The dynamic effects of government spending: a FAVAR approach

Pallara, Kevin

University of Lausanne

12 July 2016

The dynamic effects of Government spending: a FAVAR approach

Kevin Pallara[1]

Abstract

The aim of the following work is to assess the dynamic effects of government spending on an extensive set of variables via macroeconometric modelling. As argued in Fatas and Mihov (2001), the following analysis of government spending is not a restrictive focus, but it explicitly aims at resolving a conflict among competing theories. Considering that the intrinsic nature of fiscal policy is to be predicted by economic agents, namely there exists a problem of *fiscal foresight*, the exogenous shock in government expenditure cannot be regarded as the structural ones. Hence, it is crucial to build a time series that unmistakably conveys *fiscal news* to both econometrician and economic agents. In Auerbach and Gorodnichenko (2012) and in Fragetta and Gasteiger (2014), it is proposed to consider the effects of the shock in the forecasting of the growth rate of government spending, which is defined as *purified spending shock*; the latter fiscal variable should contain the relevant information regarding changes in public expenditure and aim at resolving the *fiscal foresight* issue. Furthermore, the econometrician can include in the VAR only a limited number of variables. The narrowness of the included variables could lead to *non-fundamental* shocks and, thus, to biased estimates. In fact, small scale VARs might suffer of deficiency of information given that the information set spanned by the endogenous variables in the VAR might be smaller than the one detained by economic agents. A way to uncover the comovements in the economy is to extract factors from a large informational dataset via Principal Component analysis. Thus, including principal components that are consistent estimates of the factors in the model in order to build a factor-augmented VAR (FAVAR) as in Bernanke et al. (2005) should amend the non-fundamentalness problem. Therefore, applying the above-mentioned methodology, the impact on key macroeconomic variables is similar across VAR and FAVAR specifications, besides the effect on inflation that is negative and significant in the FAVAR estimation; the latter result is quite puzzling and it relates to the interaction between the forward-looking nature of inflation and the information-augmenting factors.

[1] University of Lausanne; kevin.pallara@unil.ch

Contents

List of Figures

List of Tables

Introduction

The study of the impact of fiscal policy has received little interest compared to the extensive analysis of the dynamic effects of monetary policy. This lack of concern is in contrast with the assumption of the effectiveness of fiscal policy in stabilizing business cycle fluctuations. Moreover, fiscal expansion through Government spending increases has generated an extensive debate regarding its effects on key macroeconomic variables. In fact, according to the standard RBC model, the effects of a rise in Government spending should lead to a fall in consumption. Conversely, New-Keynesian models predict an increase in private consumption following a spending expansion. Evenly, for what concerns private investment, different competing theories predict disparate responses of investment components to Government spending hikes. The aim of the following work is to assess the dynamic effects of Government spending on an extensive set of variables via macroeconometric modelling. Lastly, as already argued in Fatas and Mihov (2001), the following analysis of Government spending is not a restrictive focus, but it explicitly aims at resolving a conflict among competing theories.

Most of the literature on Fiscal VAR analysis regarded the exogenous shocks in Government spending as the structural ones. Considering that the intrinsic nature of fiscal policy is to be predicted by the economic agents, namely there exists a problem of *fiscal foresight*, the exogenous shocks in Government expenditure cannot be regarded as the structural ones. Hence, it is crucial to build a time series that unmistakably conveys *fiscal news* to both the econometrician and the economic agents. In Auerbach and Gorodnichenko (2012) and in Fragetta and Gaisteger (2014), it is proposed to consider the effects of the shock in the forecasting of the growth rate of Government spending, which is defined as *purified spending shock*; the latter fiscal variable should contain the relevant information regarding changes in public expenditure and aim at solving the *fiscal foresight* issue.
Furthermore, the econometrician can include in the VAR only a limited number of variables. The narrowness of the included variables could lead to *non-fundamental* shocks and, thus, to biased estimates. In fact, small-scale VARs might suffer from deficiency of information given that the information set spanned by the endogenous variables in the VAR models might be smaller than the one detained by the economic agents. A way to uncover comovements between macroeconomic indicators observed by the economic agents is to implement Principal Component Analysis on

a large informational dataset. The estimated *Principal Components* are consistent estimates of Factors conveying the relevant information in the economy. Thence, estimating a Factor augmented Vector Autoregressive model (or FAVAR) *à la* Bernanke et al. (2005) should amend the *non-fundamentalness* problem and the closely related *limited information* issue.

Thus, the twofold strategy of studying the effects of a disturbance in the *purified spending shock* and building a Factor augmented VAR *à la* Bernanke et al. (2005) should lead to unbiased estimates. Thence, the empirical analysis of changes in Government expenditure will be implented through both VAR and FAVAR estimation. Compared to VAR estimation, the FAVAR leads to different conclusions regarding the effects of spending increases on the inflation rate. Across all the VAR model specifications, the response of the inflation rate is either not significantly negative or not significantly positive, while it is significant and negative across all the FAVAR specifications. As underlined in Fatas and Mihov (2001) and in Mountford and Uhlig (2005), a negative response of prices following a rise in public expenditure is quite *puzzling*. Therefore, based on the assumption that the Factors included in the regression convey all the relevant information needed in the empirical analysis, it will be provided an interpretation of the inflation rate decrease. For what concerns the other key macroeconomic variables considered, the effects of Government spending in the FAVAR model proved to be similar to the ones found in VAR estimation. The latter finding should stress the consistency of the results so that the economic interpretation is not supported by biased estimates.

The subsequent work is organized as follows: the review of the relevant Fiscal VAR analysis, a refresher on *fundamentalness*, the *fiscal foresight* issue, the *limited information* problem and the FAVAR approach *à la* Bernanke et al. (2005) will be presented in Chapter 1. In Chapter 2, the empirical analysis will be carried on. In the first section of Chapter 2, the VAR analysis and the *purified spending shock* will be commented. In the second section of Chapter 2, the estimation and selection of Factors will be discussed and the FAVAR model will be implemented. In Chapter 3, the empirical findings will be showed and it will be provided an economic interpretation of the results. The *Appendix A* and *B* report respectively the relevant figures and the significant tables linked to the subsequent work.

Chapter 1

Literature Review

1.1 Fiscal VAR analysis

With respect to the extensive empirical literature on the dynamic effects of monetary policy, the analysis of fiscal policy shocks has generated little interest in economic research. The aforementioned little interest is in a lit contrast with the extensive public debate on the macroeconomic importance of fiscal policy: the discussions regarding the limits of the Growth and Stability Pact in the EU, the Balanced Budget Amendment in the USA and the possibility of appointing independent fiscal policy institutions are all established on the fact that fiscal policy is an effective instrument in order to stabilize business cycles fluctuations.

The typical issue of assessing the dynamic effects of discretionary policy shocks on key macroeconomic variables in large macroeconometric models was revived by Blanchard and Perotti (2002) whose article is considered the seminal paper in the VAR analysis of fiscal policy shocks. In the Blanchard and Perotti (2002) paper, the identification approach is based on the institutional information about the tax transfer and the timing of tax collections in order to disentangle the effects of the automatic stabilizers of taxes and spending to economic activity and the fiscal shocks. The implication of their analysis is that positive government spending shocks have positive and persistent effects on output, while positive tax shocks yield a negative effect on output. In addition, for what concerns both the identified shocks, the size of the fiscal multipliers is small. One of the findings of Blanchard and Perotti (2002) is that both increases in spending and taxes imply a large crowding-out effect on investment.

In Fatas and Mihov (2001), the identification is based on the recursive approach and they estimate a semi-structural VAR, which means that they only identify the shock in government spending using Cholesky decomposition (short-run restrictions). In their paper, they want to document the macroeconomic effects of government spending and compare that empirical evidence with the findings of the real business cycle model. Fatas and Mihov (2001) argued that their analysis of government spending effects is not a restrictive focus, but it aims at resolving a conflict among competing theories; in fact, quoting Fatas and Mihov (2001):

> "alternative theories imply different economic dynamics following a change in government spending while having qualitatively similar predictions for the effects of changes in tax rates."

In Fatas and Mihov (2001), the set of endogenous variables consists of Government Spending, GDP, GDP Price Deflator, Net Taxes and 3-month T-bill rate[2]. Looking at the non-accumulated responses, the authors found a persistent and positive response of private output to a spending shock. Moreover, the authors included investment, consumption and labour market components in the set of endogenous variables one at a time. A key finding is that the spending shock implies a persistent increase in all components of consumption. Private investment increases as well, but the driving force behind the latter rise is residential investment given that non-residential investment drops. The negative response of non-residential investment is not consistently explained in the paper and it is openly declared that such drop should deserve further research.

Furthermore, in Fatas and Mihov (2001), it is found that an increase in Government spending leads to a decrease in the GDP Price deflator. The same *puzzling* effect is found also in Mountford and Uhlig (2005). Using the sign-restriction approach, Mountford and Uhlig (2005) observed a decrease in Government receipts, interest rate and investments. The effect on prices and the decrease in investments following a fall in the interest rate is found to be inconsistent with the theory and is defined as ambiguous.

Blanchard and Perotti (2002) and Fatas and Mihov (2001) along with Perotti (2007) provided the main empirical findings within the classic SVAR approach and their papers backed New-Keynesian theory, which predicts a rise in cosumption and

[2] All the variables are taken in logarithms and the nominal variables are deflated by the GDP implicit price deflator.

real wage following a positive spending shock. On the other hand, the empirical findings on the effects of fiscal policy depends on the empirical approach employed; one of the consequences of the diverse empirical findings is a conflict regarding the most suitable model in order to analyse such a policy in theory. Perotti (2007) actually points out the issue:

> " ...perfectly reasonable economists can and do disagree on the basic theoretical effects of fiscal policy, and on the interpretation of the existing empirical evidence"

One alternative approach is the Narrative one followed by Ramey and Shapiro (1998), Edelberg et al. (1999), Burnside et al. (2004) and Ramey (2011b) in which the authors found out that an increase in Government spending in the US leads to a fall in both cosumption and real wage. In this case, the empirical findings support Neoclassical theories. One of the virtues of these papers is that they overcome the *fiscal foresight* issue that is linked to the anticipation of the policy by the economic agents, which causes a misalignment of the information sets between the economic agents and the econometricians.

In conclusion, Caldara and Kamps (2008) showed that the classic SVAR approach, the Narrative approach and the sign-restrictions approach all lead to similar results. Therefore, using a Bayesian VAR and controlling for different identification approaches, the authors found out that an increase in government spending leads to a rise in real GDP, real private consumption and to a non significant reaction of employment. Caldara and Kamps (2008) compared their empirical findings with most current-generation DSGE models and they argued that the persistent rise in GDP and consumption and the sluggishness in the reaction of employment are not backed by the theory.

1.2 The Fiscal Foresight issue and the limited information problem

The macroeconometric literature has identified two sources of misalignment of the information set of the econometrician with respect to the economic agents and to the economy as a whole: the first one is *fiscal foresight* and the second one is limited information.

1.2.1 A refresher on fundamentalness

Firstly, it is worthy to consider a statistical MA representation

$$X_t = \Phi(L)e_t, \tag{1.1}$$

in which $X_t = (X_{1t} \ldots\ X_{nt})'$ is an n-vector of weakly stationary variables, $\Phi(L)$ is an $(n \times q)$ matrix of rational functions in the lag operator L, with $n \geq q$, and e_t=$(e_{1t} \ldots\ e_{qt})$ is a q-dimensional white-noise normalized to have identity variance-covariance matrix, namely it is a vector of structural shocks. The MA representation in 1.1 implies that X_t belongs to the space that is spanned by $\{e_{t-k}, k \geq 0\}$. The fact that e_t is spanned by $\{X_{t-k}, k \geq 0\}$ must not automatically and necessarily hold; the latter occurrence could hold under peculiar conditions for $\Phi(L)$. Assuming $n \geq q$ and $\Phi(L)=I - AL$, we have that $X_t=(I - AL)e_t$ is invertible if and only if the subsequent conditions hold:

1. *e_t is a weak white noise vector*
2. *$\Phi(z)$ does not have poles within the unitary circle*
3. *det($\Phi(z)$) must have all its roots outside the unitary circle*

Therefore, under these three conditions, it is possible to rewrite 1.1 in the following way:

$$\sum_{i=0}^{\infty} A^i X_{t-i} = e_t, \tag{1.2}$$

From equation 1.2 we understand that in order to identify the structural shocks it is exclusively required the vector of past values of X_t. In fact, the latter finding derives from the evidence that $\Phi(z)^{-1}$ incorporates just positive powers of z. In case there existed one $z \in \mathbb{C}$ such that $\Phi(z) = 0$ and also $|z| = 1$, then the invertibility of $\Phi(z)$ would not be possible. For $|z| \neq 1$, if one condition among the listed above was violated, the future values of X_t would be necessary in order to correctly identify the structural shocks; the latter predicament leads to an identification issue regarding the contemporaneous shocks. The structural shocks are assumed to be economy-driving and they are monitored by the economic agents. Therefore, the innovations estimated through equation 1.1 do not unquestionably coincide with the structural shocks. In the occurence for which the invertibility of the lag polynomial is granted and the aforementioned conditions are not fulfilled, then $\{X_{t-k}, k \geq 0\} \subset \{e_{t-k}, k \geq 0\}$ and the information set of the economic agents is actually larger than the econometrician's one. So, in this particular eventuality, the estimated shocks in 1.1 ,e_t, do not match with the structural innovations and e_t is labelled X_t- **non-**

fundamental; if the assumptions are verified and the lag polynomial is invertible, then the structural shocks correspond to the estimated shocks e_t and the latter would be labelled X_t- **fundamental**. In the previous example it is implicitly assumed that $n > q$, but it is possible to recover the structural shocks also in case $n = q$ with more stringent conditions. Thence, non-fundamentalness could surely be an issue in the $n = q$ occurence, but not in the $n > q$ eventuality. In fact, the Factor augmented VAR model (which will be further discussed and implemented in the following sections) represents a solution to the non-fundamentalness problem through the crafting of a tall system ($n > q$), namely a dynamic factor model. To conclude,for what concerns fiscal policy, the non-fundamentalness problem could have its roots both in the anticipation of the fiscal measures by the economic agents (namely *fiscal foresight*) and in the limited information held by the econometrician with respect to the complete informative set detained by the economic agents, which is spurred by the comovements underlying the economic system as a whole.

1.2.2 The Fiscal Foresight issue

As already brought up in Fatas and Mihov (2001) and Perotti (2007), the fiscal policy innovations can be foreseen and, then, anticipated. In this case, the estimated structural shocks are likely to mismatch with the true ones, namely they are *non-fundamental*[3]. Furthermore, more recently, in Leeper et al. (2008) and Mertens and Ravn (2010) it is suggested that the intrinsic and unavoidable feature of fiscal policy is to be predicted. In fact, economic agents pocket signals of future fiscal policy changes before these modifications turn up. The reason behind this anticipation mechanism is the presence of implementation and legislative lags, which outlines the so-called phenomenon of *fiscal foresight.* In Leeper et al. (2008), it is shown that the *fiscal foresight* issue challenges the econometrician in a daunting way. The aforementioned authors take a neoclassical growth model with the presence of two shocks, a technology and an anticipated tax shock; thence, they reveal that the shocks in the MA representation of any pair of endogenous variables among technology, capital and taxes are *non-fundamental*[4]. The consequence of such *non-fundamental* repre-

[3]As already pointed out in Forni and Gambetti (2010), the estimation of the government spending shock with identification *á la* Blanchard and Perotti (2002) is proven not to be orthogonal to the contemporaneous forecasts of government spending (*Survey of Professional Forecasters*), which actually implies that the government spending shock can be anticipated and cannot be assumed to be the true structural shock.

[4]As already showed in the previous subsection, *non-fundamentalness* of the structural shocks means that the determinant of the MA matrix has roots smaller than one in modulus.

sentation is that there is no VAR representation in the structural shocks, so that the true structural policy innovations and the linked impulse response functions are actually overlooked through VAR estimation. Therefore, as already noticed, the *fiscal foresight* issue is rooted in the misalignment of the information sets: the econometrician observes the economic variables, which convey information regarding the shocks unless the impact effects are small and the delayed ones are large; on the other hand, the economic agents observe the true structural shocks. Thence, the information held by the econometrician is not enough to recover the shocks (Lippi and Reichlin (1993)).
Strong evidence that the information set employed in the fiscal VAR analysis is insufficient is furnished in Ramey (2009). Ramey proved that the structural shock estimated in a VAR framework *'a la* Perotti (2007) cannot be considered an innovation with respect to the accessible macroeconomic information. In fact, Ramey showed that the aforementioned estimated shock is Granger-caused by the forecast of government spending (*Survey of Professional Forecasters*).
Two main strategies surged in order to overcome the *fiscal foresight* issue. The first strategy was developed in Mertens and Ravn (2010), in which the authors estimated the effects of spending shocks using the estimation procedure based on Blaschke matrices and proposed in Lippi and Reichlin (1994). One pitfall of this strategy is that it requires several restrictions, which partly depend on the appropriate specification of the model in theory.

Based on the assumption that what the econometrician believes to be fiscal innovation is actually a discounted sum of past and current fiscal news detected by the economic agents, the second strategy was firstly developed by Hamilton (1985). This strategy requires an identification approach that takes into account *fiscal foresight* and tries to align the information sets of the econometrician and of the economic agents. Thence, the implementation of such a strategy is founded on building a time series that conveys the net present value of disclosed spending or tax modifications that are going to be in place in the future[5]. Such a time series should unmistakably contain *fiscal news* to both the econometrician and the

[5]Ramey and Shapiro (1998) started to work on a narrative dummy variable approach in order to correctly identify innovations to spending, being focused on forecasts of increases in defense spending announced on the Business Week magazine. In Ramey (2011b), it is actually built a continuous variable that contains the net discounted value of modification in defense spending foreseen by the Business Week magazine. The use of this *defense news* suggests that the SVAR analysis attains different conclusion since it overlooks the correct timing.

economic agents. This Narrative strategy seems to be consistent in order to take into account *fiscal foresight* even though, as argued in Forni and Gambetti (2010), it is hard to understand whether the built time series is successful in capturing all the relevant information. Therefore, it must be considered another source of misalignment between the information sets of the econometrician and the economic agents, which is actually related to the *fiscal foresight* issue and, at the same time, it outpaces this problem.

1.2.3 The limited information problem

The main goal of this subsection is to underline the second source of misalignment in the information sets that could yield biased estimations. Usually, an econometrician can include a restricted number of variables in a VAR model and, so, she could confront a limited information problem. In fact, the econometrician may ignore a wide array of economic indicators that convey useful information; thence, it is clear that the econometrician's information set is smaller than the economic agents' one. Therefore, the estimated coefficients in the small VAR may be biased and the econometrician should take into account the fundamental economic indicators in her analysis.

In order to clearly understand the limited information problem, it is noteworthy and necessary to unfold the *sufficient information* concept and to illustrate the difference between *fundamentalness* and *information sufficiency* as in Forni and Gambetti (2014).
Using the terminology and the notation as in Forni and Gambetti (2014), we firstly assume that χ_t is observed by the econometrician with the likely presence of an error and that the econometrician's information set X_t^* is provided by past and present values of the variables in χ_t^*; so, $X_t^* = \overline{span}(\chi_{1t-k}^*, ..., \chi_{nt-k}^*, k = 1, ..., \infty)$, where

$$\chi_t^* = \chi_t + \xi_t = F(L)u_t + \xi_t \tag{1.3}$$

in which ξ_t is equal to a vector of white noise measurement errors and orthogonal to any past values of u_t (that is a q-dimensional vector) and to its own ones; χ_t is equal to $F(L)u_t$, which is the MA representation of an n-dimensional vector χ_t of macroeconomic time series. Given that n is large, the econometrician is obliged to reduce the number of observable variables in order to correctly estimate a VAR model. Therefore, assuming that $z_t^* = W\chi_t^*$ [6] is an s-dimensional linear combination of χ_t^*, the vector z_t^* is not unquestionably influenced by the whole array of structural shocks affecting the economy, i.e. z_t^* is spurred by u_t^z (a sub-vector of u_t with dimension equal to $q_z \leq q$). Thence, the VAR information set is $Z_t^* = \overline{span}(z_{1t-k}^*, ..., z_{nt-k}^*, K = 0, ..., \infty)$. So,

$$z_t^* = WF(L)u_{t-k} + W\xi_t = B(L)u_{t-k}^z + W\xi_t \tag{1.4}$$

where $B(L) = \sum_{k=0}^{\infty} B_k L^k$ has rank equal to q_z. Now, examine the theoretical projection equation of z_t^* on its past values, i.e.

$$z_t^* = P(z_t^* | Z_{t-1}^*) + \epsilon_t \tag{1.5}$$

The SVAR approach involves the estimation of a VAR in order to obtain ϵ_t, the VAR shocks, and then trying to recovery the structural shocks moving z_t^* as a linear combinations of the estimated items of ϵ_t. Therefore, a pivotal property of z_t^* and its information set is that the items of ϵ_t span the structural shocks, namely the information contained in the past values of z_t^* is sufficient in order to properly estimate the innovations; in fact, this property is called *sufficient information* and, quoting Forni and Gambetti (2014), it is defined in the following way:

> "Let ν_t be any sub-vector of u_t^z. We say that z_t^* and the related VAR is *informationally sufficient for* ν_t if and only if there exists a matrix M such that $\nu_t = M\epsilon_t$. We say that z_t^* is *globally sufficient* if it is informationally sufficient for u_t^z."

Note that, in order to make global sufficiency holding, we only need that z_t^* is sufficient for the structural shocks driving it. Thence, it is likely that even a small VAR with $s < q$ is globally sufficient.

As anticipated, *fundamentalness* and informational sufficiency are related by the following proposition that holds under equation 1.3, 1.4 and 1.5: *If there exists a matrix R such that $\tilde{z}_t = Rz_t^* = Rz_t$ and u_t^z is fundamental for $\tilde{z}_t$, then the information contained in z_t^* is sufficient for u_t^z.*

This proposition states that in order to have z_t^* sufficient we need a linear combination of z_t^* itself spare of measurement errors and with a fundamental representation in the structural innovations. Thence, informational sufficiency and *fundamentalness* are equivalent besides the fact that informational sufficiency requires the absence of

[6] For the sake of completeness, keep in mind that W is an $s \times n$ matrix

errors or that the errors must be small. Moreover, even though *fundamentalness* is reached, if the errors in the VAR variables are large the information could turn out to be insufficient.

1.3 The FAVAR approach

In order to overcome the *non-fundamentalness* and *informational insufficiency* issues, we need to build-up a tall model that includes a vector of unobserved factors extracted from a large informational dataset; such factors should convey all the relevant information underlying the economy and be relevant for modelling the dynamics of the selected endogenous variables. The inclusion of factors in a multivariate time-series framework leads to supplementary identification issues with respect to a classic VAR. According to Stock and Watson (2005), the interconnection between the unobserved factors and the large informational dataset outlined in a measurement equation incorporates an idiosyncratic component. Therefore, estimating a dynamic factor model and setting up structural inference on an MA representation of the state equation that accounts for the unobserved factors could be deceitful. In fact, the errors in this occurence would be a combination of the idiosyncratic constituent in the state and measurement equation. Thence, as underlined in Koop and Korobilis (2010), with respect to a VAR, a dynamic factor model requires further restrictions in order to attain identification.
Conversely, I decided to opt for a Factor Augmented Vector Autoregressive approach *'a la* Bernanke et al. (2005). This type of approach improves the dynamic factor model to the degree that explicit variables are part of the measurement equation. So, the FAVAR state equation would be the following:

$$\begin{bmatrix} Y_t \\ F_t \end{bmatrix} = \Phi_0 + \Phi(L) \begin{bmatrix} Y_{t-1} \\ F_{t-1} \end{bmatrix} + U_t \tag{1.6}$$

where Y_t is an $n \times 1$ vector of endogenous observable variables, F_t is a $k \times 1$ vector of unobserved factors and U_t is an $(n+k) \times 1$ vector of i.i.d. errors $N(0, \Sigma^f)$, in which Σ^f is the covariance matrix; Φ_0 is an $(n+k) \times 1$ vector of constants and $\Phi(L)$ is $(n+k) \times (n+k)$ matrix ploynomial in the lag operator L with order p of non-negative powers. Relying on a FAVAR framework, it is necessary to take into account an $M \times 1$ vector of informational time series, X_t, and, so, a *factor and* *observation measurement equation*

$$X_t = \Lambda_0 + \Lambda^f F_t + \Lambda^y Y_t + \epsilon_t \tag{1.7}$$

where X_t is the vector of informational time series not included in the FAVAR specification and ϵ_t is an $M \times 1$ vector of i.i.d errors $N(0, \Sigma)$ with $\Sigma = diag(\sigma_1^2, ..., \sigma_M^2)$, which actually ensures the treatment of the equations as M independent regressions under the condition that we know F_t. Λ_0 is a vector of constants, Λ^f is an $M \times k$ matrix of the so-called *factor loadings* and Λ^y is an $M \times n$ matrix of coefficients. Rewriting 1.7 in the following way

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} 0_{n\times 1} \\ \Lambda_0 \end{bmatrix} + \underbrace{\begin{bmatrix} I_n & 0_{n\times k} \\ \Lambda^y & \Lambda^f \end{bmatrix}}_{\equiv \tilde{\Lambda}} \begin{bmatrix} Y_t \\ F_t \end{bmatrix} + \underbrace{\begin{bmatrix} 0_{n\times M} \\ I_M \end{bmatrix} \epsilon_t}_{\equiv \tilde{\epsilon_t}} \tag{1.8}$$

it is possible to substitute the MA representation of 1.6 within 1.8 in order to show that the resultant vector of errors in the obtained MA representation is uniquely connected to Y_t; indeed the $n \times 1$ idiosyncratic component of the errors within the MA representation of 1.8 connected to the observed variables is made by zeros. In section *2.2* will be discussed the two-steps estimation procedure of the FAVAR model: the first step is the extraction of the factors from the large informational dataset via Principal Component analysis; the second phase consists firstly in augmenting the VAR by the selected factors and lastly in estimating the model with standard methods.

Chapter 2

Empirical analysis

2.1 VAR analysis

2.1.1 Data, Model specification and Identification approach

I decided to use US seasonally adjusted data at averaged quarterly frequency. The fiscal time series, the components of national income and the GDP deflator are taken from the NIPA files released by the *Bureau of Economic Analysis*; the 3-month T-bill rate, the Total Civilian Non-Institutional population and the Manufacturing hours worked per week are picked up from the FRED database; the Non-Farm Business Sector real wage is drawn from the *National Bureau of Labor Statistics*. The time span selected starts at 1955:Q1 and it ends at 2015:Q4 in order to analyse the effects of government spending through the post-WWII span, the Volcker period, the post-Volcker or *Great Moderation* phase and the Financial Crisis. As argued in Fatas and Mihov (2001), the selected endogenous variables are considered the minimal set of time series essential for studying the dynamic effects of government spending. The baseline VAR consists of a model specification with five endogenous variables $Y_t = (G_t, y_t, \pi_t, T_t, r_t)$; In the aforementioned set of variables, G_t is the logarithm of the real per capita government cosumption and investment, namely government spending; y_t is the logarithm of real per capita Gross Domestic Product; π_t is the first difference of the logarithm of the GDP price deflator, which is actually the GDP implicit price deflator inflation rate; T_t is the logarithm of the real per capita Net Government current receipts[7]; r_t is the 3-month T-bill interest rate. Following

[7] Net Government current receipts are obtained by subtracting from the total government receipts the total paid interests and the total transfers (all the variables used in order to get the measure of Net Government current receipts are taken from the NIPA files).

the approach used in Fatas and Mihov (2001), the baseline VAR is augmented by an endogenous variable x_t that could be a consumption, an investment or a labor market component. The strategy of rotating one variable at a time in place of x_t within the new set of endogenous variables, $Y_t = (G_t, x_t, y_t, \pi_t, T_t, r_t)$, allows to analyse the effects of government spending on a wide range of variables. The endogenous variables added in place of x_t are the following: C_t, which is the logarithm of real per capita total private consumption[8]; $Durables_t$, which is the logarithm of real per capita private consumption of durables; $NonDurables_t$, which is the logarithm of real per capita private consumption of non durables; $Services_t$, which is the logarithm of real per capita private consumption of services; I_t, which is the logarithm of real per capita total private investment; $Residential_t$, which is the logarithm of real per capita private residential investment; $NonResidential_t$, which is the logarithm of real per capita private non residential investment; S_t, which is the logarithm of real per capita private savings; $Hours_t$, which is the logarithm of Manufacturing hours worked per week; w_t, which is the logarithm of the real Non-Farm Business Sector wage. It is noteworthy to underline that all the series are transformed in order to get stationarity according to the results of the Augmented Dickey-Fuller test at the 5% significance level; such transformations are necessary for the FAVAR analysis[9] and, so, in order to make the results of the VAR models and the Factor Augmented versions comparable, stationarity is ensured also in the VAR[10].

Firstly, it is considered the reduced form VAR model with the aforementioned set of endogenous variables with a 4^{th} order Lag polynomial. According to Blanchard and Perotti (2002) and Caldara and Kamps (2008), the selection of a lag length of four quarters seems to be a natural choice in a Fiscal-based model that involves quarterly-frequency data and, additionally, using a higher lag order does not influence the results. Given that the reduced form VAR errors are in gen-

[8] Note that the private total consumption as drawn from the NIPA tables includes categories of goods other than Durables,Non Durables and Services.

[9] As it will be explained in the following section, in order to build the Factor Augmented VAR, it will be carried on the *Principal Component Analysis*. The latter statistical procedure for the extraction of Factors is based on the divergence of the eigenvalues, which are obtained by decomposition of a large dataset covariance matrix. Therefore, if it is present a process $I(1)$ in the data, the eigenvalue of that process diverges leading to biased estimates.

[10] The transformation, namely first-differencing, is applied to the real per capita variables and to the interest rate. the inflation rate proved to be stationary according to the results of the ADF test at the 5% significance level. Moreover, note that the real per capita variables are obtained via deflation by the GDP implicit price deflator and normalization by the Total Civilian Non Institutional population.

eral correlated, it is mandatory to transform the reduced form VAR in its structural form. Remembering that without any restriction the structural VAR is not correctly identified, I decided to impose short-run restrictions through Choleski factorization of the innovation covariance matrix. The latter identification approach entails the characterization of the contemporaneous relationships among the endogenous variables, which means uncovering the causal ordering of the variables.
Thence, I decided to select the same causal ordering as in Caldara and Kamps (2008) and as in Fatas and Mihov (2001): government spending G_t is ordered as the first endogenous variable, the second one is output y_t, the third is inflation rate π_t, the fourth position is filled by Net Government receipts T_t and ordered last is the interest rate r_t. The selected ordering implies that government spending G_t has no contemporaneous reaction to any other endogenous variable, while y_t does react contemporaneously to G_t, but it does not respond to π_t, T_t and r_t, and so on and so far for the rest of the endogenous variables up to r_t that reacts contemporaneously to any of the shocks. It is noteworthy to point out that after the first period the endogenous variables are free to interact.

As in Caldara and Kamps (2008), this peculiar causal ordering could be justified in the subsequent manner:
First off, changes in government spending are broadly unconnected to the business cycle. Thus, it is assumed that G_t does not respond contemporaneously to shocks in the private sector. Secondly, since Government receipts should be related to the business cycle, it is fair to infer that y_t and π_t must be ordered before T_t because a shock in these two variables certainly affect the tax base and, so, Government receipts. This structure in the ordering surely grabs the effects of the automatic stabilizers on government receipts, while it plays out the contemporaneity of the impacts of discretionary modifications in tax on inflation rate and output. The reasoning behind ordering r_t last is that, relying on a central bank reaction function, the interest rate is set as a function of inflation rate and output gap. Moreover, G_t and T_t are taken net of the interest payments so that they are not sensitive to interest rate shocks.

2.1.2 The *purified spending shock*

The restrictions identified in the previous section are justified by the implementation and legislation lags so that Government spending does not respond contemporaneously to the other economy shocks. Such timing restrictions, as in Fatas and Mihov (2001)[11], are at the core of the classical SVAR literature. Nevertheless, by virtue of the implementation and legislation lags that justify the aforementioned identification approach, it could result that the identified shock in G_t is not regarded as fiscal news by the economic agents. In this circumstance, any measurement of fiscal news, $\mathfrak{n}_t$, could Granger-cause the shock in government spending G_t[12]. Therefore, the *fiscal foresight* issue arises. Thence, instead of making use of the model specification in the previous section, it is possible to estimate a VAR with the following set of explicit variables:

$$Y_t = (\mathfrak{n}_t, x_t, G_t, y_t, \pi_t, T_t, r_t)^{13} \tag{2.1}$$

where $\mathfrak{n}_t$ is an endogenous variable[14] that unmistakably includes fiscal news to the econometrician and to the economic agents. Thence, following such a narrative strategy, one could scrutinize the shocks in $\mathfrak{n}_t$. As suggested in Auerbach and Gorodnichenko (2012) and in Fragetta and Gasteiger (2014), $\mathfrak{n}_t$ can stand for the forecasting of the growth rate in G_t at time t made at time $t-1$ so that $\mathfrak{n}_t = \Delta g_{t|t-1}$. Thence, a shock in G_t is orthogonal by construction to $\Delta g_{t|t-1}$ in a Cholesky ordering so that the identification strategy derived in subsection *2.1.1* still holds. Since everything related to government spending that could have been foreseen by the economic agents is enclosed in $\Delta g_{t|t-1}$, such time series will be labelled *purified spending shock* and will be named $g_{t|t-1}$ for the sake of parsimoniousness.

In order to obtain the forecast of the growth rate of government spending at time t made at time $t-1$, it is necessary to correctly specify a model for the growth rate of the real per capita government spending G_t. Using the Shwarz's Bayesian information criterion[15], the correct model specification turns out to be an Autoregressive model with a 2-lags length order [16]. Thus, I implemented a moving window one-step ahead forecast of the government spending growth rate using a sample starting from

[11]The Cholesky ordering approach was firstly implemented in Sims (1980)

[12]As correctly pointed out in Ramey (2011b).

[13]Remember that the baseline VAR does not include x_t.

[14]It is noteworthy to underline that it is also feasible to include the *fiscal news* variable as an exogenous regressor following the VARX approach. In both cases, as showed in Edelberg et al. (1999), there is no difference asymptotically.

[15]The table that reports the results for the BIC criterion of the estimated models is reported in the *Appendix*.

[16]Considering that the focus is on exogenous Government spending shocks and assuming adaptive expectations.

1948:Q1. Thence, the recursive one-step ahead forecast of the government spending growth rate is computed stretching the sample one quarter at a time from 1954:Q4 until 2015:Q3. The result of such an estimation is reported in Figure 2.1.

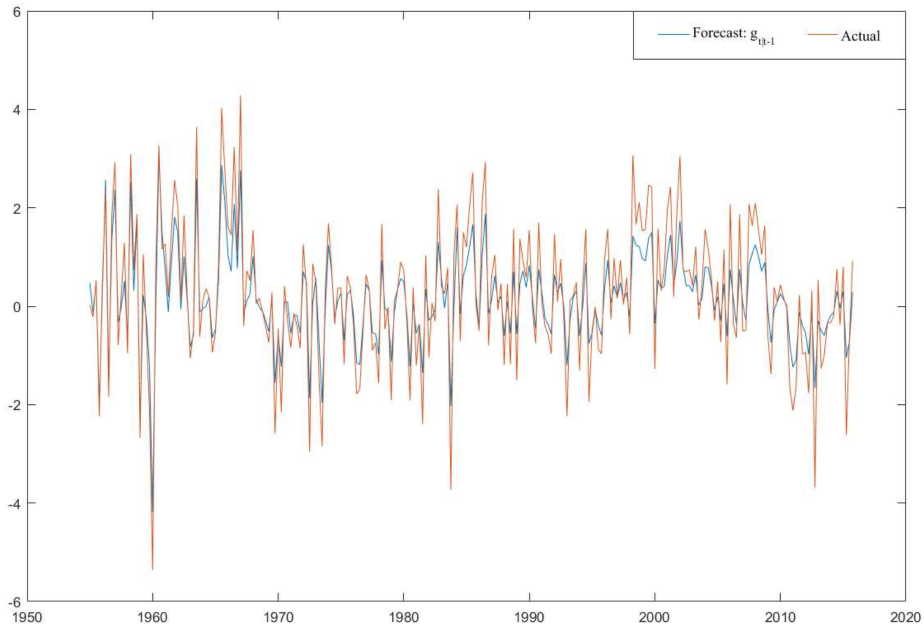

Figure 2.1: *Purified spending shock*

As argued in Ramey (2011b), the built measure of fiscal news should Granger cause the identified structural shock in government spending within the baseline VAR model without $g_{t|t-1}$ as an endogenous variable[17]. In this case, it will be proven that the structural shock in the non-augmented baseline VAR does not represent news to both the economic agents and to the econometrician (namely, it is not *fundamental*). Thus, I implemented an univariate Granger cause test (asymptotic version of the F-test) in order to verify the aforementioned hypothesis. The resulting χ^2-statistic value (17.5) exceeds the critical value (9.4877) so that it is possible to reject the null hypothesis for which the shock in the VAR is not Granger caused by $g_{t|t-1}$[18].

Once the test has confirmed the expectations regarding the structural shock in

[17] It is noteworthy to mention that an issue regarding the testing procedure using generated regressors might arise. The classical reference for further reading is "Pagan, Adrian. *Econometric issues in the analysis of regressions with generated regressors*, International Economic Review (1984): 221-247".

[18] The maximum lag order considered is the 20^{th}, α is fixed at 0.05 and $dof = 4$.

the VAR without $g_{t|t-1}$, it is possible to conclude that the correct set of endogenous variables is the one in equation 2.1 and the structural disturbance in the so-called *purified spending shock* conveys information the economic agents have on government spending changes. From now on, the model specification will consist of the variables in equation 2.1 with a 4^{th} order Lag length. The dynamics of the impulse response functions in the VAR models[19] will be showed and commented in Chapter 3 along with the results of the FAVAR models.

2.2 FAVAR analysis

2.2.1 The large informational dataset

As outlined in Chapter 1, in order to estimate a FAVAR model, it is necessary to follow a two-steps procedure: firstly, extract through Principal Component Analysis the *Principal Components* that actually converge to a basis of the factor space and, so, they are consistent estimates of the Factors F_t[20]; secondly, once included the Factors as endogenous variables in the VAR model, estimate the parameters in the standard way. As in Bai (2004), it is assumed that the *Principal Components* approximate the Factors; in order to fulfill the asymptotic convergence, a necessary condition is to extract the *Principal Components* from a large dataset of n time series where n tends to ∞. Therefore, the large informational dataset from which Principal Component Analysis will be carried on consists of 77 macroeconomic time series[21] including the series of the endogenous variables used in the VAR. The considered macroeconomic series are at averaged quarterly frequency covering the same time span of the VAR analysis ($1955 : Q1 - 2015 : Q4$) for the US. All the series are transformed to ensure stationarity following the results of the Augmented Dickey-Fuller test at the 5% significance level. In the *Appendix*, a table including all the series considered in the Large dataset will be showed. The series are taken from the FRED database, NIPA files (BEA) and Datastream.

[19]Both the augmented baseline model and the augmented models that include the rotating variable x_t.

[20]Note that *Principal Components* and Principal Component Analysis will be analysed in the following subsection.

[21]It is proved that the described asymptotic theory holds with $n > 40$.

2.2.2 *Principal Component Analysis*

As anticipated, in order to estimate a Factor Augmented VAR model it is necessary to extract the factors through Principal Component Analysis from a large informational dataset as in Bernanke et al. (2005). The *Principal Components* approach provides a non-parametric way of uncovering the common space spanned by the large dataset described in the previous subsection. The idea behind Principal Component Analysis (or PCA for brevity) is the elimination of the redundancy of the information within the data that is represented by the autocorrelation. Geometrically, PCA determines the most significant reference base in order to illustrate the data and to filter the noise showing the underlying structures within the dataset. Moreover, PCA is an orthonormal transformation that maximises the information (*Feature selection*), measured by the variance, and minimises the redundancy (*Dimension reduction*), measured by the correlation.

Consider a time series dataset composed by n observations and p informational time series

$$H = \begin{bmatrix} H_{11} & H_{12} & \cdots & H_{1p} \\ H_{21} & H_{22} & \cdots & H_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ H_{n1} & H_{n2} & \cdots & H_{np} \end{bmatrix} \tag{2.2}$$

for which PCA will be implemented. Moreover, keep in mind that such orthonormal transformation must be carried on standardized data (if the variables have different magnitudes) such that $S_{ij} = (H_{ij} - \mu_j)/\sigma_j \ \forall j$, where μ_j and σ_j are respectively the mean and the standard deviation of series j. With standardized data, PCA should be carried on the Covariance matrix C of the data that is actually equal to the Correlation matrix R. Therefore, the first step of PCA is to diagonalize the Covariance matrix C in order to obtain the matrix of the corresponding eigenvalues Λ and the corresponding eigenvectors W (a $p \times p$ matrix) arranged according to the descending order of the eigenvalues as follows

$$W = \underbrace{\begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1p} \\ w_{21} & w_{22} & \cdots & w_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p1} & w_{p2} & \cdots & w_{pp} \end{bmatrix}}_{\lambda_1 \ > \ \lambda_2 \ > \ \lambda_p} \tag{2.3}$$

Since by decomposition $C = W\Lambda W^T$ and $\Lambda = diag(\sigma_1^2, \sigma_2^2, ..., \sigma_p^2) = W^T C W$, then disciplining the eigenvectors according to the descending order of the eigenvalues means giving importance to the most informational dimension (the one that explains the largest share of the variance). It is noteworthy to underline that the eigenvector matrix is orthonormal, namely $W^T = W^{-1}$. The aforementioned decomposition aims at crafting the so-called *Principal Components*, which is a linear combination of the ordered eigenvectors and the standardized dataset. Thence, the principal components convey the same information of the large dataset with the peculiarity of being uncorrelated and they are defined as $Z = SW$, where Z are the principal components, S is the standardized version of H and W is the matrix of eigenvectors. Therefore, the *Principal Components* offer an alternative explanation of the observed variability and they have the advantage of describing the common trends underlying the dataset via orthogonal dimensions ordered according to their explanatory importance.

In conclusion, as outlined in Bai (2004), the *Principal Components* converge to a basis of the factor space and, so, they are consistent estimates of the Factors. Thence, from now on, the *Principal Components* Z will be referred to as Factors F_t. In the following section, it will be analysed a two-steps procedure in order to determine the number of *Principal Components*, namely Factors, to be included in the FAVAR model. The first step consists of a heuristic strategy in order to select an upper-bound number r of Factors F_t based on the eigenvalues Λ. Following the recursive orthogonality test (F-test) approach as suggested in Forni and Gambetti (2011) and the Granger Cause test strategy as in Forni and Gambetti (2014), the second step lies in the selection of $d < r$ Factors to be retained in the FAVAR model.

2.2.3 Selection of Factors

As anticipated in the conclusion of the previous subsection, it is necessary to select the correct number of Factors d to be included in the FAVAR model. Therefore, the selection of the Factors F_t will be implemented via a two-steps procedure. The first step is based on the percentage of the variance explained by the *Principal Components*, which are actually ordered according to the diagonal variance matrix Λ. Therefore, it is necessary to compute the cumulative amount of variance, namely $\lambda_j / \sum_{i=1}^{p} \lambda_i \; \forall j$, which each *Principal Component* accounts for[22]. Thence, by observ-

[22]In the *Appendix*, it is readily available a table with the variance explained by each *Principal Component*

ing cumulatively the variance explained by the *Principal Components*, I selected an upper-bound number of factors r equal to 7 based on the evidence that those *Principal Components* account for more than 60% of the variance[23].

The first phase of the second step consists in applying a recursive orthogonality test in order to check the *fundamentalness* of the structural shock with the Factors included into the model. The testing procedure is the subsequent:

1. *Estimate the structural shock from the Factor Augmented model with the first Principal component*

2. *Estimate the lags of the Factors in the FAVAR with the inclusion of the first two Principal Components*

3. *Test using an F-test whether or not the estimated structural shock is orthogonal to the lags of the Factors; the null of fundamentalness is rejected if and only if orthogonality is rejected*[24]

4. *Repeat steps 1. and 2. until having tested the estimated structural shock in the FAVAR with $r-1$ Factors against the lags of the FAVAR model with r Factors*

Following the above-mentioned testing procedure for the Baseline Models, it is evident that it must be retained a number $d = 4$ of Factors for the implementation of the FAVAR model so that *fundamentalness* is ensured[25].

The last phase of the second step resides in testing whether or not the retained d Factors F_t Granger Cause the endogenous variables Y_t. In case the null hypothesis of no Granger Causality is not rejected, the set of Factor F_t is not *informationally sufficient* for the set of endogenous variables Y_t. Therefore, I implemented a Multivariate Linear Granger Causality test based on the Likelihood Ratio test-statistic. It is noteworthy to further explain the Multivariate Granger Cause Test in theory. As in Bai,Wong and Zhang (2010), in pursuance of testing the linear causality relationship between two sets of different stationary time series, namely $x_t = (x_{1,t}, ..., x_{n_1,t})'$ and $y_t = (y_{1,t}, ..., x_{n_2,t})'$, in which $n_1 + n_2 = n$ series are present, it is possible to

[23]Indeed, the mentioned approach is in line with the findings in Alessi et al. (2008). In fact, in the latter paper, the authors refine the *non-parsimonious* Bai and Ng (2002) criteria and find that the upper bound number of factors outlining the US economy is equal to 5-6. Furthermore, implementing the PC_2 criterion of Bai and Ng (2002) on the 77 obtained *Principal Components* leads to a maximum number of factors equal to 27 so that the lack of parsimoniousness of such criterion is proved.

[24]In this case, fitting the linear model and using an F-test procedure leads to the conclusion of orthogonality when the p-value is high. The closer the p-value is to one the more the evidence for orthogonality is stressed.

[25]The p-values for the orthogonality test are showed in the *Appendix* using 1 and 4 lags of the Factors.

build-up the subsequent n-equation Vector Autoregressive model

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} A_{x[n_1 \times 1]} \\ A_{y[n_2 \times 1]} \end{bmatrix} + \begin{bmatrix} A_{xx}(L)_{[n_1 \times n_1]} & A_{xy}(L)_{[n_1 \times n_2]} \\ A_{yx}(L)_{[n_2 \times n_1]} & A_{yy}(L)_{[n_2 \times n_2]} \end{bmatrix} \begin{bmatrix} x_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} u_x \\ u_y \end{bmatrix} \tag{2.4}$$

where $A_{xx}(L)_{[n_1 \times n_1]}$, $A_{xy}(L)_{[n_1 \times n_2]}$, $A_{yx}(L)_{[n_2 \times n_1]}$ and $A_{yy}(L)_{[n_2 \times n_2]}$ are the Lag-polynomial matrices of order p, while $A_{x[n_1 \times 1]}$ and $A_{y[n_2 \times 1]}$ represent the intercept terms. Let us assume that we want to test whether there exists a unidirectional causality from y_t to x_t, namely it is necessary to test whether any term of $A_{xy}(L)_{[n_1 \times n_2]}$ is not significantly different from zero. Therefore, the null hypothesis for such test would be $H_0 : A_{xy}(L)_{[n_1 \times n_2]} = 0$. In order to test the null hypothesis, the first step to pursue would be to estimate the covariance matrix Σ from the full model without restrictions on the parameters and, then, to estimate the covariance matrix Σ_0 from the restricted model with restrictions imposed by the null hypothesis H_0. Thence, as in Sims (1980), instead of making use of an F-test, it is possible to use a testing procedure based on the subsequent likelihood ratio test statistic

$$(T - c)(\log |\Sigma_0| - \log |\Sigma|) \tag{2.5}$$

where T is the number of observations, c is the number of estimated parameters in the unrestricted model and $\log |\Sigma_0|$ along with $\log |\Sigma|$ are respectively the logarithm of the determinant of the restricted and unrestricted covariance matrix. Under H_0, the asymptotic ditribution of the likelihood ratio statistic converges to a χ^2 with q degrees of freedom[26], where q is equal to the number of restrictions on the coefficients in the system. Thus, in order to test $H_0 : A_{xy}(L)_{[n_1 \times n_2]} = 0$, it is needed to impose c equal to $np + 1$ and, in the first n_1 equations, $n_2 \times p$ restrictions on the coefficients. In this case, 2.5 becomes $(T - (np+1))(\log |\Sigma_0| - \log |\Sigma|)$ that converges asymptotically to a χ^2 with degrees of freedom equal to $n_1 \times n_2 \times p$. Making use of the above-mentioned Multivariate Granger Cause test, I tested whether the retained d Factors were *informationally sufficient* for the set of endogenous variables Y_t. The results for any specification of the FAVAR imply that F_t Granger Causes Y_t with the evidence of infinitesimal p-values[27]. Therefore the Factors are *informationally sufficient* for the set of endogenous variables.

In conclusion, once the number of Factors is determined, it is significant to build

[26] The asymptotic convergence of the Likelihood Ratio Test statistic to a χ^2 is proved by the Wilk's Theorem.

[27] α is set at 0.01.

the Factor Augmented VAR model and analyse whether or not the FAVAR actually outplays the responses in the variables in the VAR models following a government spending shock (in our case a so-called *purified spending shock*). The FAVAR model that will be estimated is equal to the one showed in the state equation 1.6 and discussed in section 1.3, which follows the approach of Bernanke et al. (2005). Remember that the Factors are included in the set of endogenous variables at last. The latter procedure is justified by the assumption that the factors stand for the unobservable pillars driving the economy and, thus, they react once the endogenous observed variables have changed. Note also that the lags considered are four as in the VAR analysis given that one of the aim of this work is to compare the results between the two models.

Chapter 3

The effects of Government Spending

In this Chapter, the results of the impulse response functions for all the VAR and all the FAVAR specifications will be presented, analysed and discussed. Secondly, it will be provided the economic interpretation of the results in view of the existent competing theories.

3.1 Preliminaries

Once the structural model is recovered and identification through short-run restrictions is achieved as discussed in Chapter 2, it is crucial to analyse the impulse response functions in order to study the effects of a positive disturbance in the *purified spending shock*. It is noteworthy to underline that the impulse response functions are accumulated[28] and the responses to a unitary shock in the *purified spending shock* are in percentage[29]. Moreover, in all the figures, I report the median impulse response functions and the 68% standard errors bands based on bootstrap standard errors computed by 500 replications.

[28]Remember that all the data are transformed in order to ensure the absence of unit roots conforming to the ADF test results at the 5% significance level.

[29]Even though it was not explicitly mentioned in Chapter 2, the variables are taken in logarithms and then multiplied by hundred in order to get the percentage responses.

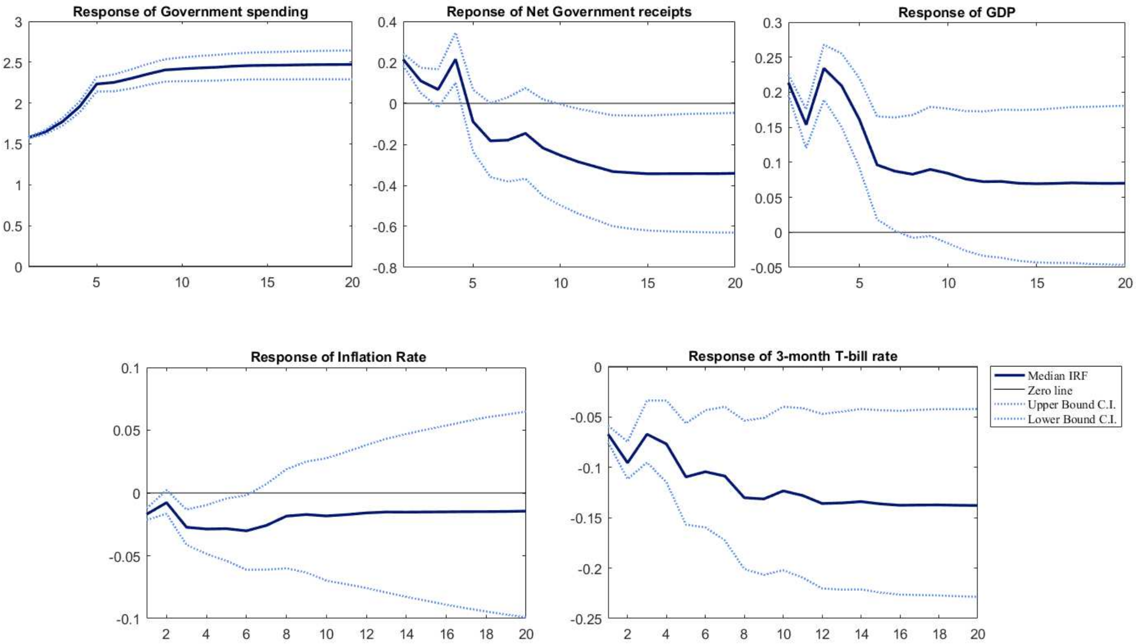

Figure 3.1: *VAR Baseline Model - Accumulated IRFs*

3.2 Empirical evidence

As analysed in the previous Chapter, the set of endogenous variables proved to be Granger caused by the selected factors. Even though the *purified spending shock* explicitly takes into account the anticipation effects linked to changes in Government spending, the *informational insufficiency* problem leads to biased estimates.

In fact, the responses of the inflation rate in the VAR models proved to be remarkably different with respect to the effects found in the FAVAR. Across all the 11 FAVAR specifications, the inflation rate responds negatively and significantly to a disturbance in the *purified spending shock*. Conversely, across all the 11 VAR specifications, the response of the inflation rate ranges from being not significantly negative (as reported in the IRF of the Baseline Model) to not significantly positive (e.g., in the specification in which $x_t = NonResidential_t$). Moreover, the response of the inflation rate in the FAVAR specifications does not lie in the confidence bounds of the VAR IRFs meaning that the difference is qualitative and not merely quantitative. As it could be expected, a forward looking variable such as the inflation rate relies meaningfully on the presence of the Factors that capture the

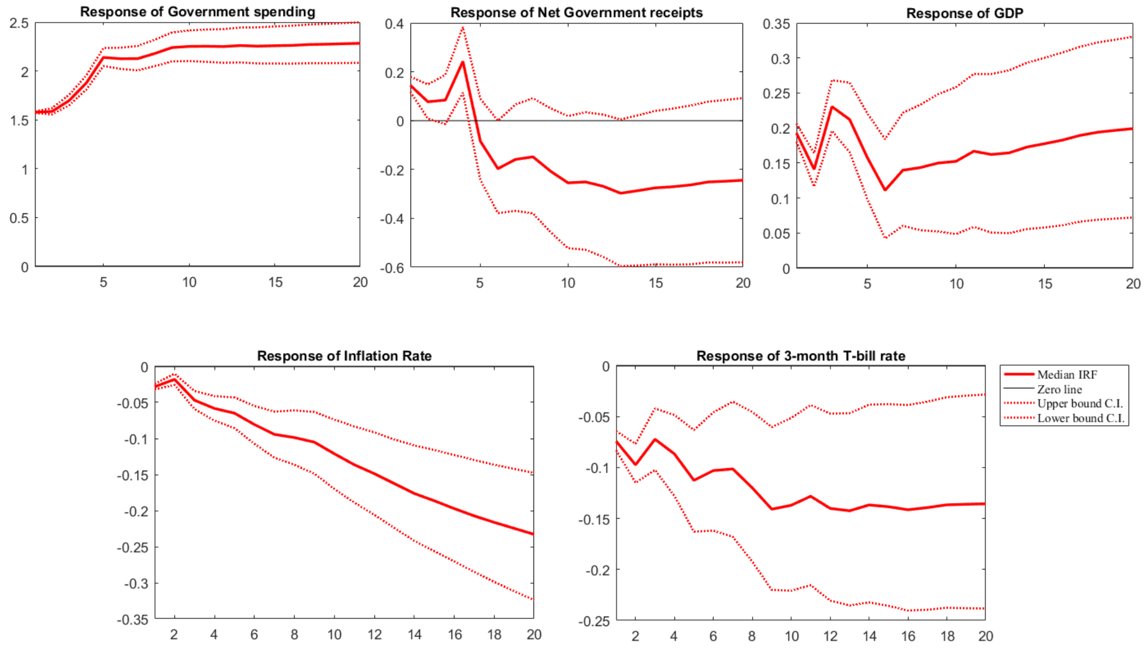

Figure 3.2: *FAVAR Baseline Model - Accumulated IRFs*

comovements in the economy.

For what concerns all the other variables considered in the specifications, the responses are similar in all the VAR and FAVAR models. The latter result could support the importance of considering the shock in the built time series, which should convey the relevant information regarding the anticipation and implementation lags of Government spending changes. Therefore, the twofold strategy of including a time series that explicitly tries to overcome the *fiscal foresight* issue and amending the VAR by building an informative Factor augmented model seems to be effective and to yield consistent estimates of the effects of an exogenous spending shock.

The reaction of Government Spending and the Government receipts are equal both in the VAR and in the FAVAR: the effect on spending is positive and persistent, while the effect on receipts is at first positive (about 0.21%) and then negative (about -0.30%) meaning that the spending shock is deficit-financed (Figure 3.1 and 3.2). The response of receipts is similar to the empirical findings in Mountford and Uhlig (2005). The effects on output are positive in both models and the peak is reached after three quarters at 0.23% (Figure 3.1 and 3.2) . It is important to remark that, in the FAVAR, the impact on output is more persistent. The same positive

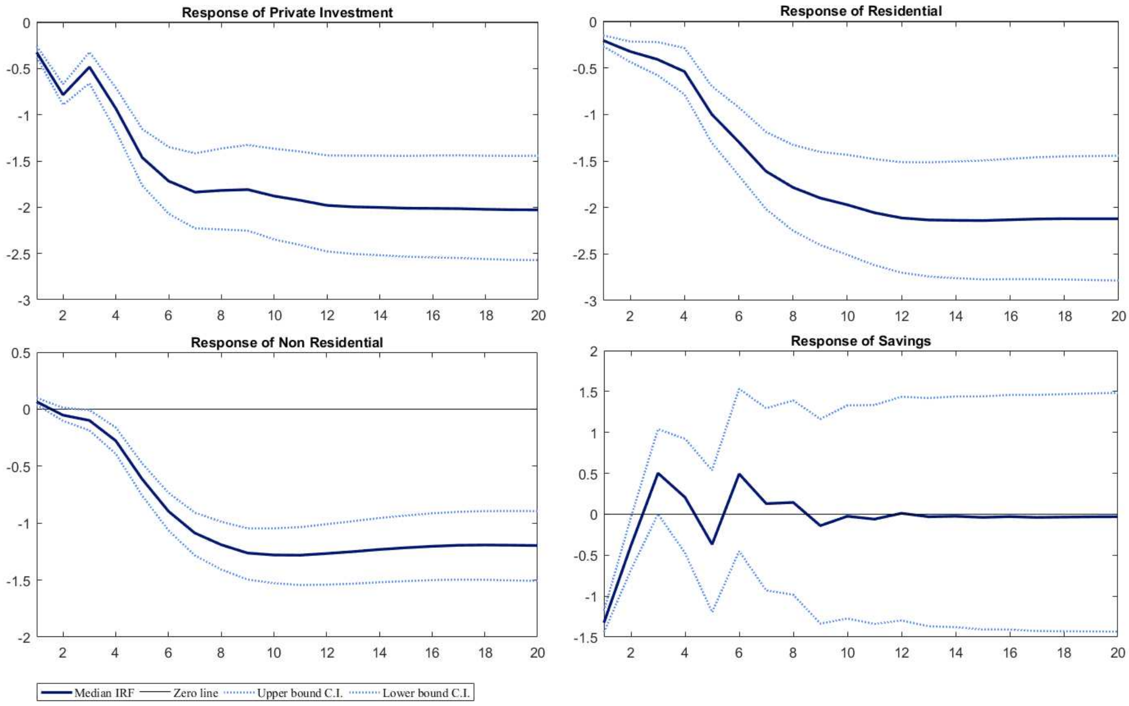

Figure 3.3: *VAR - Accumulated IRFs for Private, Residential and Non Residential Investment and Private Savings*

response of ouput to a spending shock are found in Blanchard and Perotti (2002) , Fatas and Mihov (2001) and Caldara and Kamps (2008). Furthermore, the effects of the spending shock on output in Blanchard and Perotti (2002) are milder than in Fatas and Mihov (2001) because of the observed large and significant crowding-out effect on investment; in fact, as in Blanchard and Perotti (2002) and in Mountford and Uhlig (2005) , in my analysis, the response of investment and its components are significantly negative and persistent. In the VAR, the crowding-out impact on investment and its components (about -2.0%) are even larger than in the FAVAR model. In fact, in the Factor Augmented analysis, the peak responses of Private domestic investment, Non-Residential investment and Residential investment are respectively -1.25% after six quarters,-1.14% after ten quarters and -1.77% after sixteen quarters (Figure 3.4). Such a significant crowding-out effect on investment could retrieve a Keynesian effect, but the mechanism operating through the interest rate is not verified in my empirical findings.

Actually, as previously observed in Mountford and Uhlig (2005) and Fragetta and Gaisteger (2014), the effect on the 3-month T-bill rate is negative in both the VAR and the FAVAR models. The impact on the interest rate is negative, but not

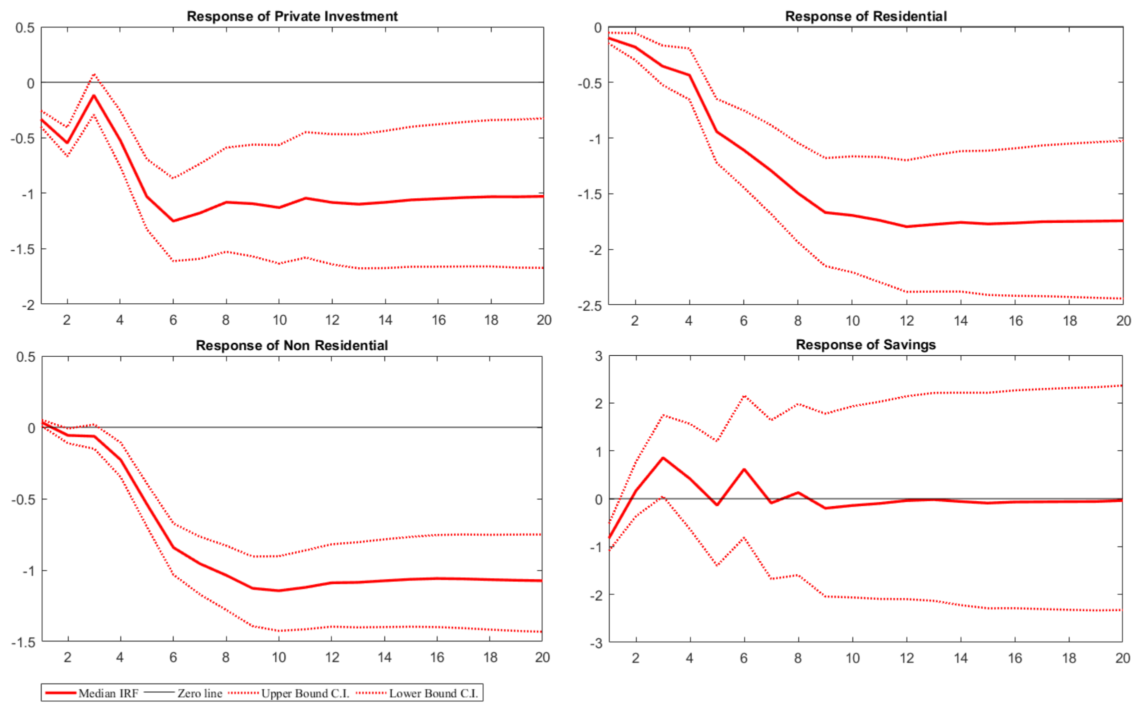

Figure 3.4: *FAVAR - Accumulated IRFs for Private, Residential and Non Residential Investment and Private Savings*

strongly significant in the models during the first four quarters (about -0.06%). In the VAR, savings respond negatively for the first two quarters and positively between two and five quarters, then they oscillates around zero (Figure 3.3). In the FAVAR, the effect on savings resembles the one found in the VAR with the difference that the positive impact across all the time-span is stronger (Figure 3.4).

As anticipated, the main difference regarding the results lies in the response of the inflation rate. In the VAR, the impact on the inflation rate ranges from being not significantly negative (-0.02% on average) in the Baseline model, as reported in Figure 3.1, to not significantly positive (0.025% on average between ten and twenty quarters in the specification with $x_t = NonResidential_t$) as showed in Figure 3.5. Conversely, across all the FAVAR specifications, the response of the inflation rate is significant and negative (on average -0.15%) as found in Fatas and Mihov (2001) and in Mountford and Uhlig (2005) for what concerns the GDP implicit price deflator (Figure 3.2) . For what concerns market labour variables, it is found a significant increase in the real wage (about 0.4%) in both the models. The response of real wages is in line with the empirical findings in Caldara and Kamps (2008). The response of manufacturing hours worked per week is negative in the

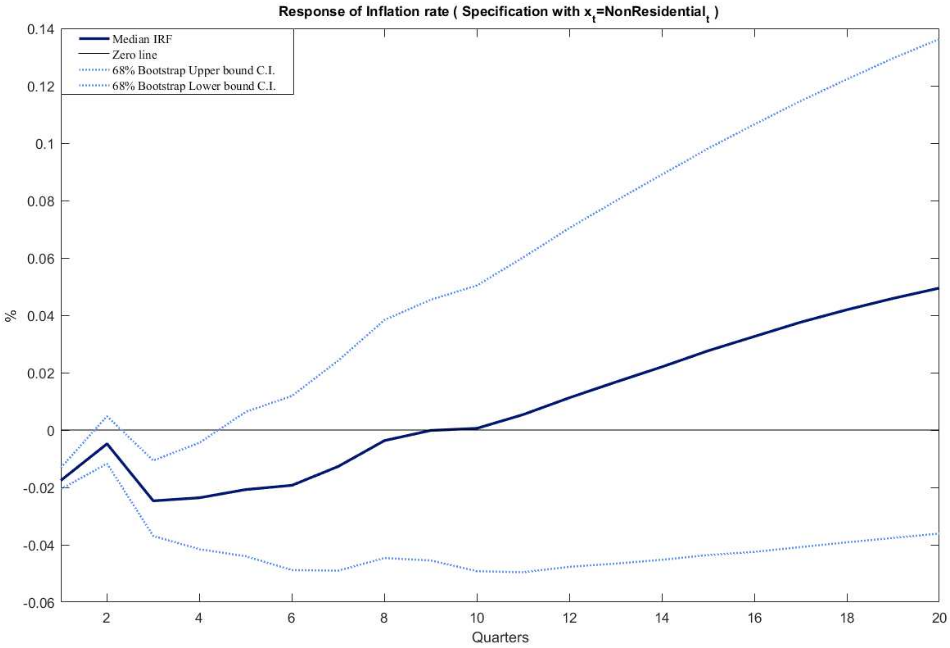

Figure 3.5: *VAR (specification with $x_t = NonResidential_t$) - Response of Inflation Rate*

VAR and not significantly negative in the FAVAR. The negative and not significant response of hours is found also in Fragetta and Gaisteger (2014). The effect of an increase in spending on consumption is positive in both the models. In the VAR, private consumption peaks at 0.14% after four quarters. In the FAVAR, the impact on private consumption is positive and more persistent than in the VAR model (Figure 3.9). Moreover, in the VAR, the response of Durable consumption is slightly negative, while, in the FAVAR, the effect on Durable consumption is positive and persistent (0.2% on average). Furthermore, the impact on Non Durable consumption is positive in both the models even though, in the FAVAR, the response is stronger and more persistent. For what concerns Services consumption, in both the models, the impact is positive and quantitatively similar. The positive effect on consumption is a feature across most of the empirical research on the effects of Government spending. The empirical findings supporting the evidence observed in this paper are found in Blanchard and Perotti (2002), Fatas and Mihov (2001) and Caldara and Kamps (2008) among others. In Fatas and Mihov (2001), the positive impact on consumption is defined as not in line with Neoclassical theory.

Moreover, it is actually interesting to study whether the considered disturbance in the *purified spending shock* could be regarded as a primary source of business

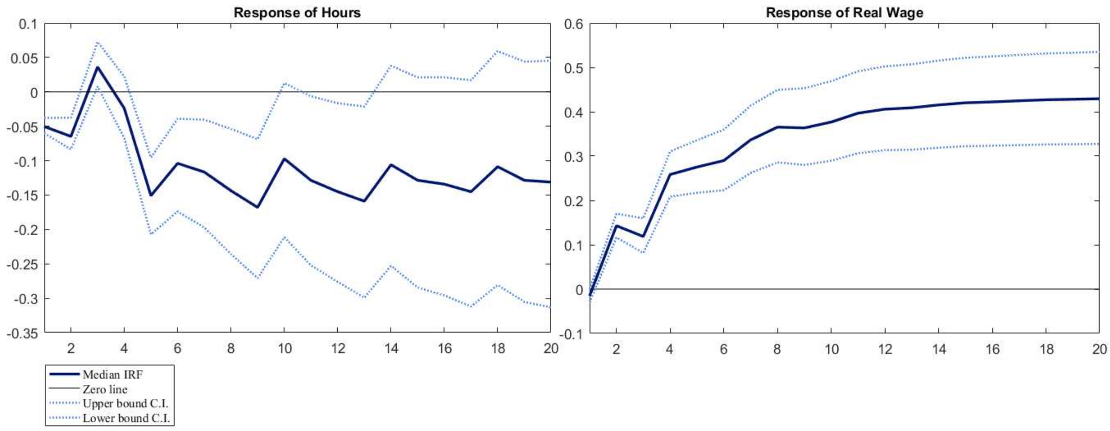

Figure 3.6: *VAR - Accumulated IRFs for Market Labour variables*

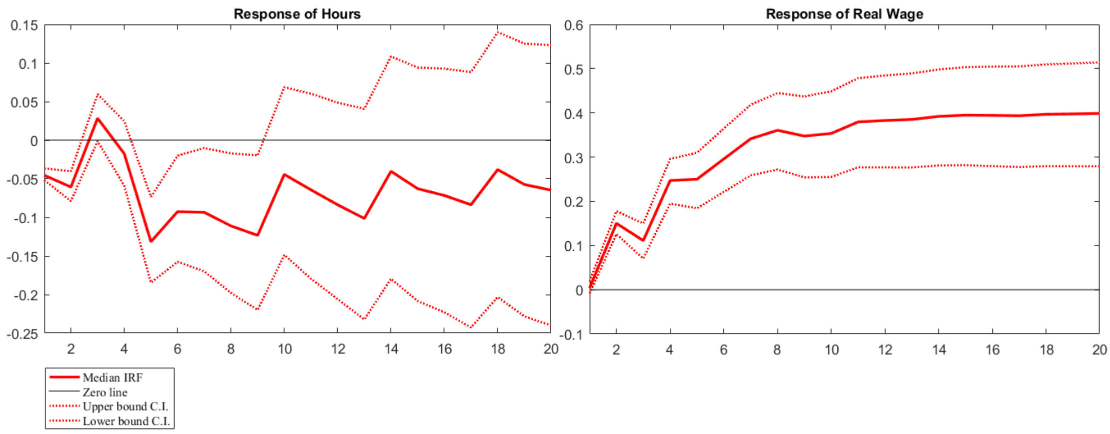

Figure 3.7: *FAVAR - Accumulated IRFs for Market Labour variables*

cycle fluctuations or not. According to the relevant theory and empirical findings, fiscal policy shocks are not primary source of business cycle fluctuations. In fact, as expected, the forecast error variance decomposition[30] (or FEVD) of output to a *purified spending shock* is approximately equal to 6.7% at the *business cycle frequencies*[31] in the VAR. In the Baseline FAVAR model, the forecast error variance decomposition of output to a *purified spending shock* is approximately equal to 5.6%. Therefore, it is possible to conclude that such spending shock is not a primary source of business cycle fluctuations. Another component of the so-called *Structural Analysis* is the historical decomposition[32] (or HD), which is useful to further investigate the contribution of the *purified spending shock* to the variation

[30]The forecast error variance decomposition evaluates the contribution of the structural shock to the h-steps ahead forecast error variance of the considered variable.

[31]From 8 to 32 quarters.

[32]The aim of historical decomposition is at decomposing the series in order to obtain the contribution of the identified structural disturbance to the selected variable across the time span

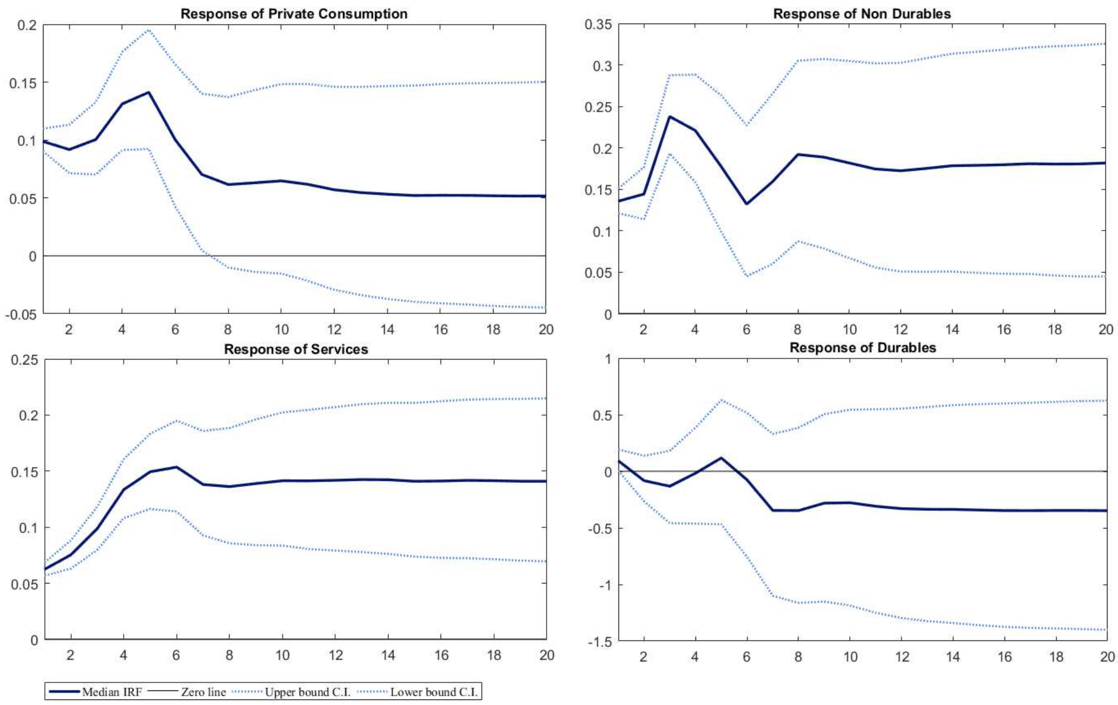

Figure 3.8: *VAR - Accumulated IRFs for Private, Durables, Non-Durables and Services Consumption*

of output from its trend. As expected, in the FAVAR model, the HD of output to the identified shock shows that the spending disturbance accounts for approximately 0.5% of the deviation of output from its trend.
Moreover, it is interesting to analyse the forecast error variance decomposition of Government spending to a *purified spending shock*. Such analysis could unmistakably prove that the built variable conveying *fiscal news* accounts for a great portion in the variability of Government spending. In fact, in the Baseline FAVAR, the FEVD of Government spending to a *purified spending shock* is equal to 65% at the *business cycle frequencies*. The results for the FEVD and the HD are reported in the *Appendix*.

It seemed interesting to repeat the Baseline Model analysis on a different sample in order to gauge the sturdiness of the obtained results. For instance, one could object that the inclusion of the Great Recession timeline (2007-2009) could have led to biased estimates. The main concern is to analyse whether the different response of the inflation rate in the FAVAR is effectively due to *informational insufficiency* of the VAR or, rather, affected by the presence of the downturn of the Economic

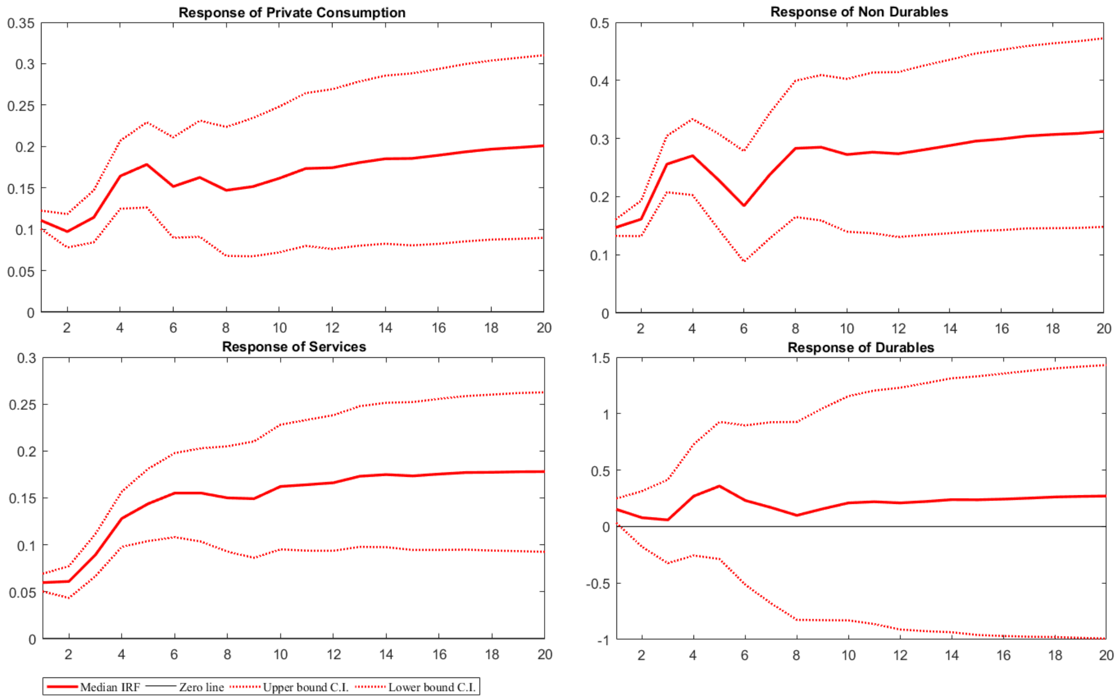

Figure 3.9: *FAVAR - Accumulated IRFs for Private, Durables, Non-Durables and Services Consumption*

Crisis within the data. In fact, the Great Recession led to a slowdown in price developments. Thence, the VAR and FAVAR Baseline model analysis on the time span $1955 : Q1 - 2006 : Q4$ is implemented with the same features as described in Chapter 2. In this case, the difference between the responses of the inflation rate is even more noticeable. The IRFs for this *robustness check* are reported in the *Appendix*.

3.3 Economic Interpretation

Even though the greatest part of macroeconomic models predict an expansionary impact on output following an increase in Government spending, the effects of such a policy on consumption is controversial among competing theories. For instance, the textbook IS-LM model and the standard RBC model astonishingly differ in assessing the effects of spending increase on consumption. In fact, the IS-LM model underlines that an increase in spending should lead to an increase in consumption that, *ceteris paribus*, amplifies the effects on output. Furthermore, in the textbook IS-LM model, a rise in Government spending leads to an upward pressure on the interest rate that yields a crowding-out effect on investment. On the contrary, the standard RBC model clearly shows that an expansion in Government spending must lead to a *negative wealth effect* and, so, to a decline in consumption. The main reason behind this theoretical difference relies on the behaviour of consumers. In the IS-LM models, the consumers behave in a *Non-Ricardian* fashion: the consumption decisions are based on the current disposable income. Conversely, the RBC model is characterized by infinitely-lived households and their consumption decisions are established on an intertemporal budget constraint at any point in time. Thence, an expansion in Government spending reduces the consumers' net present value of disposable income and this *negative wealth effect* unmistakably leads to a fall in consumption. In fact, in the RBC model, consumers are assumed to behave in a *Ricardian* fashion. On the empirical evidence side, a rise in Government spending clearly induces an increase in consumption. The positive effect on consumption is found in Blanchard and Perotti (2002) and in Fatas and Mihov (2001). For what concerns investment, the effect is ambiguous: in Blanchard and Perotti (2002), the impact on investment is negative and significant, while it is overall insignificant in Fatas and Mihov (2001). Moreover, in Mountford and Uhlig (2005), it is found a negative and significant response of both Residential and Non-Residential investment without a decrease in consumption. It is important to remark that, in my empirical findings, the effects on consumption and investment are respectively positive and negative.

Surprisingly, the response of the real wage[33] is pivotal in order to understand the underlying mechanisms that lead to an increase in consumption and to a fall in investment. Lastly, as stated in Fatas and Mihov (2001), the response of private consumption is even stronger when government wage expenditure increases and, as it will be consistently explained in the following subsections, this feature will help to assess also the negative impact on investment for what concerns the firms perspective.

3.3.1 Consumption

In the RBC model built in Fatas and Mihov (2001), the rise in Government spending leads to a fall in the net present value of the after-tax income; the latter *negative wealth effect* induces the infinitely-lived households to decrease consumption. The fall in consumption drives an increase in the quantity of labour supplied at any given

[33]In this paper, the real wage is measured as the real compensation per hour in the Non-Farm Business sector as in Fatas and Mihov (2001).

wage. The resultant on the labour market is an increase in employment that raises the expected return to capital and, so, to an increase in investment. As anticipated, in the empirical analysis of Fatas and Mihov (2001), this theoretical causal chain is not confirmed. Therefore, the *Ricardian* behaviour of all the consumers that should lead to a fall in consumption has no strong evidence in the empirical findings. In fact, as outlined in Galì et al. (2007), there exists a fraction of consumers who do not behave in a *Ricardian* fashion: the *rule-of-thumb* consumers. This category of consumers do not borrow or save and they base their consumption decisions only on their disposable income. The presence of the *rule-of-thumb* consumers is supported by the evidence that a substantial portion of households have near-zero net worth and by the extant proof of failure in smoothing consumption with respect to income fluctuations (e.g., Wolff (1998) and Campbell and Mankiw (1989)) . Thence, Mankiw (2000) claimed for the introduction of the *rule-of-thumb* consumers within macroeconomic models given that their presence considerably changes the evaluation of policies. The presence of the *rule-of-thumb* consumers actually insulates a significant share of aggregate consumption from being eroded by the *negative wealth effect*, which is caused by the future increase in taxes needed to finance the fiscal expansion, while making the consumption decisions largely sensitive to current labour income. The interpretations of this *Non-Ricardian* consumption behaviour could rely on *myopia*, lack of access to capital markets, ignorance of intertemporal trading opportunities and *fear* of saving.

It is important to report the main features of the Galì (2007) New-Keynesian model in order to deeply understand the previously reported empirical findings on consumption. In Galì et al. (2007), it is built a standard New-Keynesian dynamic stochastic general equilibrium model with staggered price setting *à la* Calvo that explicitly allows for the presence of *Non-Ricardian* consumers. The economy is described by two types of households, a perfectly competitive final goods firm, a continuum of monopolistically competitive firms producing differentiated intermediate goods, a fiscal authority and a central bank. The main assumption regarding consumers is that there exist two types of a continuum of infinitely-lived households: a fraction λ of households can access to capital markets in order to trade securities and sell or buy physical capital that could be accumulated or rented out to firms; thence, they represent the *Ricardian* households with intertemporal optimizing consumption behaviour. A portion $(1-\lambda)$ of households behave in a *Non-Ricardian* way,

namely they are the *rule-of-thumb* ones[34]. The *rule-of-thumb* consumers are financially excluded or, problably, subject to persistent binding borrowing constraints; thence, they are unable of smoothing consumption with respect to variations in labour income and unfit of intertemporally substituting in the face of fluctuations in the interest rates.
The monopolistically competitive firms are assumed to follow a staggered price setting, namely conforming to the Calvo (1983) stochastic time dependent rule. Any firm could adjust its price with probability equal to $(1-\theta)$ at any period regardless the time elapsed since the previous resetting. Therefore, each period, a portion θ of firms does not reset its price, namely the prices are unaltered, while a fraction $(1-\theta)$ does. Lastly, the central bank sets the interest rate according to a special case of the lionized Taylor rule, in which the coefficient attached to the output gap is zero and the coefficient assigned to the inflation rate is grater than one.

In order to assess the positive effect on consumption of an exogenous increase in Government spending, the main features of the above-described New-Keynesian DSGE model are the presence of the *rule-of-thumb* consumers and nominal rigidities. In fact, although the marginal product of labour falls, the assumption of sticky prices allows real wage to rise given that the price mark-up could decrease adequately in order to more than compensate the plunging marginal product of labour. The upward pressure on the real wage yields a rise in the current labour income and, thus, it arouses consumption of the *rule-of-thumb* households[35]. Thence, the presence of the *Non-Ricardian* consumption behaviour and nominal rigidities are needed in order to explain the latter intuition and to obtain the desired procyclical response of consumption following an increase in Government expenditure. In the face of the previously described empirical findings, the New-Keynesian DSGE model *à la* Galì et al. (2007) provides a clear explanation of the reason behind the observed positive and persistent effect of a spending shock on consumption. Indeed, the increase of consumption and its components is in line with the theoretical prediction (Figure 3.9) and the positive impact on real wage is positive and persistent as expected (Figure 3.7). Furthermore, as outlined in Galì et al. (2007) and as observed in Figure 3.2 for what concerns Government receipts, the increase in labour income is even stronger in case the spending shock is deficit-financed so that the procyclical

[34]Note that the two subsets of households represent the whole set of households extant in the economy.

[35]In Galì et al. (2007), note that the fraction $(1-\lambda)$ of *rule-of-thumb* consumers is estimated to be equal to 1/2 according to the findings of Mankiw (2000).

effect on consumption is persistent. Moreover, as expected, the positive effect on Non-Durable consumption is the leading component of such an expansionary path of private consumption (Figure 3.9). As a further proof of the theoretical model, as previously reported, the empirical effect on savings is oscillatory so that it would prove the presence of a significant fraction of households who do not borrow or save, but they actually consume their wage (Figure 3.4).

3.3.2 Investment

In the previously described empirical findings, the effect of an exogenous spending increase leads to a decrease in the inflation rate[36], which yields a fall in the 3-month T-bill rate according to a Taylor rule based behaviour of the central bank. Thence, the standard Keynesian effect of a downward pressure on investment following an expansion in Government expenditure has no sound proof in the previously described empirical findings. Furthermore, the negative effect on investment and interest rate are observed also in Fragetta and Gaisteger (2014); in the latter paper, the explanation provided to support the empirical evidence of a fall in investment is based on the increase of the BAA Corporate bond yield. Since it would have been a likely interpretation of the crowding-out effect on investment in a standard Keynesian way, I decided to include the BAA rate both in the VAR and in the Factor augmented analysis. Unfortunately, the rise in the BAA rate proved to be insignificant so that it could not provide a consistent reason supporting the observed significant crowding-out effect on investment (Figure 3.10).

Thus, at least on the firms perspective, it is needed an interpretation established on the analysis of the *Non-Keynesian* effect of a Government spending increase. Moreover, neither the standard RBC models could provide a sturdy explanation of a fall in private investment following a rise in Government spending. In fact, in the Neoclassical theoretical framework, a positive shock on Government expenditure should depress consumption and lead to an increase in the quantity of labour supplied at any given wage; consequently, it follows an increase in employment and a rise in the expected return to capital, which yields an upward pressure on private

[36] As observed in Fatas and Mihov (2001) and in Mountford and Uhlig (2005), the surprising negative response of GDP price deflator (in our case, the inflation rate based on the GDP implicit price deflator) will be analysed in the following subsection. It is noteworthy to say that an explanation for such unexpected response of prices is not consistently provided in neither of the mentioned empirical researches.

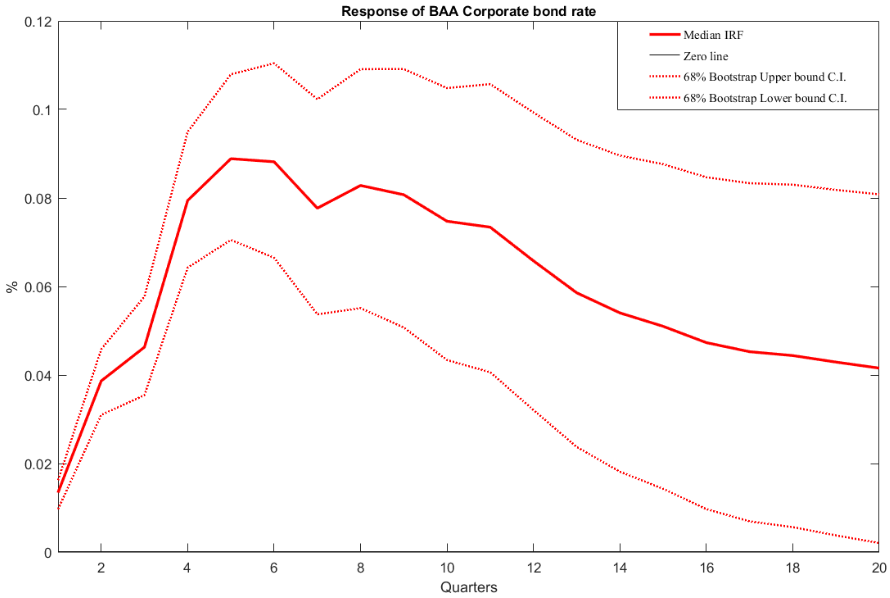

Figure 3.10: *FAVAR - Response of BAA Corporate bond rate*

investment.

The negative response of private investment has at least two consistent explanations: firstly, on the households perspective, the deficit-financed spending increase leads to a rise in public debt and, thus, any saving accumulated by the households should finance the latter liability. Secondly, the spending increase leads to an increase in government wage that yields an upward pressure on real wage; hence, the resultant is an increase in the capital to labour ratio that negatively affects the net marginal product of capital and, so, investment.

In order to gauge the first explanation of the crowding-out effect on investment, it is crucial to include both in the VAR and in the Factor augmented analysis a measure of the end-of-period total public debt. Unfortunately, due to unavailabilty of data before $1966 : Q1$, the empirical study is repeated on the subsample $1966 : Q1 - 2015 : Q4$ with the same features described in Chapter 2. Not surprisingly, the results previously obtained for the larger sample are confirmed[37]. As expected, an exogenous deficit-financed spending increase leads to a persistent rise in public debt (Figure 3.11). Therefore, on the households perspective, the signif-

[37]Indeed, it is possible to interpret the described analysis as a *robustness check*.

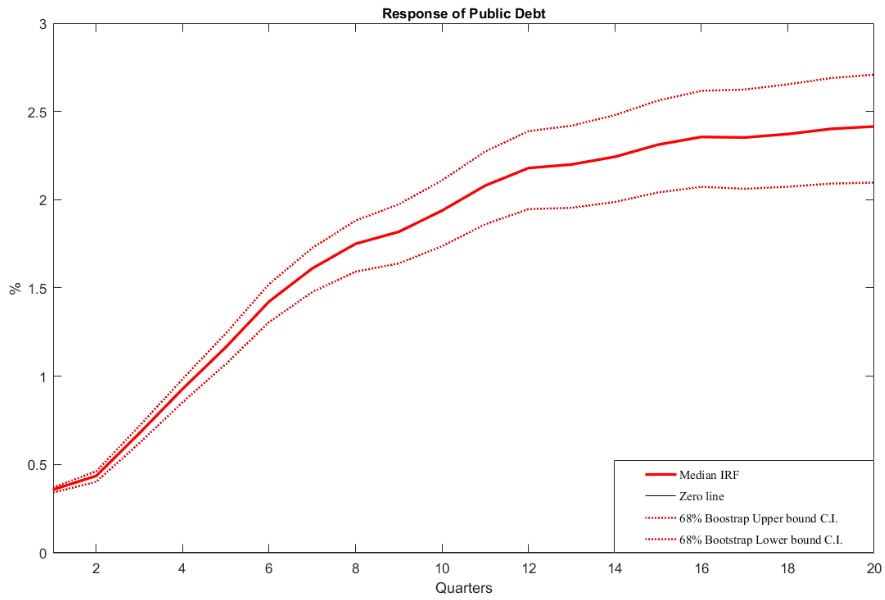

Figure 3.11: *FAVAR - Response of Public Debt*

icant crowding-out effect on investment (Figure 3.4) is caused by the increase in public debt. Moreover, recalling the New-Keynesian model described in the previous subsection, the fraction of *Ricardian* households devote any saving to the financing of the rising public debt; it is true that, as previously claimed, the response of saving is ambiguous, but, in the FAVAR, the positive response is stronger than in the VAR. Therefore, it is possible to conclude that the aforementioned causal relationship yields a decrease in the investment components.

On the firms perspective, a lively literature strand has pointed out the *Non-Keynesian* effects of fiscal expansions. As brilliantly studied in Alesina et al. (2002), fiscal expansions proved to crowd-out investment through the profit channel both in a theoretical and in an empirical framework for what concerns OECD countries. As claimed in Fatas and Mihov (2001), the latter study should deserve a deeper analysis for the US. Since, in the previously analysed empirical findings, the crowding-out effect on investment of an expansion in Government expenditure has no standard Keynesian interpretation, the research of Alesina et al. (2002) would help to better understand the causal relationship between a rise in spending and a fall in private investment. Moreover, in Alesina et al. (2002), it is emphasized the labour market

effect of fiscal policy through which a rise in spending leads to plunging investments more than what a tax hike would cause.
Besides nominal rigidities, the persistent rise in real wage should be also caused by the increase in the Government wage and transfer components. In fact, a raise in Government wage expenditure puts upward pressure on the real wage demanded by Unions. Such feature of Government spending influences the reservation utility of being unemployed by firms because of the alternative of public employment, but also because of the transfer programs and the unemployment subsidies. Therefore, the so-generated increase in real wages decreases total hours worked given that the income effect is small compared to the substitution effect (Figure 3.7)[38]. Furthermore, the rise in real wage increases the capital to labour ratio. Hence, the expansion in the capital to labour ratio leads to a fall in the net marginal product of capital. Indeed, the net marginal product of capital is decreasing in the capital to labour ratio dimension and also a function of the investment rate. Consecutively, the investment rate is a function of the shadow value of capital that is dependent upon the expected present value of the net marginal product of capital. Therefore, the lionized increase in the real wage depresses both the shadow value of capital and the net current marginal product of capital so that investment unmistakably falls (Figure 3.4).

3.3.3 The inflation rate *puzzle*

The insignificant response of the inflation rate across the VAR specifications would be consistent with the assumption of staggered price setting *à la* Calvo that supports the response of consumption. Conversely, the additional information spanned by the introduction of the Factors leads to a more surprising result: a significant and negative response of the inflation rate. Since the identified structural shock in the VAR is *non-fundamental*, the true response of the inflation rate must be regarded as the one found in the FAVAR analysis. The Factors included in the analysis represent the structure of the economy capturing the comovements among the variables contained in the large informational dataset and, thus, the inflation rate as a forward looking variable is obviously influenced by these *Principal Components*.

Considering the endogenous growth model of Barro (1990), the effects of an increase in the productive component of Government spending should boost economic

[38] As already pointed out, the negative impact on hours is not strongly significant.

growth and also private investment. Therefore, in the previously discussed empirical findings, the Government spending increase is regarded as a *leaky bucket* by the economic agents[39]. The rise in Government spending is indeed perceived as a waste of resources and, thus, it fails to sustain the economy in the long-run. Actually, the fact that deficit and public debt both increase unmistakably depresses the expectations of the economic agents. The latter effect is captured by the *Principal Components* included in the FAVAR that transmit through the inflation rate the information of the unsustainability of the fiscal expansion[40].

By observational enquiry, the IRFs of the inflation rate and the second Factor seem to comove. In fact, the correlation between the aforementioned functions is equal to 0.7546. Thence, it is interesting to underline some features of the second unobserved Factor. As discussed in Chapter 2, PCA is carried on a large informational dataset containing the characterizing series of the US economy. The *Principal Components* are equal to SW, where S stands for the standardized version of the dataset and W is the matrix of the eigenvectors. Interpreting the elements in W as *weights* attached to each series in the dataset, it is possible to find a pattern through the large dataset that could be useful to shed some light on the second *Principal Component*. As expected, the coefficients attached to the price series are positive and the highest in value[41]. Thence, it is possible to infer that the inflation rate is influenced by this Factor, which contains the price series as means of capturing the expectations of economic agents. Furthermore, as previously implemented on the complete set of endogenous variables and the selected Factors, I verify whether the second Factor Granger causes the inflation rate so that the information set contained in the unobserved Factor spans the information set included in the inflation rate. As

[39] As Martin Feldstein claimed for what concerns the current size of Federal spending in the USA, deadweight losses caused by fiscal expansions *"may exceed one dollar per dollar of revenue raised, making the cost of incremental governmental spending more than two dollars for each dollar of government spending"*

[40] As already pointed out, fiscal policy shocks are not primary sources of business cycle fluctuations and, thus, they cannot sustain the economy beyond the short run.

[41] Keeping in mind that the squared sum of each column in W must be equal to one, the labels of the price series and the relative attached values of the elements of W_{j2} are the following: Consumer Price Index for All Urban Consumers: All Items (0.256), Consumer Price Index for All Urban Consumers: All Items less Energy (0.2527), Consumer Price Index for All Urban Consumers: All Items less Food and Energy (0.2371), Consumer Price Index for All Urban Consumers: Food (0.19), Consumer Price Index for All Urban Consumers: All Items less Food (0.24), Producer Price Index by commodity for finished goods: Capital equipment (0.22), Producer Price Index by commodity for finished consumer goods (0.193), Producer Price Index by commodity for finished goods (0.216), Unit Labour Cost (0.194), GDP: Chain-type Price Index (0.2629), GNP: Chain-type Price Index (0.263), GNP: Implicit Price Deflator (0.2599).

expected, the univariate Granger Cause test (F-test) with maximum lag equal to 20 and $\alpha = 0.05$ rejects the null-hypothesis that the second Factor does not Granger cause the inflation rate[42].

Even though the previous procedures do not stand for a consistent strategy to interpret the unobserved Factors, it is still possible to conclude that the inflation rate as a forward looking variable captures the expectations of the unsustainability of the fiscal expansion through the Factors channel and, thus, its response is negative. The latter mechanism could not be consistently exploited by the information set spanned by the VAR since the latter model fails to contain the complete information set detained by the economic agents.

It is remarkable to implement the FEVD on the inflation rate to further investigate the effect on price developments of a *purified spending shock*. As expected, in the FAVAR, the FEVD of the inflation rate to $g_{t|t-1}$ is approximately equal to 2% meaning that fiscal expansions are not primary sources of fluctuations in price developments. The latter finding should confirm the *information-conveying* nature of the inflation rate and the importance of including the information set spanned by the Factors. Looking at the historical decomposition of the inflation rate to the identified shock in the FAVAR, it is found that the *purified spending shock* makes little contribution to the deviation of the inflation rate from its trend[43].

[42] F-test Statistics (34.3477) $>$ Critical value (3.8817) with 233 degrees of freedom.
[43] Results of FEVD and HD of the inflation rate are reported in the *Appendix*

Conclusions

The aim of this work was twofold: *a)* amending the *informational insufficiency* of the Fiscal VAR models via both the study of the disturbance in the *purified spending shock* and the Factor augmented approach *à la* Bernanke et al. (2005); *b)* highlighting the dynamic effects of Government spending on key macroeconomic variables.

Even though the *purified spending shock* should convey the relevant information regarding the changes in Government expenditure, the implemented structural VAR approach led to biased estimates. Thence, including the estimated Factors in the analysis involved an enhancement of the information set so that the response of the inflation rate was dissimilar to the one found in the VAR estimation. In fact, the Factors as expectations transmitters affected the inflation rate that is by-definition an *information-conveying* variable. Therefore, the FAVAR estimation proved to be a solid alternative in order to study the effects of shocks that turned out to be *non-fundamental* in the VAR approach. Furthermore, the Factors enlarged the information set of the econometrician so that it is aligned with the information set of the economic agents.

As found out, the effect of a spending increase on consumption and its components is positive and persistent. The latter finding is in line with New-Keynesian Theory. Adopting the New-Keynesian DSGE Galì (2007) model with staggered price-setting *à la* Calvo as a benchmark, the causal link among *Non-Ricardian* consumers, nominal rigidities, raise in real wages and increase in private consumption is confirmed in the presented empirical findings. For what concerns investment, the empirically observed crowding-out effect on investment has no standard Keynesian explanation. Indeed, the fall in investment is not caused by an increase in the interest rate. Therefore, the significant increase in both deficit and public debt, on the households side, along with the decrease of the net marginal product of capital due to rising real wages (*Non-Keynesian* effect), on the firms side, implied a fall in private investment. In the FAVAR estimation, the negative response of the inflation rate is *puzzling*: the explanation provided relies on the assumption that the inflation rate conveys the information of the unsustainability of the fiscal expansion via the Factors, which transmit the expectations of the economic agents.

The natural refinement of this work would be the implementation of the FAVAR analysis interpreting the estimated Factors via rotation methods. In fact, it would be thrilling to open up the *black box* of the Factors in order to further analyse the *puzzling* dynamics of the inflation rate. As previously pointed out, Factors estimation via Principal Component Analysis requires the absence of unit roots amongst the series. It is clear that stationarity within the data leads to a loss of information; thus, as carried out in Banerjee et al. (2014), it would be interesting to implement the empirical analysis adopting a Factor Augmented Error Correction Model approach.

Bibliography

1. Alesina, Alberto, et al. *Fiscal policy, profits, and investment*, The American Economic Review 92.3 (2002): 571-589.

2. Alessi, Lucia, Matteo Barigozzi, and Marco Capasso. *A robust criterion for determining the number of static factors in approximate factor models*, European Central Bank 0903 (2008).

3. Auerbach, Alan J., and Yuriy Gorodnichenko. *Measuring the output responses to fiscal policy*, American Economic Journal: Economic Policy 4.2 (2012): 1-27.

4. Bai, Jushan. *Estimating cross-section common stochastic trends in nonstationary panel data*, Journal of Econometrics 122.1 (2004): 137-183.

5. Bai, Jushan, and Serena Ng. *Determining the number of factors in approximate factor models*, Econometrica 70.1 (2002): 191-221.

6. Bai, Jushan, and Serena Ng. *A PANIC attack on unit roots and cointegration.* Econometrica 72.4 (2004): 1127-1177.

7. Bai, Zhidong, Wing-Keung Wong, and Bingzhi Zhang. *Multivariate linear and nonlinear causality tests*, Mathematics and Computers in Simulation 81.1 (2010): 5-17.

8. Banerjee, Anindya, Massimiliano Marcellino, and Igor Masten. *Forecasting with factor-augmented error correction models*, International Journal of Forecasting 30.3 (2014): 589-612.

9. Barro, Robert J. *Government Spending in a Simple Model of Endogenous Growth*, The Journal of Political Economy 98.5 (1990): S103-S125.

10. Blanchard, Olivier, and Roberto Perotti. *An empirical characterization of the dynamic effects of changes in government spending and taxes on output.* The Quarterly Journal of Economics 117.4 (2002): 1329-1368.

11. Bernanke, B. S. J. Boivin and P. Eliasz. *Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) approach*, Quarterly Journal of Economics, Feb 387 (2005): 422.

12. Burnside, Craig, Martin Eichenbaum, and Jonas DM Fisher. *Fiscal shocks and their consequences.* Journal of Economic theory 115.1 (2004): 89-117.

13. Caldara, Dario, and Christophe Kamps. *What are the effects of fiscal policy shocks? A VAR-based comparative analysis.* European Central Bank 0877 (2008).

14. Calvo, Guillermo A. *Staggered prices in a utility-maximizing framework*, Journal of monetary Economics 12.3 (1983): 383-398.

15. Campbell, John Y., and N. Gregory Mankiw. *Consumption,Income, and Interest Rates: Reinterpreting the Time Series Evidence*, NBER Macroeconomics Annual 1989.4 (1989): 185-216.

16. Centoni, Marco, and Gianluca Cubadda. *Modelling comovements of economic time series: a selective survey*, Statistica 71.2 (2011): 267-294.

17. Edelberg, Wendy, Martin Eichenbaum, and Jonas DM Fisher. *Understanding the effects of a shock to government purchases.* Review of Economic Dynamics 2.1 (1999): 166-206.

18. Fatas, Antonio, and Ilian Mihov. *The effects of fiscal policy on consumption and employment: theory and evidence.* CEPR Discussion Papers 2760 (2001).

19. Favero, Carlo A., Massimiliano Marcellino, and Francesca Neglia. *Principal components at work: the empirical analysis of monetary policy with large data sets*, Journal of Applied Econometrics 20.5 (2005): 603-620.

20. Forni, Mario, and Luca Gambetti. *Fiscal foresight and the effects of goverment spending.* CEPR Discussion Papers 7840 (2010).

21. Forni, Mario, Luca Gambetti, and Luca Sala. *No news in business cycles*, CEPR Discussion Paper 8274 (2011).

22. Forni, Mario, and Luca Gambetti. *Sufficient information in structural VARs*, Journal of Monetary Economics 66 (2014): 124-136.

23. Forni, Mario, et al. *The generalized dynamic-factor model: Identification and estimation*, Review of Economics and statistics 82.4 (2000): 540-554.

24. Fragetta, Matteo, and Emanuel Gasteiger. *Fiscal Foresight, Limited Information and the Effects of Government Spending Shocks*, Oxford Bulletin of Economics and Statistics 76.5 (2014): 667-692.

25. Galì, Jordi, J. David Lòpez Salido, and Javier Vallès. *Understanding the effects of government spending on consumption*, Journal of the European Economic Association 5.1 (2007): 227-270.

26. Hamilton, James D. *Historical causes of postwar oil shocks and recessions.* The Energy Journal 6.1 (1985): 97-116.

27. Koop, Gary, and Dimitris Korobilis. *Bayesian Multivariate Time Series Methods for Empirical Macroeconomics*, Now Publishers Inc., Foundations and Trends in Econometrics 3.4 (2010): 267-358.

28. Koop, Gary, and Dimitris Korobilis. *UK macroeconomic forecasting with many predictors: Which models forecast best and when do they do so?*, Economic Modelling 28.5 (2011): 2307-2318.

29. Leeper, Eric M., Todd B. Walker, and Shu Chun Susan Yang. *Fiscal Foresight: Analystics and Econometrics.* NBER Working Papers 15188 (2008).

30. Lippi, Marco, and Lucrezia Reichlin. *The dynamic effects of aggregate demand and supply disturbances: Comment.* The American Economic Review 83.3 (1993): 644-652.

31. Lippi, Marco, and Lucrezia Reichlin. *VAR analysis, nonfundamental representations, Blaschke matrices.* Journal of Econometrics 63.1 (1994): 307-325.

32. Mankiw, N. Gregory. *The savers-spenders theory of fiscal policy.* American Economic Review 90.2 (2000): 120-125.

33. Mertens, Karel, and Morten O. Ravn. *Measuring the impact of fiscal policy in the face of anticipation: a structural VAR approach.* The Economic Journal 120.544 (2010): 393-413.

34. Mountford, Andrew, and Harald Uhlig. *What are the Effect of Fiscal Policy Shocks*, SFB Discussion Paper No. 2005-039 (2005).

35. Perotti, Roberto. *In search of the transmission mechanism of fiscal policy*, NBER Macroeconomics Annual 2007.22 (2007): 169 - 226

36. Ramey, Valerie A., and Matthew D. Shapiro. *Costly capital reallocation and the effects of government spending*, Carnegie-Rochester Conference Series on Public Policy. Vol. 48. North-Holland (1998).

37. Ramey, Valerie A. *Defense News Shocks, 1939-2008: Estimates Based on News Sources.* Unpublished paper, University of California, San Diego (2009).

38. Ramey, Valerie A. *Can government purchases stimulate the economy?*, Journal of Economic Literature 49.3 (2011a): 673-685.

39. Ramey, Valerie A. *Identifying Government Spending Shocks: It's All in the Timing.* The Quarterly Journal of Economics, 126.1 (2011b): 1-50.

40. Sims, Christopher A. *Macroeconomics and reality*, Econometrica: Journal of the Econometric Society (1980): 1-48.

41. Stock, James H., and Mark W. Watson. *Macroeconomic forecasting using diffusion indexes*, Journal of Business & Economic Statistics 20.2 (2002): 147-162.

42. Stock, James H., and Mark W. Watson. *Forecasting using principal components from a large number of predictors*, Journal of the American statistical association 97.460 (2002): 1167-1179.

43. Stock, James H., and Mark W. Watson. *Implications of dynamic factor models for VAR analysis.* NBER Working Papers 11467 (2005).

44. Stock, James H., and Mark W. Watson. *Dynamic factor models*, Oxford handbook of economic forecasting 1 (2011): 35-59.

45. Wolff, Eric N. *Recent Trends in the Size Distribution of Household Wealth.* Journal of Economic Perspectives 12 (1998):131-150.

Appendix A

Figures

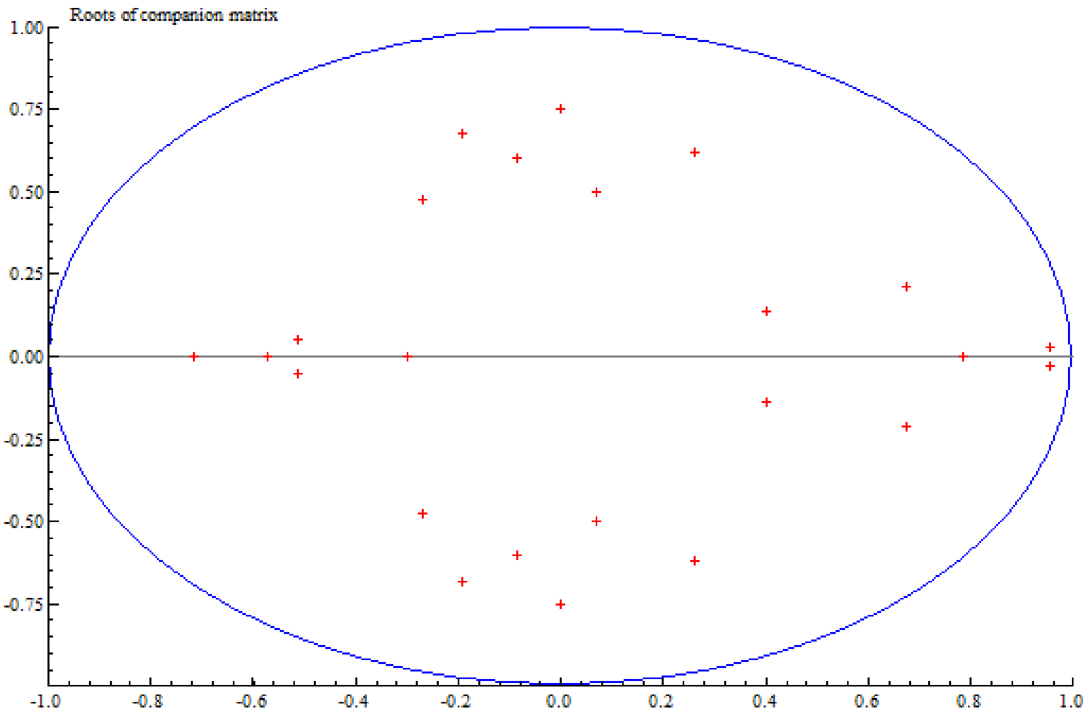

Figure A.1: *VAR Baseline Model - Companion Matrix Roots*

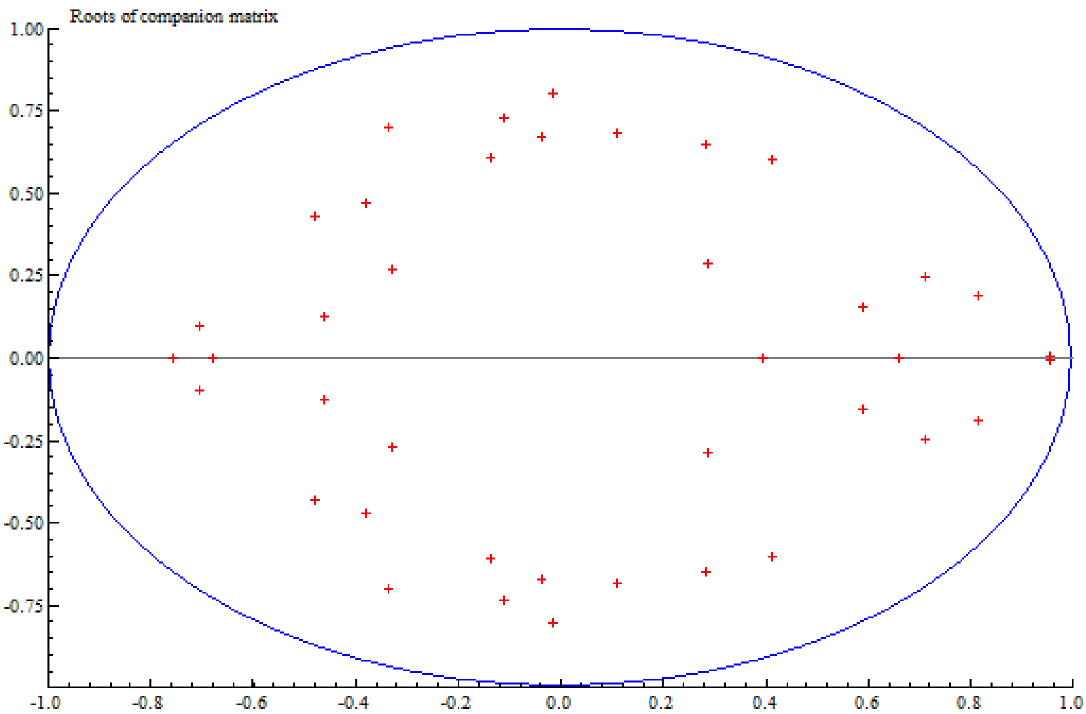

Figure A.2: *FAVAR Baseline Model - Companion Matrix Roots*

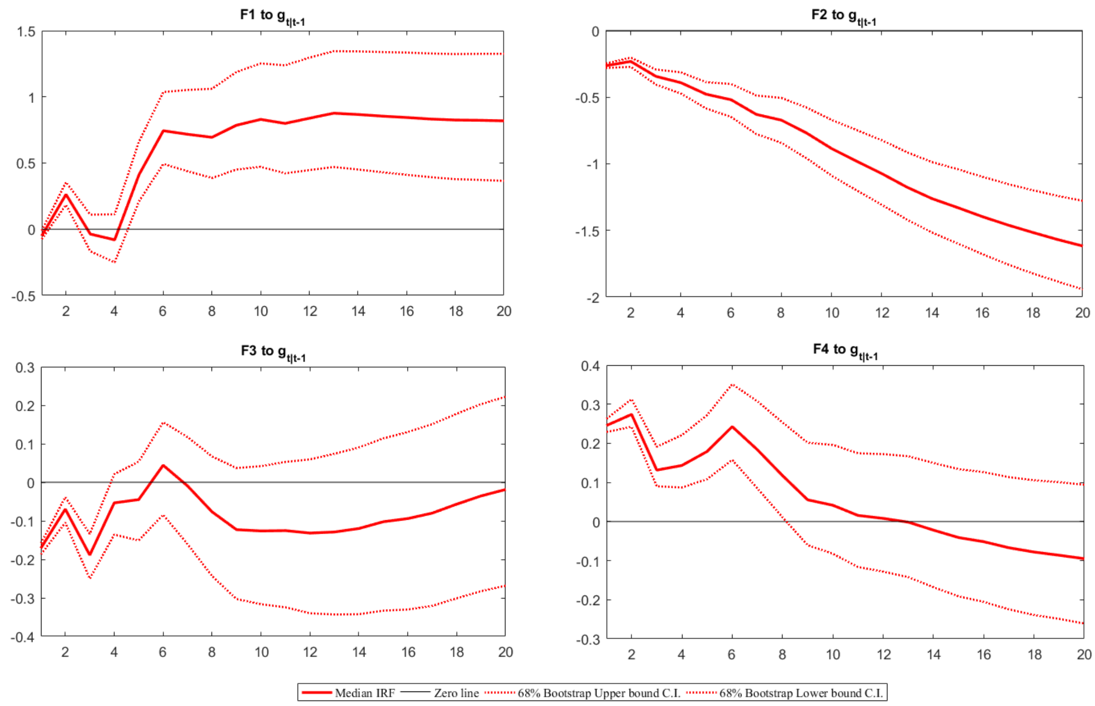

Figure A.3: *FAVAR - Accumulated IRFs for Factors (Baseline Model)*

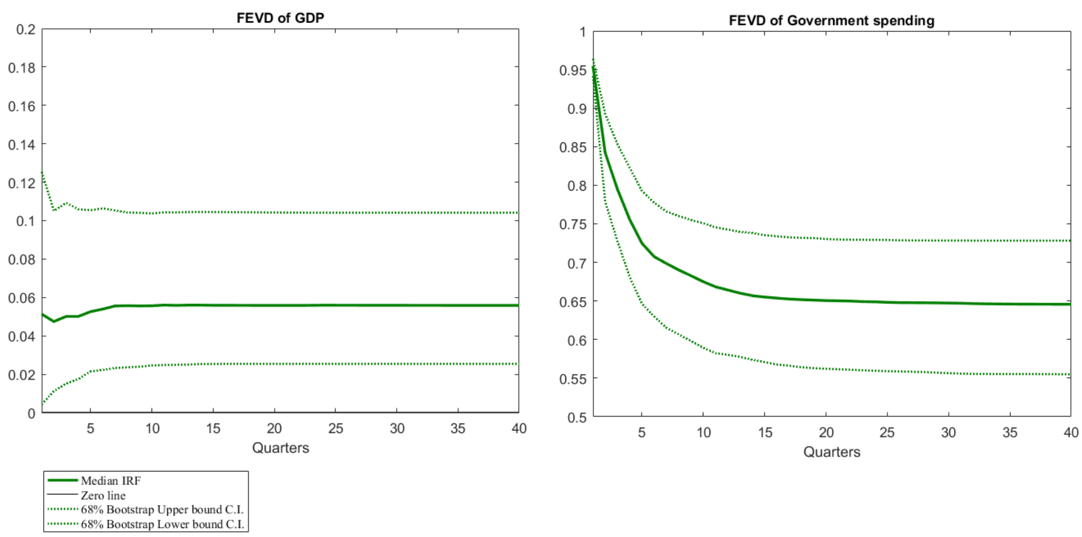

Figure A.4: *FAVAR - FEVD of GDP and Government spending*

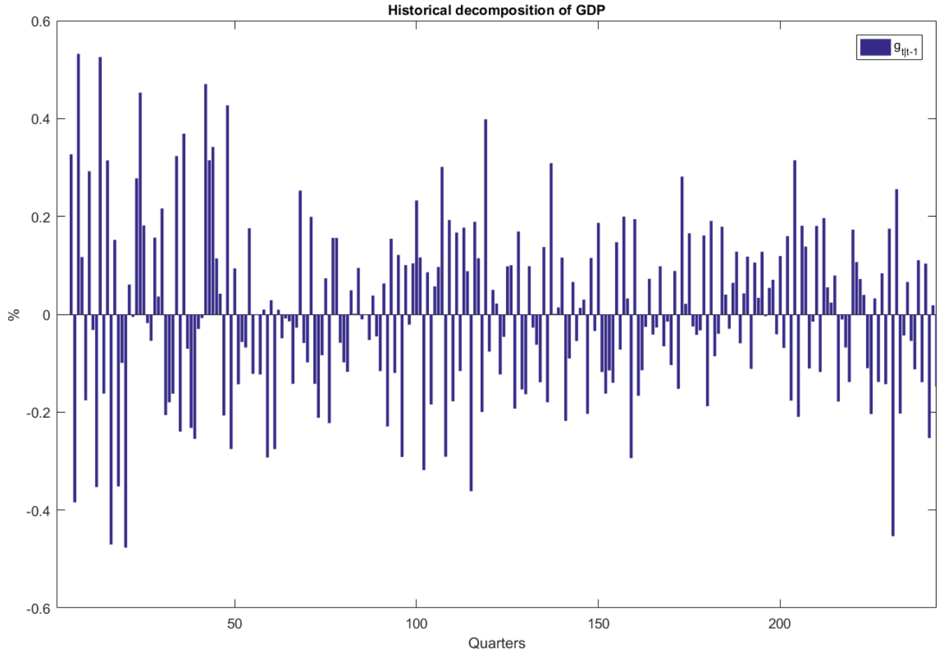

Figure A.5: *FAVAR - HD of GDP*

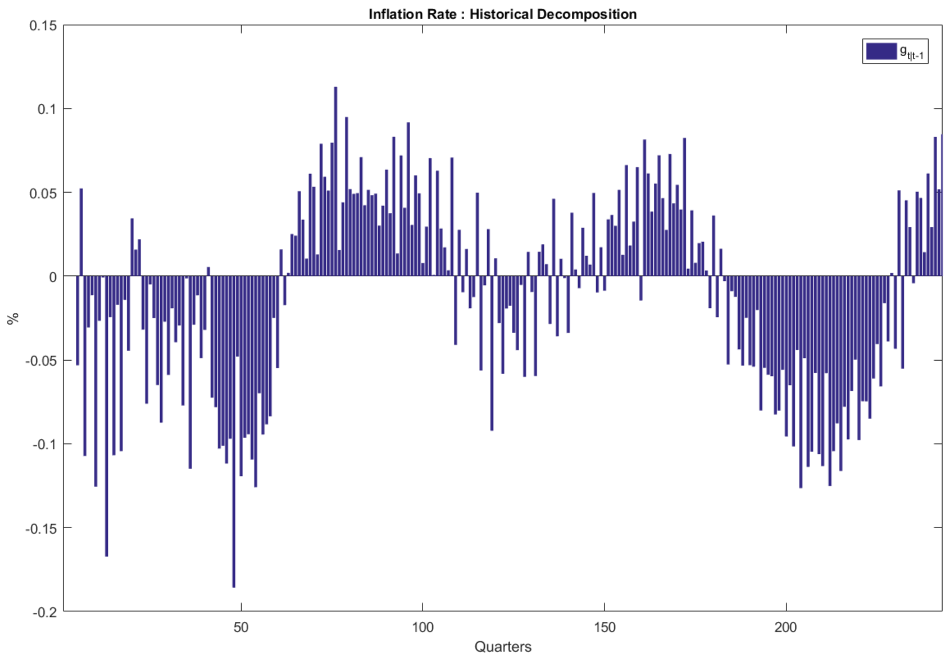

Figure A.6: *FAVAR - HD of Inflation Rate*

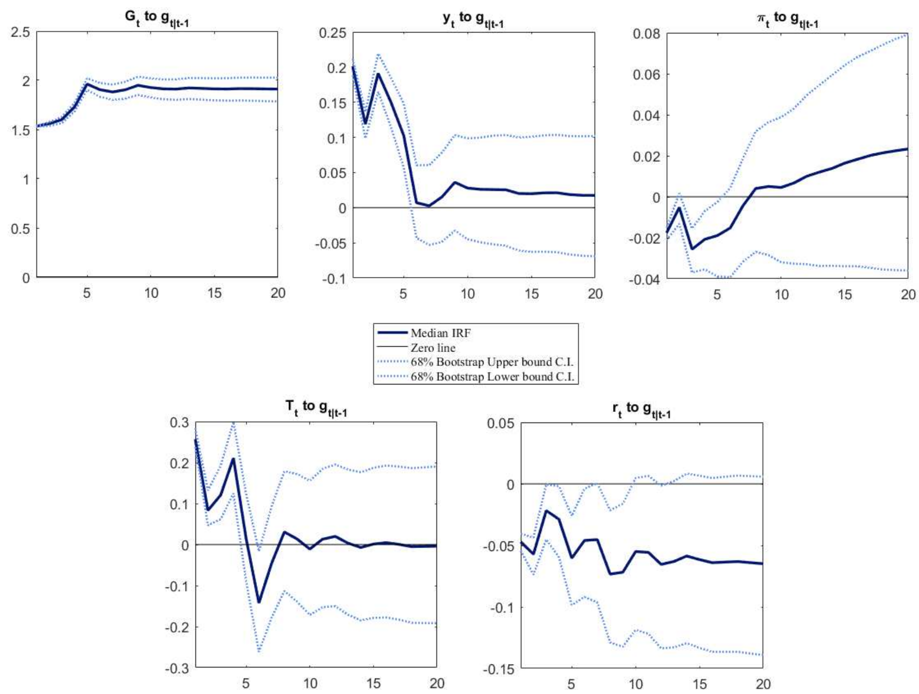

Figure A.7: *VAR - Accumulated IRFs Baseline Model (1955:Q1 - 2006:Q4)*

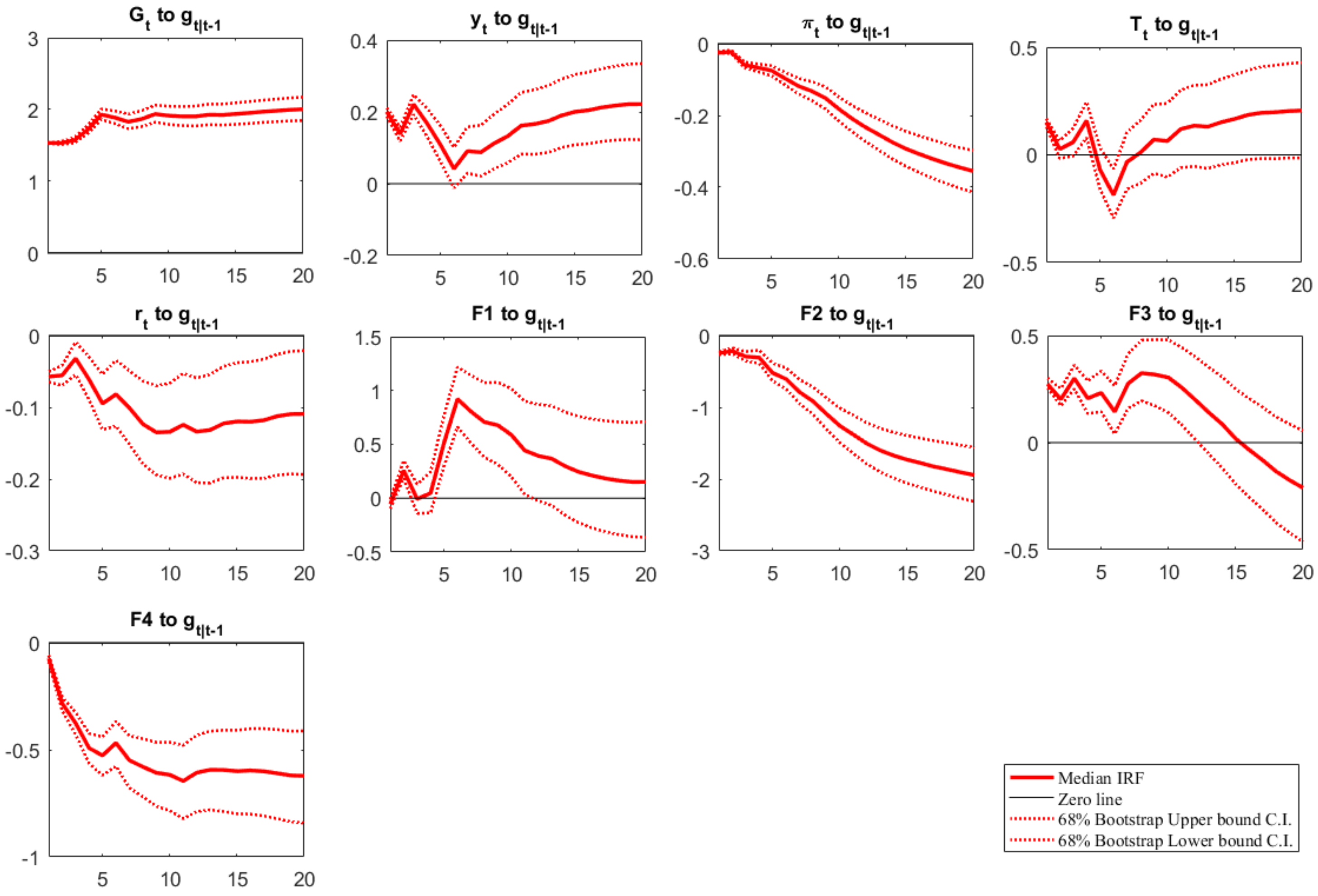

Figure A.8: *FAVAR - Accumulated IRFs Baseline Model (1955:Q1 - 2006:Q4)*

Appendix B

Tables

Table B.1: *Model selection of the Forecast for the growth rate of Government Spending*

p	***d***	**BIC**
0	0	1172.35574113678
0	1	1161.84958354684
0	2	1431.69495215539
0	3	1749.93550147385
1	0	1093.45032743954
1	1	1129.59223474552
1	2	1297.50847197491
1	3	1540.53438650466
2	0	1092.2258736465*
2	1	1129.84549186235
2	2	1252.40737925452
2	3	1448.39684314067
3	0	1097.79962810004
3	1	1131.85279686988
3	2	1226.32776005469
3	3	1374.13769622010
4	0	1103.27285093391
4	1	1136.26802063949
4	2	1225.44325709918
4	3	1355.24145041187
5	0	1107.63468338297
5	1	1129.87154027869
5	2	1212.18496721466
5	3	1324.95763448815

Note: In the table above, it is showed the column of the BIC values used for the selection of the correct autoregressive model specification for the Forecast of the growth rate of Government Spending. the p column displays the considered Lag orders and the d column displays the considered Integration orders. As discussed in subsection 2.1.2, I selected an $AR(2)$ model specification.

Table B.2: *Recursive Orthogonality Test*

			Principal Components					
			2	3	4	5	6	7
e_1		1	0.98	-	-	-	-	-
e_1		4	0.98	-	-	-	-	-
e_2		1	-	0.88	-	-	-	-
e_2		4	-	0.78	-	-	-	-
e_3		1	-	-	1.00 *	-	-	-
e_3	Lags	4	-	-	1.00 *	-	-	-
e_4		1	-	-	-	0.57	-	-
e_4		4	-	-	-	0.95	-	-
e_5		1	-	-	-	-	0.99	-
e_5		4	-	-	-	-	1.00	-
e_6		1	-	-	-	-	-	1.00
e_6		4	-	-	-	-	-	0.74

Note: In the table above, it is presented the matrix of the p-values obtained from the Recursive Orthogonality Test as described in subsection 2.2.3. The variables denoted by $e_j \, \forall j = 1...7$ stand for the identified structural shocks in the FAVAR models with j Factors (*Principal Components*). Remember that fitting the linear model and using an F-test procedure leads to the conclusion of orthogonality when the p-value is high. The closer the p-value is to one the more the evidence for orthogonality is stressed. Thence, I selected 4 *Principal Components* to be included in the FAVAR model.

Table B.3: *VAR - Accumulated IRFs for GDP, Inflation rate, Government Receipts, 3-month T-bill rate, Hours and Real wage*

Quarters	y_t to $g_{t\|t-1}$	π_t to $g_{t\|t-1}$	T_t to $g_{t\|t-1}$	r_t to $g_{t\|t-1}$	$Hours_t$ to $g_{t\|t-1}$	w_t to $g_{t\|t-1}$
1	0.213621	-0.01697	0.214523	-0.06712	-0.05038	-0.01272
2	0.15372	-0.0077	0.109753	-0.09551	-0.06476	0.140052
3	0.23408	-0.02731	0.067515	-0.06708	0.036203	0.116999
4	0.2092	-0.02872	0.215018	-0.07682	-0.02384	0.254762
5	0.16114	-0.02846	-0.08932	-0.1095	-0.15095	0.267848
6	0.096339	-0.03017	-0.18308	-0.10433	-0.10393	0.280904
7	0.08735	-0.02584	-0.17931	-0.10865	-0.11657	0.327437
8	0.082941	-0.01844	-0.1464	-0.13013	-0.14369	0.355803
9	0.089836	-0.01718	-0.21772	-0.13135	-0.16799	0.355224
10	0.08423	-0.01831	-0.25357	-0.12337	-0.09724	0.368088
11	0.076106	-0.01727	-0.2846	-0.12792	-0.12867	0.385185
12	0.072312	-0.0159	-0.30868	-0.13586	-0.1451	0.393253
13	0.072671	-0.01518	-0.33262	-0.13532	-0.15893	0.395637
14	0.070053	-0.01528	-0.33824	-0.13397	-0.10601	0.401317
15	0.069412	-0.01516	-0.34338	-0.13627	-0.12859	0.40495
16	0.069819	-0.01505	-0.34297	-0.13762	-0.13418	0.407798
17	0.070617	-0.01489	-0.3427	-0.13737	-0.14519	0.409912
18	0.07008	-0.01487	-0.34251	-0.13727	-0.1088	0.412218
19	0.069877	-0.01473	-0.34277	-0.13763	-0.1286	0.413365
20	0.070105	-0.01446	-0.34127	-0.13784	-0.13118	0.414599

Table B.4: *VAR - Accumulated IRFs for Private, Durable, Non Durable and Services consumption*

Quarters	C_t to $g_{t\|t-1}$	$Durables_t$ to $g_{t\|t-1}$	$NonDurables_t$ to $g_{t\|t-1}$	$Services_t$ to $g_{t\|t-1}$
1	0.098845	0.092711	0.135729	0.062391
2	0.09178	-0.08295	0.144264	0.075387
3	0.100459	-0.13242	0.237807	0.098853
4	0.131225	-0.01701	0.220897	0.133503
5	0.141204	0.117444	0.177851	0.149408
6	0.100191	-0.07617	0.132095	0.153537
7	0.070297	-0.34644	0.158971	0.138046
8	0.061561	-0.34736	0.191978	0.13618
9	0.063066	-0.28158	0.188815	0.138907
10	0.064748	-0.27824	0.181731	0.141402
11	0.061748	-0.30942	0.17459	0.141293
12	0.05707	-0.3303	0.172346	0.141813
13	0.05465	-0.33582	0.175195	0.142468
14	0.053232	-0.33677	0.178418	0.142294
15	0.052109	-0.34231	0.178945	0.140917
16	0.052278	-0.34738	0.179638	0.141146
17	0.052226	-0.34792	0.180819	0.141727
18	0.051856	-0.34651	0.180435	0.14144
19	0.051632	-0.3467	0.180576	0.140976
20	0.051736	-0.34831	0.181737	0.140934

Table B.5: *VAR - Accumulated IRFs for Private, Residential and Non Residential investment, Savings and BAA Corporate bond rate*

Quarters	I_t to $g_{t\|t-1}$	Res_t to $g_{t\|t-1}$	$NonRes_t$ to $g_{t\|t-1}$	S_t to $g_{t\|t-1}$	BAA to $g_{t\|t-1}$
1	-0.32571	-0.20471	0.06536	-1.32526	0.018424
2	-0.78479	-0.32373	-0.0527	-0.38286	0.045587
3	-0.48456	-0.40773	-0.09906	0.502551	0.062224
4	-0.93339	-0.53946	-0.27692	0.206266	0.093596
5	-1.46373	-0.99675	-0.61295	-0.36732	0.105149
6	-1.71775	-1.29589	-0.89603	0.493077	0.106271
7	-1.83736	-1.61039	-1.08728	0.129921	0.107859
8	-1.81846	-1.78486	-1.1899	0.144282	0.118029
9	-1.80971	-1.89853	-1.26283	-0.13956	0.118749
10	-1.87986	-1.97125	-1.27984	-0.02436	0.122237
11	-1.92647	-2.0567	-1.28156	-0.05978	0.122255
12	-1.98062	-2.11284	-1.26688	0.012057	0.121197
13	-1.99633	-2.13433	-1.25037	-0.03035	0.120577
14	-2.0027	-2.13846	-1.23147	-0.0242	0.121447
15	-2.01085	-2.14078	-1.21636	-0.03794	0.121664
16	-2.0127	-2.13218	-1.20355	-0.02839	0.121275
17	-2.01557	-2.12395	-1.19474	-0.03839	0.121565
18	-2.02271	-2.12078	-1.19215	-0.03398	0.12181
19	-2.02774	-2.12161	-1.19413	-0.03093	0.121761
20	-2.02867	-2.12169	-1.19705	-0.02939	0.121508

Table B.6: *FAVAR - Accumulated IRFs for GDP, Inflation rate, Government Receipts, 3-month T-bill rate, Hours and Real wage*

Quarters	y_t to $g_{t\|t-1}$	π_t to $g_{t\|t-1}$	T_t to $g_{t\|t-1}$	r_t to $g_{t\|t-1}$	$Hours_t$ to $g_{t\|t-1}$	w_t to $g_{t\|t-1}$
1	0.192837	-0.0283	0.155294	-0.07419	-0.04546	0.003743
2	0.140926	-0.01805	0.083096	-0.09739	-0.06072	0.15011
3	0.230498	-0.04698	0.093146	-0.07227	0.02836	0.111108
4	0.212086	-0.05839	0.255789	-0.08674	-0.01749	0.247023
5	0.157619	-0.0649	-0.05293	-0.11256	-0.13156	0.249848
6	0.110974	-0.08066	-0.15005	-0.103	-0.0926	0.295815
7	0.139655	-0.09432	-0.09881	-0.10142	-0.09348	0.341312
8	0.1435	-0.0987	-0.08125	-0.11997	-0.11108	0.360559
9	0.149964	-0.10509	-0.14354	-0.14083	-0.12334	0.347441
10	0.152331	-0.12121	-0.19786	-0.13704	-0.04438	0.353378
11	0.166773	-0.13644	-0.19399	-0.1282	-0.06433	0.379437
12	0.162126	-0.14876	-0.21342	-0.14009	-0.08372	0.382687
13	0.164477	-0.1625	-0.24189	-0.14246	-0.10141	0.384998
14	0.172724	-0.17622	-0.23145	-0.13675	-0.0403	0.391982
15	0.177609	-0.18633	-0.21728	-0.13846	-0.06288	0.39479
16	0.182665	-0.19716	-0.21367	-0.14143	-0.07164	0.394231
17	0.189427	-0.20729	-0.20759	-0.13932	-0.08369	0.393424
18	0.193955	-0.21627	-0.19732	-0.13658	-0.03813	0.396686
19	0.196649	-0.22458	-0.19384	-0.13603	-0.05741	0.397538
20	0.199113	-0.23289	-0.18885	-0.1356	-0.0647	0.398689

Table B.7: *FAVAR - Accumulated IRFs for Private, Durable, Non Durable and Services consumption*

Quarters	C_t to $g_{t\|t-1}$	$Durables_t$ to $g_{t\|t-1}$	$NonDurables_t$ to $g_{t\|t-1}$	$Services_t$ to $g_{t\|t-1}$
1	0.110673	0.15257	0.146749	0.059769
2	0.09713	0.078237	0.161163	0.061008
3	0.114297	0.059061	0.255771	0.089281
4	0.164223	0.269146	0.270313	0.128126
5	0.1782	0.358566	0.228995	0.143843
6	0.151591	0.230946	0.184102	0.155155
7	0.162517	0.168387	0.237705	0.155147
8	0.146995	0.099133	0.282971	0.150007
9	0.151471	0.156802	0.284935	0.14919
10	0.161477	0.209389	0.272363	0.162173
11	0.173301	0.219426	0.276385	0.164059
12	0.174268	0.209248	0.27371	0.166135
13	0.18039	0.221676	0.28062	0.173106
14	0.185053	0.238292	0.287861	0.174824
15	0.185471	0.236996	0.295379	0.17344
16	0.18924	0.243012	0.299018	0.175405
17	0.193352	0.251546	0.304156	0.177034
18	0.196682	0.261867	0.306773	0.177274
19	0.198626	0.267072	0.308652	0.177853
20	0.200834	0.270332	0.312044	0.178031

Table B.8: *FAVAR - Accumulated IRFs for Private, Residential and Non Residential investment, Savings and BAA Corporate bond rate*

Quarters	I_t to $g_{t\|t-1}$	Res_t to $g_{t\|t-1}$	$NonRes_t$ to $g_{t\|t-1}$	S_t to $g_{t\|t-1}$	BAA to $g_{t\|t-1}$
1	-0.333	-0.10045	0.034582	-0.82632	0.013429
2	-0.54817	-0.18256	-0.0567	0.166198	0.038656
3	-0.11666	-0.35352	-0.06308	0.856888	0.046293
4	-0.52372	-0.43558	-0.22813	0.415252	0.079427
5	-1.03066	-0.94173	-0.54095	-0.13679	0.088867
6	-1.25138	-1.10787	-0.84195	0.618652	0.088171
7	-1.17886	-1.29179	-0.95476	-0.08977	0.077686
8	-1.08166	-1.496	-1.03583	0.128238	0.082817
9	-1.09444	-1.66874	-1.12726	-0.19935	0.080724
10	-1.12974	-1.69483	-1.14427	-0.14185	0.074737
11	-1.04473	-1.73904	-1.121	-0.09944	0.073397
12	-1.08363	-1.79642	-1.0887	-0.03933	0.06579
13	-1.09893	-1.77632	-1.08585	-0.01934	0.058576
14	-1.08212	-1.7577	-1.07451	-0.05895	0.05403
15	-1.05995	-1.77171	-1.06428	-0.09091	0.051001
16	-1.04977	-1.76342	-1.05867	-0.06898	0.04731
17	-1.03884	-1.75166	-1.06116	-0.06476	0.045267
18	-1.03173	-1.74926	-1.06667	-0.0611	0.044389
19	-1.03225	-1.74662	-1.07098	-0.05879	0.042916
20	-1.02841	-1.74352	-1.07414	-0.03693	0.041557

Table B.9: *FAVAR - FEVD of Government Spending, Output and Inflation Rate to* $g_{t|t-1}$ *(%)*

Quarters	G_t *to* $g_t \mid t-1$	y_t *to* $g_t \mid t-1$	π_t *to* $g_t \mid t-1$
1	95.48	5.13	1.29
2	84.21	4.74	1.4
3	79.48	5.01	2.12
4	75.55	5.01	2.12
5	72.47	5.26	2.01
6	70.74	5.39	2.16
7	69.85	5.56	2.13
8	**69.02**	**5.57**	**2.18**
9	**68.27**	**5.56**	**2.19**
10	**67.5**	**5.56**	**2.24**
11	**66.84**	**5.6**	**2.31**
12	**66.42**	**5.58**	**2.32**
13	**66.02**	**5.6**	**2.33**
14	**65.69**	**5.6**	**2.33**
15	**65.51**	**5.59**	**2.33**
16	**65.38**	**5.59**	**2.35**
17	**65.26**	**5.59**	**2.37**
18	**65.17**	**5.59**	**2.41**
19	**65.12**	**5.58**	**2.43**
20	**65.06**	**5.58**	**2.49**
21	**65.03**	**5.58**	**2.48**
22	**64.99**	**5.58**	**2.49**
23	**64.92**	**5.59**	**2.5**
24	**64.89**	**5.59**	**2.49**
25	**64.83**	**5.59**	**2.51**
26	**64.79**	**5.59**	**2.52**
27	**64.78**	**5.59**	**2.53**
28	**64.77**	**5.59**	**2.54**
29	**64.76**	**5.59**	**2.54**
30	**64.74**	**5.59**	**2.55**
31	**64.71**	**5.59**	**2.55**
32	**64.67**	**5.59**	**2.55**
33	64.63	5.59	2.56
34	64.62	5.59	2.56
35	64.6	5.58	2.56
36	64.59	5.58	2.56
37	64.59	5.58	2.56
38	64.58	5.58	2.56
39	64.58	5.58	2.56
40	64.58	5.58	2.56

Table B.10: *Variance explained - Principal Component Analysis*

Principal Components n°	*Variance explained*	*Principal Components n°*	*Variance explained*
1	0.248471	40	0.0024065
2	0.161109	41	0.0023178
3	0.072451	42	0.0022735
4	0.051003	43	0.0020911
5	0.043007	44	0.0018962
6	0.03894	45	0.0017035
7	0.03535	46	0.0016581
8	0.025689	47	0.0015265
9	0.024941	48	0.0014953
10	0.023233	49	0.001218
11	0.019448	50	0.0011273
12	0.017943	51	0.0009538
13	0.016754	52	0.0009131
14	0.015711	53	0.000792
15	0.015342	54	0.0007266
16	0.013602	55	0.0006079
17	0.013302	56	0.000468
18	0.013008	57	0.000411
19	0.011272	58	0.0003853
20	0.010107	59	0.0003803
21	0.009751	60	0.0003147
22	0.008582	61	0.0002555
23	0.007992	62	0.0002039
24	0.007665	63	0.0001847
25	0.00692	64	0.000164
26	0.006635	65	0.0001387
27	0.00604	66	0.000116
28	0.005571	67	0.0001138
29	0.005407	68	0.00009
30	0.005104	69	0.00008
31	0.004863	70	0.00006
32	0.00459	71	0.00004
33	0.004302	72	0.00003
34	0.003736	73	0.00002
35	0.003574	74	0.00002
36	0.003053	75	0.000002
37	0.003002	76	0.00000004
38	0.00272	77	0.00000003
39	0.002628		

Table B.11: *Large Dataset*

LARGE DATASET		
n°	*Label*	*Source*
1	AAA Corporate Bond Rate	FRED
2	Average Weekly Hours of Production and Nonsupervisory Employees: Manufacturing	FRED
3	Average Weekly Overtime Hours of Production and Nonsupervisory Employees: Manufacturing	FRED
4	BAA Corporate Bond Rate	FRED
5	Commercial and Industrial Loans, All Commercial Banks	FRED
6	Change in Real Private Inventories	FRED
7	Civilian Employment Level	FRED
8	Civilian Labor Force Participation Rate	FRED
9	Civilian Labor Force	FRED
10	Corporate Net Cash Flow with IVA	FRED
11	Nonfarm Business Sector: Compensation Per Hour	FRED
12	Nonfarm Business Sector: Real Compensation Per Hour	FRED
13	Corporate Profits After Tax (without IVA and CCAdj)	FRED
14	Consumer Price Index for All Urban Consumers: All Items	FRED
15	Consumer Price Index for All Urban Consumers: All Items Less Energy	FRED
16	Consumer Price Index for All Urban Consumers: All Items Less Food and Energy	FRED
17	Consumer Price Index for All Urban Consumers: Food	FRED
18	Consumer Price Index for All Urban Consumers: All Items Less Food	FRED
19	Real Disposable Personal Income	FRED
20	Real Exports of Goods and Services	FRED

21	Effective Federal Funds Rate	FRED
22	Real Final Sales of Domestic Product	FRED
23	Gross Domestic Product: Chain-type Price Index	FRED
24	Real Gross National Product	FRED
25	Gross National Product: Chain-type Price Index	FRED
26	Gross National Product: Implicit Price Deflator	BEA
27	Real Gross Private Domestic Investment	BEA
28	1-Year Treasury Constant Maturity Rate	FRED
29	10-Year Treasury Constant Maturity Rate	FRED
30	Gross Saving	BEA
31	Nonfarm Business Sector: Hours of All Persons	FRED
32	Real imports of goods and services	FRED
33	Housing Starts: Total: New Privately Owned Housing Units Started	FRED
34	Industrial Production Index	FRED
35	Industrial Production: Business Equipment	FRED
36	Industrial Production: Consumer Goods	FRED
37	Industrial Production: Durable Consumer Goods	FRED
38	Industrial Production: Final Products (Market Group)	FRED
39	Industrial Production: Materials	FRED
40	Industrial Production: Nondurable Consumer Goods	FRED
41	Bank Credit at All Commercial Banks	FRED
42	Unemployment Rate: Aged 15-64: All persons for the US	FRED
43	M1 Money Stock	FRED
44	M2 Less Small Time Deposits	FRED

45	M2 Money Stock	FRED
46	Bank Prime Loan Rate	FRED
47	Nonfinancial Corporate Business: Profits After Tax (without IVA and CCAdj)	FRED
48	National Income	BEA
49	Nonfarm Business Sector: Real Output Per Hour of All Persons	FRED
50	Nonfarm Business Sector: Real Output	FRED
51	Producer Price Index by Commodity for Finished Goods: Capital Equipment (DISCONTINUED)	FRED
52	Producer Price Index by Commodity for Finished Consumer Goods (DISCONTINUED)	FRED
53	Producer Price Index by Commodity for Finished Goods (DISCONTINUED)	FRED
54	Real Estate Loans, All Commercial Banks	FRED
55	All Employees: Service-Providing Industries	FRED
56	Total Consumer Credit Owned and Securitized, Outstanding	FRED
57	Average (Mean) Duration of Unemployment	FRED
58	Nonfarm Business Sector: Unit Labor Cost	FRED
59	Nonfarm Business Sector: Unit Nonlabor Payments	FRED
60	Civilian Unemployment Rate	FRED
61	All Employees: Goods-Producing Industries	FRED
62	All Employees: Total Private Industries	FRED
63	Compensation of Employees: Wages and Salary Accruals	FRED
64	Dow Jones Industrials share price index	Datastream
65	Dow Jones Industrials	Datastream
66	Dow Jones Composite 65 Stock Ave	Datastream
67	Dow Jones Utilities Price Index	Datastream
68	Standard & Poor 500	Datastream

69	WTI - Oil spot Price	Datastream
70	Fed Gov Curr Receipts	BEA
71	Fed Gov curr exp	BEA