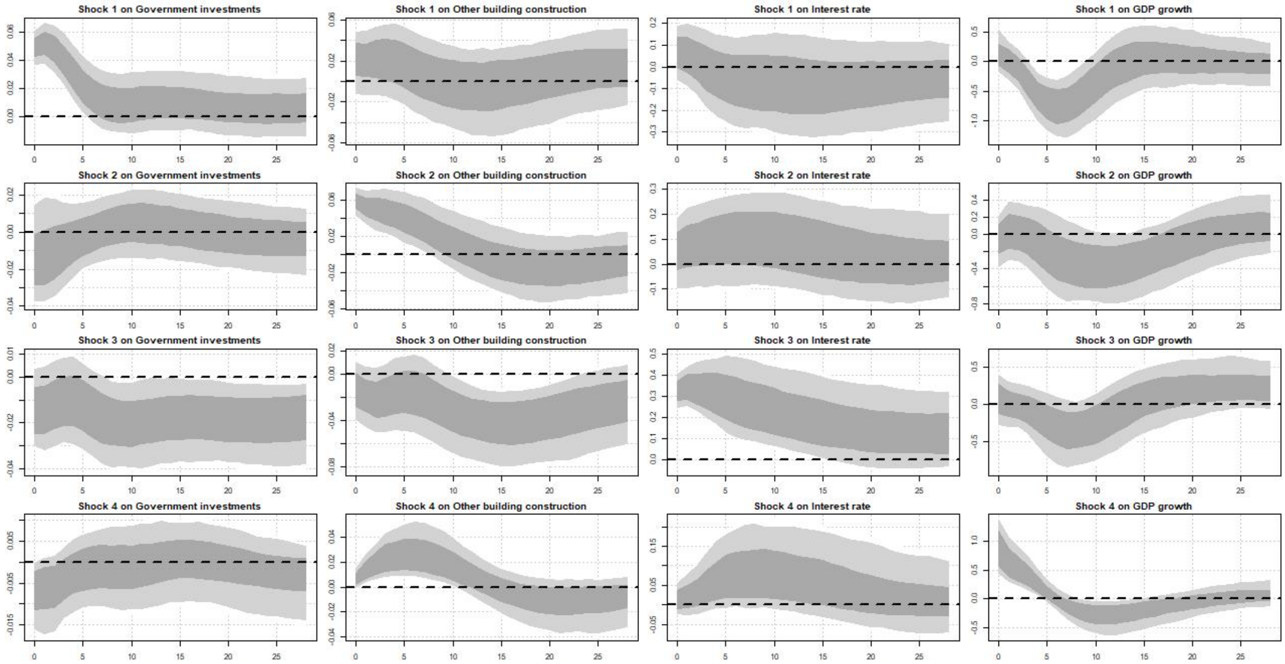


Figure 18: Other building construction

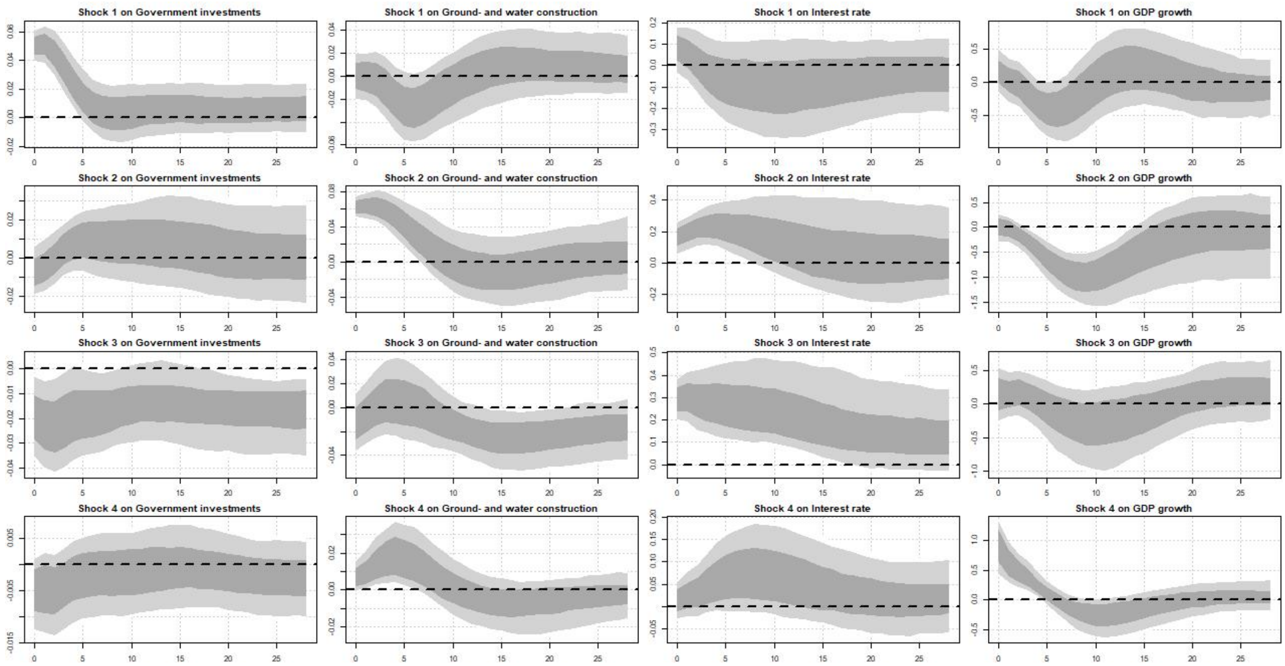


Figure 19: Ground- and water construction (infrastructure)

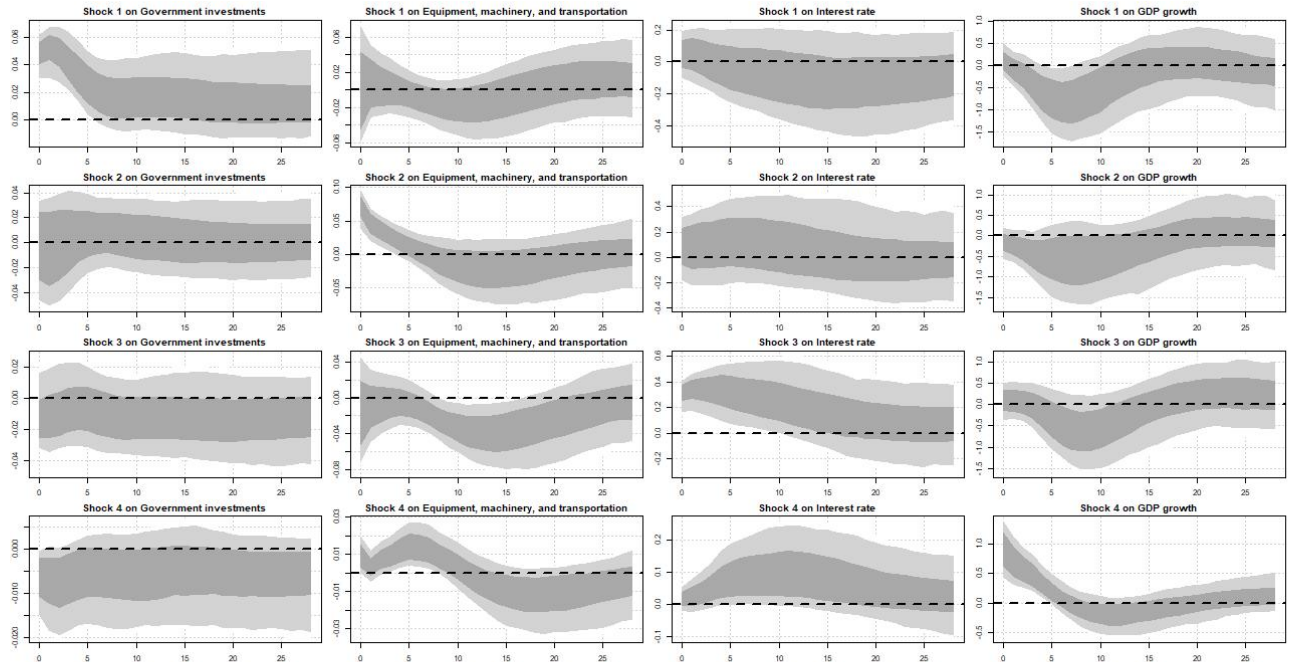


Figure 20: Equipment, machinery and transportation

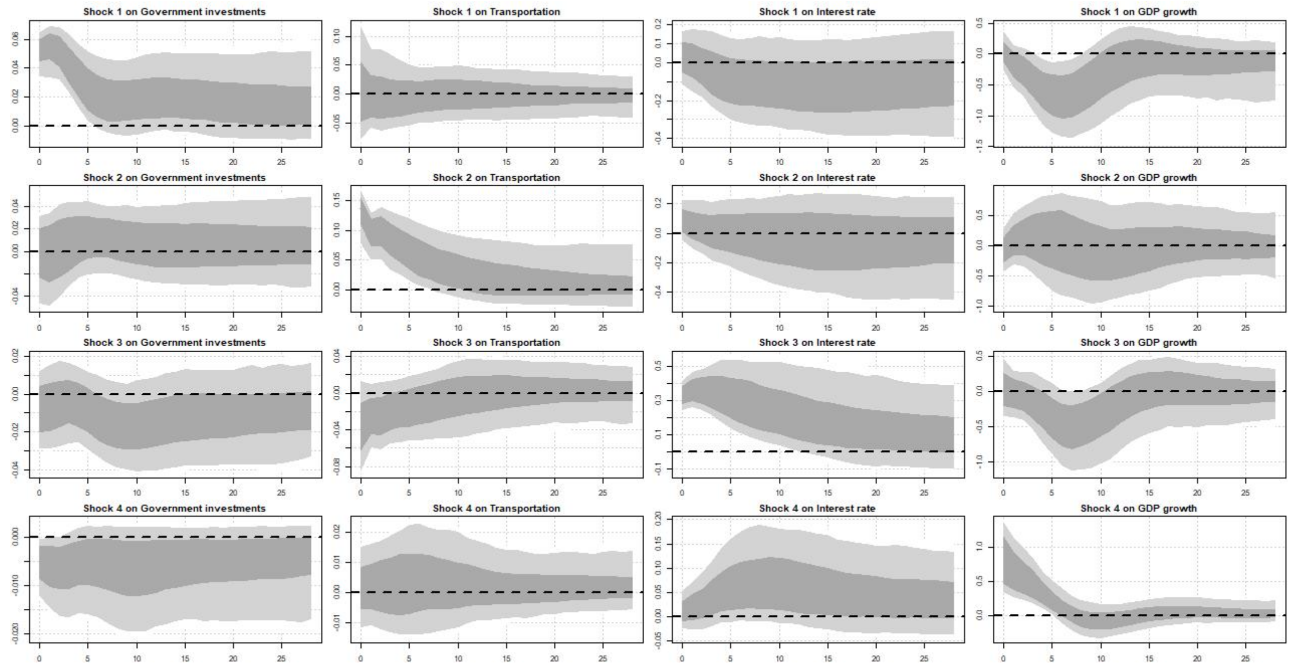


Figure 21: Transportation

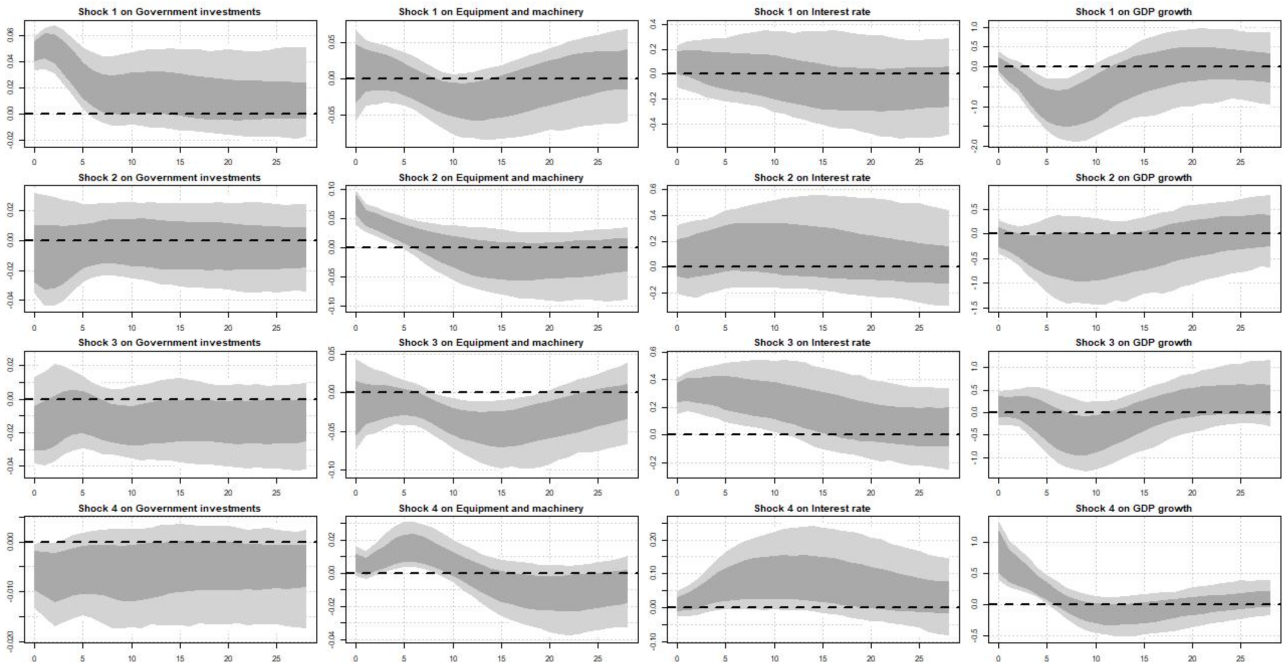


Figure 22: Equipment and machinery

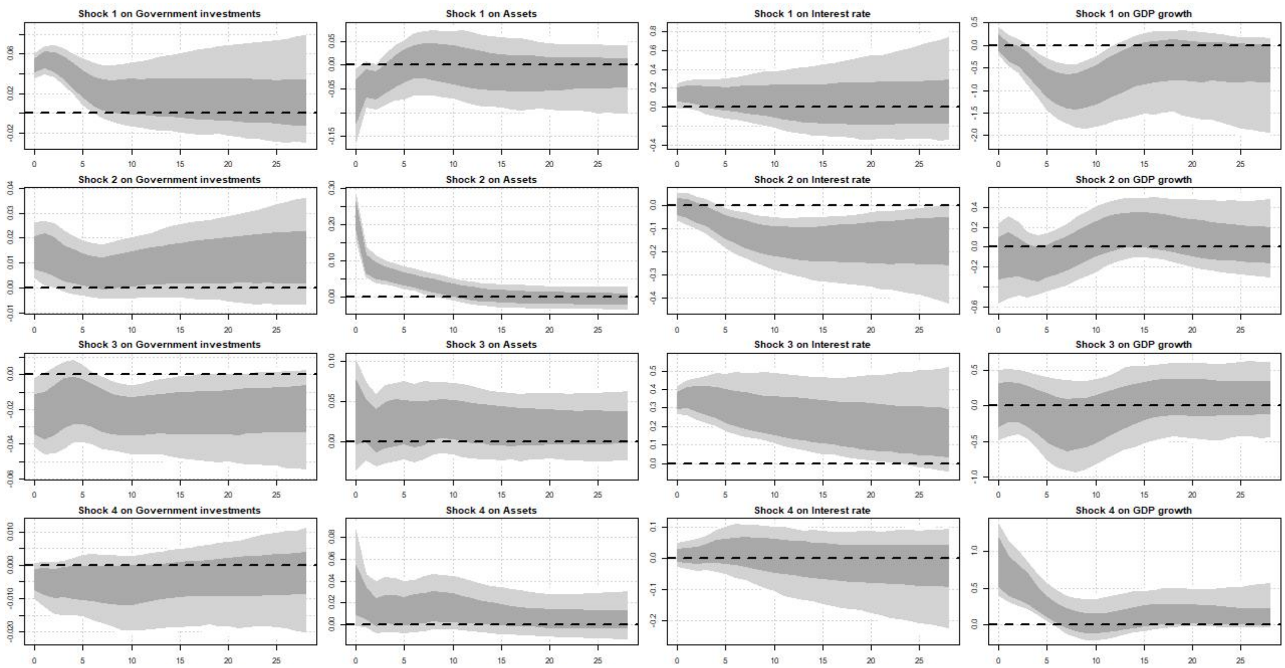


Figure 23: Growth assets

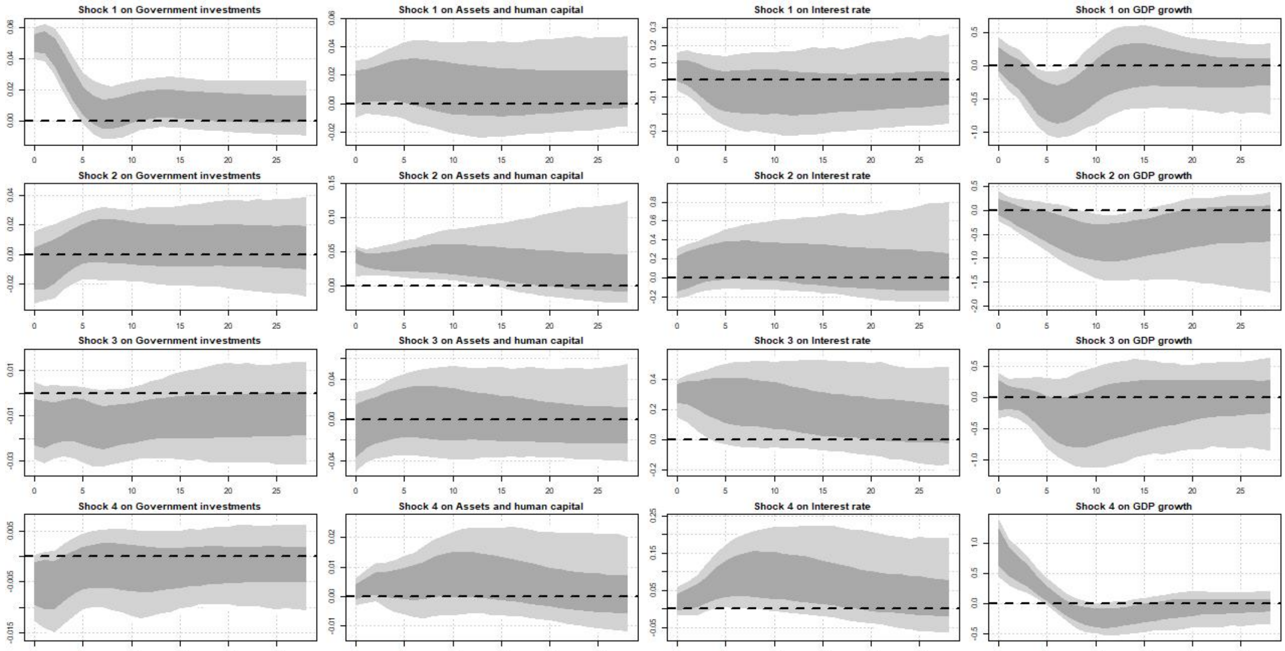


Figure 24: Assets

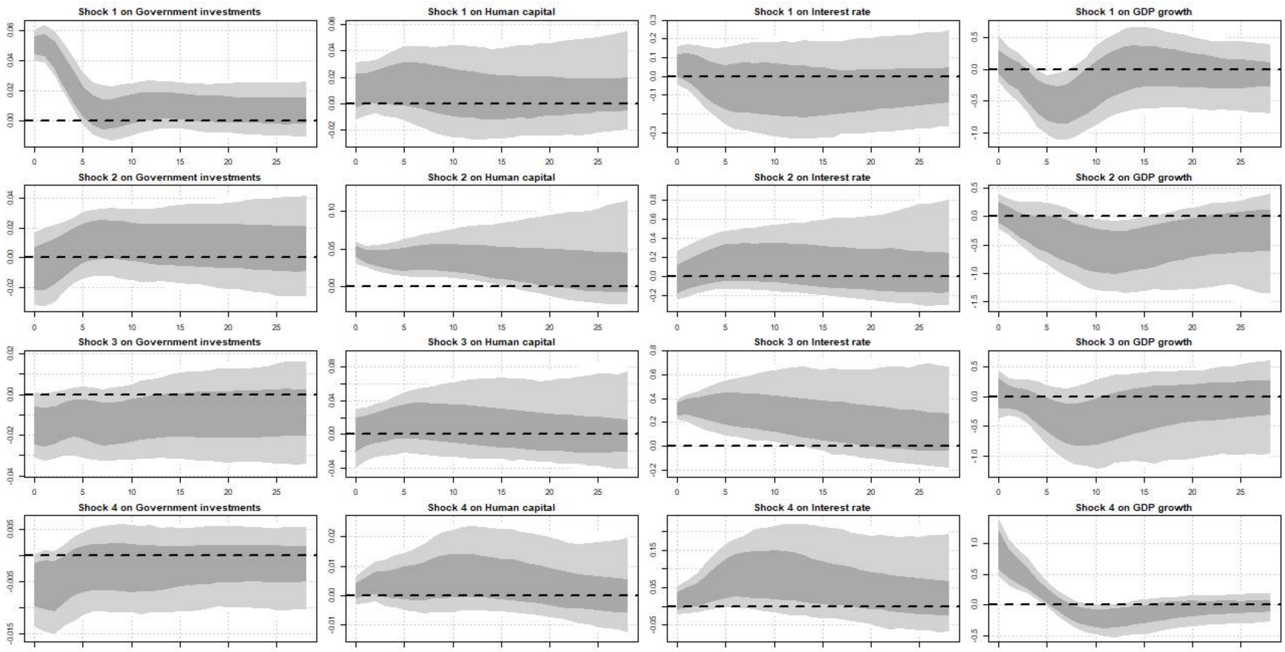


Figure 25: Human capital

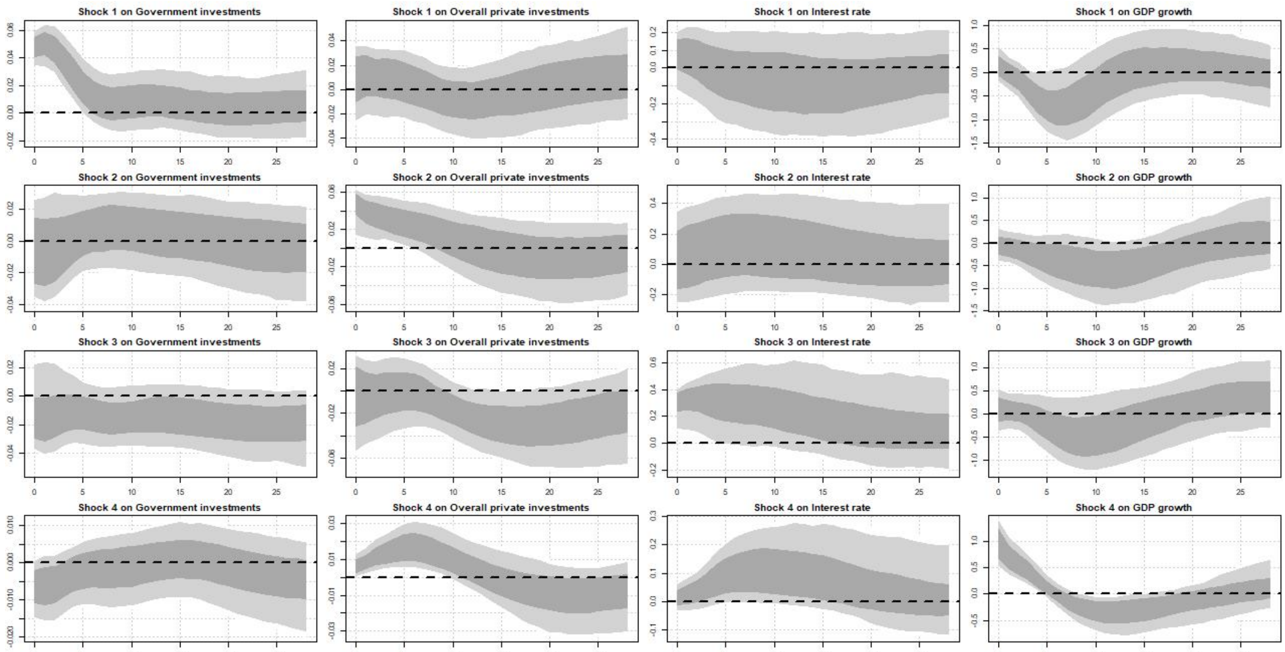


Figure 26: Overall investments