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Master's Thesis

The Dynamic Effects of Fiscal Policy : A FAVAR Approach

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Abstract

In this paper, we implement a recently developed econometric model, the Factor Augmented VAR (FAVAR), to investigate the dynamic effects of government spending on key macroeconomic variables. In line with existing literature, we find that a government spending shock has positive effects on consumption and output. By splitting the sample in a pre- and post- Volcker period, we find that the positive effects of government spending on consumption and output over the whole sample are largely due to the first part of the sample.

1 Introduction

In the aftermath of the subprime crisis, there has been a heated debate in the United States about whether the Government should engage in a fiscal stimulus or not. The main argument supporting a fiscal stimulus is that since private demand has collapsed, public demand has to take over. This argument gains a lot more traction if we consider the fact that there was no room for monetary policy intervention since the Fed Funds rate had already hit the "zero lower bound". The Government typically has two means at its disposal to achieve a fiscal stimulus: either it lowers taxes, either it increases spending. A traditional keynesian economist would suggest an increase in public spending in order to boost demand. This will only work if the implied multiplier on real GDP is higher than 1. The idea is that the increase in demand will induce firms to anticipate more demand, thus investing more, which will, in turn, increase the output. Employment will also rise, which will further boost demand. In fact, the keynesian multiplier relies on a virtuous circle. On the other hand, the neo-classical economist would suggest neither, since both the increase in government spending as well as the reduction in the tax rates will imply higher taxes in the future. This induces a negative wealth effect for the agents, which will offset the initial effect coming from the fiscal stimulus. In this case, Ricardian equivalence holds and the fiscal stimulus has not the same effects: the government spending multiplier for consumption is negative for standard assumptions; the government spending multiplier for output is typically less than one. Depending on the assumptions (about preferences, stance of monetary policy *etc.*), the government spending multiplier for output can be greater or smaller than one. To get a positive effect on consumption, we need specific assumption such as the presence of "Rule of Thumb consumers" as in Galí et al. (2004).

Now when the government official has to take his decision, he cannot rely solely on theoretical predictions. What he really needs is empirical estimations of the effects this policy might incur. Similarly to the recent events, this has been a problem after the "Internet Bubble" bursted. The same questions came up, and when the government looked for empirical estimation of the effects of fiscal policies, there was none. In fact, this is a subject that has not been much explored since the collapse of the keynesian theory in the late 70's. Following the Lucas critique, the only stabilization policy that spurred interest was monetary policy. The first recent paper to investigate such questions is Blanchard & Perotti (2002). In this paper, they estimate a VAR model with taxes, public spending and GDP. They achieve identification by using institutionnal data for the short-run transmission of fiscal policies (imposing short-run restrictions coming from lags of implementation for example). They find results that comfort old keynesian theories, namely a positive multiplier on consumption and output, but a crowding-out effect on investment. Since then, other papers —surveyed by Perotti (2007)—have been written to investigate the fiscal policy multipliers and thus compare neoclassical and new keynesian theories by focusing on wage and labour supply in addition.

Two methods have been employed to estimate the effects of a fiscal policy shock. The first one consists in generating a dummy for each exogeneous and unforeseen public spending build-up (typically the Korean War, the Vietnam war and the Carter-Reagan build-up). It has been pioneered by Ramey & Shapiro (1998). By analysing the effects of changing the dummy from zero to one, they find that consumption decreases on impact. This provides support for the neoclassical theory. The second one makes use of restrictions relating the structural shocks to the matrix of the innovations. This is the method used by Blanchard & Perotti (2002). In this line of work, we can also mention Perotti (2005). In this paper, he analyses the effects of fiscal shocks on macroeconomic variables in OECD countries. The main results are that there is no evidence that tax shocks work better than spending shocks and that the macroeconomic effects of fiscal policy have tended to fade away in the post-1979 period when compared to the pre-1979 one (yielding even negative responses for GDP and investment to a spending shock). The method of shock identification is the same as in Blanchard & Perotti (2002). Others papers have used this method, but identifying the structural shocks in an other way. In Fatás & Mihov (2001), they estimate a semi-structural VAR, which means that they only identify the structural shocks on spending, leaving aside its relationship with innovations for taxes and the other variables of the VAR. This is done using a standard Cholesky decomposition. They find that fiscal policy shocks induce strong and persistent increases in consumption and employment. Another route has been taken by Mountford & Uhlig (2009) to identify the structural shocks. In this paper, they consider sign restrictions; this amounts to imposing, for example, that the monetary policy shock has a positive effect on the 3-Month T-Bill rate (to distinguish it from monetary policy shock), on government and Federal expenditure etc.. Comparing three different scenarios for the fiscal shock, they find that deficit-financed tax cut is the most effective one.

Those methods are nevertheless subject to some pitfalls. For example, as pointed in Fatás & Mihov (2001) and Perotti (2007), the fiscal policy shock can be anticipated. If this is the case, the identification of the structural fiscal policy shock is likely to be contaminated[1]. Furthermore, those studies share the unavoidable default of the VAR approach, which imposes a limited amount of variables in the autoregressive vector. In fact, the number of coefficient to estimate is proportional to n^2 for a vector containing n variables. This renders the estimation of the effects of fiscal policy shocks on more than 6 or 7 variables hazardous since we cannot estimate the underlying coefficients with enough precision . Finally, if we want to track the effects of fiscal policy shocks on say, output, we cannot be sure that this variable will be perfectly measured by GDP.

In this paper, we will try to overcome those pitfalls using an empirical

[1]In fact, as it is shown in Forni & Gambetti (2010), when we consider contemporaneous forecast of government spending, the estimated government spending shock obtained using identification *à la* Blanchard & Perotti (2002) is not orthogonal to those forecasts. This means that the government spending shock can be predicted. It cannot then be considered as a true strucural shock

technique thas has been developed by Bernanke et al. (2005), namely Factor-Augmented VAR. This builds on the method of static factor models developped by Chamberlain & Rothschild (1983) and Chamberlain (1983). In this framework, if we think of the variables X_{it} as answers from an ability test, $i \in \{1 \ldots N\}$ will be the number of the question and $t \in \{1 \ldots T\}$ will be the individual taking the test. Those variables are composed of two components : the common factors (reading ability, writing ability etc.) and the idiosyncratic component, which can be correlated accross individuals. This has been extended to the dynamic framework —*i.e* where X_{it} will represent the macroeconomic aggregate i at time t —by Forni et al. (2000), Forni et al. (2009), Stock & Watson (2002), Stock & Watson (2005) and Bai & Ng (2002). Here, the assumption for the idiosyncratic errors is that the variance-covariance matrix will not be diagonal. The basic idea is to exploit a large set of data (*i.e* with large T and large N) and extract latent factors that are assumed to drive the dynamic co-movments of the series. Formally, this is done by extracting factors (by Principal Component Analysis, or by Maximum Likelihood through the Kalman Filter) and keeping those which explain the main part of the variance in the dataset. When combined with VAR analysis, this gives the Bernanke et al. (2005) Factor-Augmented (FAVAR) method. This method has many advantages over the "simple" VAR one. First of all, it permits to treat more information, without having to estimate a great number of coefficients. Then, it allows for the computation of the Impulse Response Functions (IRFs) of the variables that are not explicitely in the autoregressive vector through the factor loadings. Instead of focusing on GDP, we can extract latent factors from a dataset containing variables for real activity (capacity utilization, output gap, GDP etc.) and treat it as a generated regressor. Finally, since the VAR model is nested in the FAVAR one, it is possible to assess the marginal contribution of the estimated factors by comparing the decomposition of the forecast error variances.

The use of this technique can be further motivated by taking into account the problem of fundamentalness. This latter echoes the one of predictability of the estimated structural fiscal policy shocks. If the estimated shock is predicted, then the MA representation of the VAR might not be fundamental. Mathematically, this means that the modulus of the roots of the polynomial MA matrix determinant lie inside the unit circle. This implies that the variables do not have a VAR representation in the structural shocks, which renders the VAR approach not suited since it does not treat enough information. Some techniques have been used to deal with this issue, among which the use of Blaschke matrices and the structural factor method. In fact, because it consists in a tall system, the structural factor approach is immune to the fundamentalness problem. We will return to this issue later in section 2. This motivates further the use of structural factor (and thus, FAVAR) to analyse the multipliers of fiscal policy. This has recently been done by Forni & Gambetti (2010). In this paper, they estimate a structural factor model using identification restriction *à la* Mountford & Uhlig (2009). They find positive multpliers on consumption, output, investment and hours and a negative one on real wages.

In this paper, I want to address a question they do not document, namely the evolution over time of the fiscal policy multipliers. As we have already seen, this problem has been documented in the SVAR litterature by Perotti (2005). According to this literature, the effects of fiscal policy have tended to fade away across time, mainly after the Volcker turning point. This is consistent with this period being labelled as the "Great Moderation". This question has been further documented by Bilbiie et al. (2008), but again using a SVAR approach. In addition, they provide an explanation based on Limited Asset Market Participation (Bilbiie (2008)).The argument is that monetary policy switched from passive to active and that the tremendous development of financial markets enabled a growing part of the population to smooth consumption. In fact, drawing on Galí et al. (2004), the portion of consumers who do not have access to financial market ("Rule of Thumb" consumers) merely consume their real wages. With less people exhibiting this kind of behavior, the effects of fiscal policy shocks are predicted to have a reduced impact on the main macroeconomic variables.

As pointed in Perotti (2005), VAR analysis has been only recently (beginning at the end of the 20^{st} century) applied to the study of fiscal policy shocks. The VAR method was mainly used to study questions pertaining to the effects of monetary policy (see Sims & Zha (1998), Cochrane (1998)). After the Blanchard & Perotti (2002) paper has been published, a lot of papers using VAR on fiscal policy matters have been published. The same pattern seems to hold for the use of the FAVAR method. It has mainly been used for the study of monetary policy (see Bernanke et al. (2005), Boivin et al. (2009) and Boivin et al. (2010)). As far as I know, the only two papers that studies fiscal policy shocks in a dynamic factor model framework are, for the first one Benassy-Quere & Cimadomo (2006) —but they only consider a Factor-Augmented VAR for european countries, not for the US; they also use an identification scheme *à la* Blanchard & Perotti (2002), which is not fully consistent with fiscal foresight, as argued by Forni & Gambetti (2010). The second one being Forni & Gambetti (2010), which estimates probability densities for the IRFs following Mountford & Uhlig (2009); this allows them to implement sign restrictions on the IRFs. I will use a FAVAR model *à la* Bernanke et al. (2005) and identify government spending shocks by ordering government spending first through a standard Cholesky ordering procedure. My objective is to document further the dynamic effects of government spending, and to see if those effects have been fading away after the Volcker turning point. The more straightforward way to do it is to split the sample in two periods : the pre-Volcker one and the Volcker-Greenspan-Bernanke one as in Bilbiie (2008) and Perotti (2005).

The paper will be organized as follows : section 2 will present the FAVAR model and the motivations for using it to study the dynamic effects of government spending. Section 3 will describe the data used and the identification procedure in comparison with the ones that have been implemented in the fiscal SVAR literature. Section 4 deals with the empirical results using SVAR and FAVAR method in the whole sample, then on the two subsamples. Section 5 concludes. The Impule Response Functions and the tests results for the statistical properties of the data used are in the Appendix.

2 Fundamentalness and the FAVAR Model

2.1 A refresher on fundamentalness

Among the several advantages of using FAVAR techniques instead of classic SVAR ones, I will lay emphasis on the question of fundamentalness. In fact, when we deal with fiscal policy, agents receive clear signals about future policies. This can be due to implementation (it takes time for fiscal measures to come into effect once decided) as well as legislative (fiscal policy reacts slowly to economic conditions) lags. In their paper, Leeper et al. (2008) focus on the econometric implications of fiscal foresight. When this is the case, the econometrician will treat as news old information, which rational agents have already taken into account in their decisions. They also show that, in general, this induces time series with non-invertible MA process. Let us consider the following process :

$$X_t = \Phi(L)\varepsilon_t \tag{1}$$

where L is the lag operator (*i.e.* such that $LX_t = X_{t-1}$), X_t is a $(N \times 1)$ vector of observable variables, ε_t is a $(q \times 1)$ vector of structural shocks and $\Phi(L)$ is a $(N \times q)$ lag polynomial. This says that X_t lies on the space spanned by $\{\varepsilon_{t-k}, k \geq 0\}$. But the converse (*i.e* that ε_t lies on the space spanned by $\{X_{t-k}, k \geq 0\}$) does not necessarily hold. This will be true only under certain conditions for $\Phi(L)$. For the sake of simplicity, let us first assume that $N > q$, and that $\Phi(L) = I - AL$. We now have $X_t = (I - AL)\varepsilon_t$, which will be invertible only if the following three conditions are satisfied :

1. ε_t *is a weak white noise vector*
2. $\Phi(z)$ *has no poles inside the unit circle*
3. *det* $\Phi(z)$ *has all its roots lying outside the unit circle*

In this case, we can rewrite equation (1) as :

$$\sum_{i=0}^{\infty} A^i X_{t-i} = \varepsilon_t$$

From this we see that we only need past values of X_t to identify the structural shocks. This comes from the fact that $\Phi(z)^{-1}$ contains only positive powers of z. If there was one $z \in \mathbb{C}$ such that $|z| = 1$ and det $\Phi(z) = 0$, $\Phi(z)$ would not be invertible. If one of the three conditions are violated for $|z| \neq 1$, we would need future values of X_t to identify the structural shocks. This poses a problem to identify contemporaneous structural shocks. The structural shocks we want to estimate are called this way because they are assumed to drive the economy. They are observed by the economic agents and do not necessarily correspond to the innovations resulting from the estimation of equation (1). In case the lag polynomial is invertible but does not satisfy the preceding three conditions, $\{X_{t-k}, k \geq 0\} \subset \{\varepsilon_{t-k}, k \geq 0\}$ and the information set of the econometrician is smaller than the agent's one. In this case, the innovations we get after estimation will not correspond to the structural shocks and ε_t will then be labelled **X_t-nonfundamental**. If conversely the lag polynomial verifies the three conditions, then the estimated innovations will be the structural shocks and will be labelled **X_t-fundamental**. We have supposed that $N > q$ in this example. We can also recover the structural shocks under certain conditions if $N = q$, but it can be shown (see Alessi et al. (2008) and Forni & Gambetti (2010)) that those conditions are more stringent in this case. Therefore, non-fundamentalness will be a *generic* problem in the $N = q$ case, but not in the $N > q$, "tall system" one. We will now present the FAVAR model, which builds on one of those "tall systems" that enables to get rid of the fundamentalness problem, the dynamic factor model.

2.2 The FAVAR model

As we have seen, the main caveat of the VAR approach is that it doesn't allow for the econometrician to treat enough information. One way to do this in a parsimonious way is to sum up the information contained in a large dataset through a subset of latent, unobserved factors. Denote by X_t the $(N \times 1)$ vector of observable variables. Now we suppose that the comovements of the variables in this data set depend on r common factors. Formally, this gives :

$$X_t = \Lambda f_t + \xi_t \tag{2}$$

where Λ is a $(N \times r)$ matrix of factor loadings and the ξ_t's are idiosyncratic errors[2]. The approximate dynamic factor framework relies on the assumption

[2]Idiosyncratic errors can in some cases be interpretated as measurement errors. This interpretation is reasonable when we deal with purely "macro" variables such as GDP. When we consider sectoral variables, ξ_t can be interpreted as a sector-specific shock. See Forni & Gambetti (2010)

that the ξ_t are assumed to be mildly cross-section correlated and are uncorelated at all leads and lags with the factor loadings. Since the idisyncratic errors are only poorly cross-correlated, if we take an appropriate linear combination of the variables, they will vanish asymptotically. This is the Principal Component method. If we denote by $\hat{\Sigma}_X$ the empirical variance-covariance matrix of X_t, then it can be decomposed as $\hat{P}\hat{D}\hat{P}^{-1}$, with $\hat{D}$ the diagonal matrix containing the eigenvalues and $\hat{P}$ the matrix of the associated eigenvectors. If we denote by λ_i the i^{th} eigenvalue of $\hat{\Sigma}_X$ (which are sorted in decreasing order), we choose r such that $\lambda_r \gg \lambda_{r+1}$. We can then approximate $\hat{\Sigma}_X$ by $\hat{P}_1\hat{D}_1\hat{P}_1^{-1}$, where $\hat{P}_1$ is composed of the r eigenvectors corresponding to the r largest eigenvalues. From (2) we see that the factors cannot be directly identified. In fact, if we take any Q matrix such that $QQ' = I$, then $\tilde{\Lambda}\tilde{f}_t$, with $\tilde{\Lambda} = \Lambda Q$ and $\tilde{f}_t = Q' f_t$ is observationaly equivalent to Λf_t. The factors are thus unique up to a rotation matrix. We must then impose normalization assumptions. Following Bai & Ng (2002), we impose $\frac{1}{T}\sum_{t=1}^{T} \hat{F}_t\hat{F}_t' = I_r$. This implies that the factor loadings and the latent factors write, respectively, $\hat{P}\hat{D}^{1/2}$ and $\hat{D}^{-1/2}\hat{P}'X_t$.

Having an estimate of the latent factors, we can now treat them, in a second step, as generated regressors. We will estimate a *VAR* augmented with the estimated factors.

$$\begin{bmatrix} Y_t \\ \hat{f}_t \end{bmatrix} = \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ \hat{f}_{t-1} \end{bmatrix} + \nu_t \tag{3}$$

This method has been shown to be valid by Bai & Ng (2006). In fact, if $\sqrt{T}/N \rightarrow 0$ as $N, T \rightarrow \infty$, then the sampling uncertainty from tirst step estimation is negligible and standard errors for the estimates of the factor loadings can be computed as if the true f_t have been used in the VAR. Here, Y_t contains variables we are especially interested in and the $\nu_t = (\nu_{1t}\ \nu_{2t}\ \nu_{3t})'$ are linear combinations of the structural shocks. The Y_t are typically, as in Blanchard & Perotti (2002) output, taxes and government expenses.

3 Data and Identification procedure

3.1 Identification in the Fiscal SVAR literature

As we have already said, most of the literature focusing on the dynamic effects of fiscal policy shocks has relied on shocks identified through a structural VAR modelisation. We will suppose, as it is implicitely done in the SVAR literature, that the factors do not play any role. This amouns to say that $\Phi_{12}(L) = 0$. Therefore, equation (3) boils down to :

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \\ Y_{3t} \end{bmatrix} = \Phi_{11}(L) \begin{bmatrix} Y_{1t-1} \\ Y_{2t-1} \\ Y_{3t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \end{bmatrix} \tag{4}$$

An important feature of this VAR specification is that the innovation terms ϵ_t are mutually correlated. Therefore, we cannot say that a shock to ϵ_{1t} is a shock specific to the variable Y_1. What we want is to recover the shocks that are specific to one variable and are assumed to drive the economy. Those will be labelled the structural shocks, and the innovations can be viewed as a linear combinations of them.

$$\begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \end{bmatrix} \tag{5}$$

For the model equations to be identifiable, we need to impose $\frac{3(3-1)}{2} = 3$ restrictions on the matrix relating innovations to structural shocks. This is the approach taken by Blanchard & Perotti (2002), Perotti (2005) and Fatás & Mihov (2001). I will first develop the method of the latter one. Following Hamilton (1994, pp.320-323), the expression of the innovation in function of the structural shocks can be obtained by the observation that the variance-covariance matrix of the reduced form residuals is symetric; it can then be written as $\Omega = PDP'$. Taking $\tilde{P} = PD^{1/2}$, we can write $\Omega = \tilde{P}\tilde{P}'$. We can now construct the $u_t = [u_{1t}\ u_{2t}\ u_{3t}]'$ as $\tilde{P}^{-1}\epsilon_t$. The key is that $\tilde{P}$ will be a lower triangular matrix of the following form :

$$\begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \end{bmatrix} = \begin{bmatrix} \sqrt{Var(u_{1t})} & 0 & 0 \\ a_{21} & \sqrt{Var(u_{2t})} & 0 \\ a_{31} & a_{32} & \sqrt{Var(u_{3t})} \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \end{bmatrix}$$

Therefore, the inovation of the first variable in the VAR will be the structural shock of this variable multiplied by its standard deviation. This is the Cholesky decomposition. In their paper, Fatás & Mihov (2001) use this method and place the fiscal spending variable first. This specification implies that there is no contemporaneous correlation between the fiscal spending variable and the other ones in the model; which means that fiscal spending does not react within the quarter to other variables, *i.e* to macroeconomic activity. This method is valid only because they are interested in identifying one structural shock, the fiscal spending one. If we want to compare spending and taxes shocks, this method would not be appropriate.

This is what Blanchard & Perotti (2002) want to do. To cope with this issue, they use out of model data to estimate the a_{ij} coefficients. In their specification, these can be interpreted as elasticities of structural shocks with respect to innovations. Taking $Y_{1t} = G_t$, $Y_{2t} = T_t$ and $Y_{3t} = Y_t$ —where G_t are Government expenses, T_t are net taxes and Y_t is GDP —we have :

$$\epsilon_t^g = a_{11}u_t^y + a_{12}u_t^t + u_t^g$$
$$\epsilon_t^t = a_{21}u_t^y + a_{22}u_t^t + u_t^t$$
$$\epsilon_t^y = a_{31}u_t^g + a_{32}u_t^t + u_t^y$$

From this, according to Blanchard & Perotti (2002), we see that the reduced form residual of the Government spending equation depends on the automatic and discretionary response of fiscal policy to unexpected changes in output, both of which are captured by the a_{11} term. It also depends on random discretionary shocks to fiscal policies, which are captured by the structural shock u_t^g. If we assume that discretionary fiscal policy doesn't react within a quarter to output shocks, then a_{11} capture only the automatic response of fiscal policy, which can be estimated using institutional data. The authors then construct a transformed fiscal spending innovation by substracting the output shock weighted by its estimated coefficient. Doing the same for taxes, both fiscal policy innovations can be exprimed as a linear combinations of the two fiscal policy structural shocks :

$$\epsilon_t^g - a_{11}u_t^y = \epsilon_t^{g,CA} = a_{12}u_t^t + u_t^g$$
$$\epsilon_t^t - a_{21}u_t^y = \epsilon_t^{t,CA} = a_{22}u_t^t + u_t^t$$

where CA stands for Cyclically Adjusted. Finally, putting the fiscal spending or tax shock first amounts to a reduced Cholesky ordering, and since the correlation between the two cycliccaly adjusted fiscal shocks is low, the order does not matter much. The method employed in Perotti (2005) is the same, with inflation and interest rates added into the autoregressive vector.

For the sake of simplicity, we will take Fatás & Mihov (2001) approach, *i.e* ordering the government spending variable first. The main reason for this choice is that we want to focus on one specific shock, the government spending one. In this case, the government spending shock will simply be the residual from the government spending equation.

3.2 Data

We use two kinds of data. First of all, we need a large dataset from which the factors will be estimated. To this end, we use Ludvigson & Ng (2009) data. This dataset is an extension of the one used in Stock & Watson (2005). It consists of 131 monthly macroeconomic time series spanning the period 1964:1-2007:12. They can be partionned in 8 different groups of variables (output and income; labor market; housing; consumption, orders and inventories; money and credit; bond and exchange rates; prices; stock market). From this dataset, the authors extract 8 latent factors, which we will use for our Factor Augmented VAR. All the variables in the dataset have been previously stationarized, so the factors will be stationnary.[3]

The variables included in the VAR will be quarterly. Therefore, before using the factors we will temporally aggregate them to get quarterly ones. The variables in the VAR all come from the Federal Reserve Bank of Saint Louis FRED2 database. For real government spending (henceforth G_t), we use Government Current Expenditures (mnemonic in FRED2 : GEXPND) divided by the Gross Domestic Product Implicit Price Deflator (henceforth π_t, mnemonic : GDPDEF). For output we use Real Gross Domestic Product, 1 Decimal (henceforth Y_t, mnemonic : GDPC1). For real consumption we use Real Personal Consumption Expenditures, (henceforth C_t, mnemonic : PCECC96). For investment we use Gross Private Domestic Investment (henceforth I_t, mnemonic : GPDIC1). Finally, we use the monthly 3 month Treasury Bill interest rate (henceforth i_t, mnemonic T3BMS). All variables will be included in the VAR and FAVAR as a log of real (deflated by the GDP deflator when the initial data is in nominal terms), per capita variable.

4 Empirical Results

4.1 A Fiscal SVAR

We begin first by documenting further the literature on fiscal policy SVAR by considering the dynamic effects of government spending through a Cholesky ordering as in Fatás & Mihov (2001). Our objective here is to replicate their results. As in this paper, all variables will be taken in logs, except for the 3 month Treasury Bill rate. The model estimated here will be of the form :

$$X_t = C + A(L)X_{t-1} + \epsilon_t$$

with $X_t = (G_t\ C_t\ Y_t\ I_t\ \pi_t\ i_t)'$, C being a constant term. Based on the different information criteria (Akaike, Hannan-Quin and Bayesian ones) computed, we choose to include 3 lags in the VAR. We will now study the effects of a one standard deviation increase in government consumption on different variables.

[3]By doing this a part of information is lost, because most of macroeconomic time series are integrated of order 1. An extension of this paper will be to take into account such dynamics

The results we find are consistent with what is typically reported in previous studies, among which Fatás & Mihov (2001). We first note a positive effect of government spending on consumption and output (see Figure 2). The bands around the IRF represent asymptotic 95% confidence bands. Therefore we can say that the effect on consumption is significantly positive for quarters going from 0 to 18. For the effect on output, it is significant only after 8 quarters. Both effects become non significant in the long run. There is no significant effect on investment since the $y = 0$ line is always within the confidence bands. This is in contrast with the results of by Blanchard & Perotti (2002), who find a crowding-out effect on investment. This is also in contrast with Fatás & Mihov (2001), who find a slightly positive effect on investment. The first comment we can make so far is that the rise in GDP following an increase in government spending is mainly due to the rise in consumption.

We also find that both the GDP deflator and the 3-month Treasury Bill interest rates significantly decrease after a one standard deviation shock on government spending. For the interest rate the mechanism should be the following : the government spending shock pushes up the supply of Treasury Bonds, thus driving down its prices. The decreasing prices translate in increasing interest rates. Therefore, the effect we get is unexpected. For the GDP deflator, the slight decrease is also puzzling. In fact, we do not see why an increase in government spending would push down the prices. If anything, with current expenses of the government rising, the prices should go up. The shape of the response is very similar to the one reported in Fatás & Mihov (2001).

Overall, those results tend to support the results of some neo-keynesian models (among which Galí et al. (2004)) which predict a rise in consumption after a rise in government spending. Since most neoclassical models predict a decrease of consumption following a rise in government spending, the empirical results contradicts the theoretical ones.

In the Fatás & Mihov (2001) paper, there is no clear reference to the statistical properties of the series which are included in the SVAR. In fact, they do no control for it by including a linear trend or differencing the data. This can pose some problems for the computation of the IRF confidence intervals. By looking at the graph of the series, we know that they are trending. It remains however to study the nature of this trend. Are the series Difference stationary or Trend stationary? To answer this question, we run a battery of tests to check for the presence of unit roots in the series. To choose the number of lags to include in the test, we again use the information criteria along with Likelihood Ratio tests. The results of the tests (reported in the appendix) do not speak clearly in favor of the presence of unit roots in the data, at least at the 5% level[4]. Therefore, following Perotti (2005), we estimate again our model with a linear time trend in addition[5].

$$X_t = C + A(L)X_{t-1} + D * t + \epsilon_t$$

where t is an exogenous variable here. While the positive effect of a government spending shock on consumption remains, we observe that the one on output vanihes (it is only significantly different from zero with 90% confidence intervals, see Figure 3) . As we will see later, this is largely due to the contrary sign of the effects of government spending on output in the two sub-samples. Since we are not sure that this specification is the good one, we also estimate a VAR in first-differences. We also find a significantly positive effect on consumption, and a positive (but non 95% significant) effect on GDP (see Figure 4). The problem with this specification is that we loose a part of information by differencing the data. Furthermore, if there are indeed cointegration relationship between the variables, the model in first differences is ill specified. We will now see how the addition of the factors helps us treating more information and how this translates in the IRFs.

4.2 The Factor-Augmented VAR

As we have already seen, the problem with the typical SVAR is that it can treat a limited amount of information. Therefore, we fear that the government spending shock will not be properly identified, since it can be anticipated. To deal with this issue, Fatás & Mihov (2001) include forecast of government spending

[4] That is, for G_t, GDP and its components. The 3 Month T-Bill is stationary once differenced and $\Delta log(GDPDEF_t)$, the inflation rate, is also stationary once differenced.

[5] In Blanchard & Perotti (2002) they try two specifications : one with linear and quadratic trends and variables in log of levels, one with differenced data. In Perotti (2007), they try the same specifications, but they get rid of the quadratic trend in the first one.

into the VAR. We take another route here, including factors as generated regressors. For the sake of parsimony, we only include the first two factors estimated by Ludvigson & Ng (2009). Together, they account for 25% of the variance in the large dataset. By running regressions of each variable on the factors, Ludvigson & Ng (2009) show that the first factor is more related to output, employment, housing and orders. The second one is more related to money, credit and financial variables. Since the two factors are stationnary, it would not make any sense to estimate the FAVAR with the quarterly variables in log of levels. We thus differentiate all the variables in the VAR. The information criterion suggest 1 or 2 lags. We report the results with two lags. The results using only one lag are very similar. The first question we can ask is : are the factors relevant? We can answer this partially by looking at the p-values of the factors one and two in the equations for our quarterly variables. By looking at table 1, we can see that the factors are significantly different from zero most of the time[6]. Our initial intuition is thus justified : including the factors enables us to treat additional and relevant information.

We will now analyse the effects of a government spending shock within this framework. The various information criteria gives us a lag order between 1 or 3. We will retain the average number of two lags (results do not change by much by taking one or three lags). The first issue is the place of the factors. Should we place them just after the G_t equation? Or in the last position ? If we place them in the last position, this implies that the innovations for the two factors will depend on the structural shocks of all the other variables. Since the factors represent the state of the economy, this might be a reasonable specification. On the contrary, if we place them just after the government spending equation, this means that the innovations of the factors are only affected by the government spending strucutral shock and their own structural shock. We try both specifications and report here the results for the case when the factors are placed in the last position. As it turns out, results do not vary much across specifications.

[6]Where $*$ stands for significant at the 5% treshold, $**$ for significant at the 1% treshold. L is the lag operator and thus L2 stands for L^2. Results are only reported for the first four equations for the sake of space saving. Results are similar for the last two equations and are reported in the appendix (see Table 4).

Table 1: Estimation results1 : FAVAR

Variable	Coefficient (Std. Err.)
Equation 1 : Government spending	
L.factor1	0.003
	(0.002)
L2.factor1	0.000
	(0.002)
L.factor2	0.001
	(0.002)
L2.factor2	-0.004*
	(0.002)
Equation 2 : Consumption	
L.factor1	-0.003*
	(0.001)
L2.factor1	0.000
	(0.001)
L.factor2	0.006**
	(0.001)
L2.factor2	-0.002*
	(0.001)
Equation 3 : Investment	
L.factor1	-0.032**
	(0.006)
L2.factor1	0.014*
	(0.006)
L.factor2	0.005
	(0.006)
L2.factor2	0.012*
	(0.006)
Equation 4 : GDP	
L.factor1	-0.006**
	(0.001)
L2.factor1	0.000
	(0.001)
L.factor2	0.004**
	(0.001)
L2.factor2	0.000
	(0.001)

As with the SVAR, there is no significant response of investment to a government spending shock (see Figure 5). However, other SVAR results do not hold here. While the rise in consumption is common to both specifications, the rise in GDP is not. With our FAVAR, we observe a significantly different from zero rise in GDP. The message for fiscal policy would then be that the rise in consumption and output from an increase in government spending will be positive, but temporary (rapidly returning to zero impact). For the interest rates, government spending shocks have not much effect.

4.3 How have the effects of government spending evolved through time?

As we have already noted, there is empirical evidence supporting the diminishing effect of fiscal policy after the end of the 1970's. This provides support for the "Great Moderation" label that has been associated with this period. Our objective here is to document further this issue and possibly to shed new light with the FAVAR framework. Even though the tests gave no clear cut results about the underlying process for our series, we will consider the first-difference VAR as our baseline specification since its results are more comparable to the FAVAR ones. In fact, as it is commonly done in the literature, all variables in the FAVAR will be transformed to induce stationarity. For the sake of brevity, we will only focus on the effects of government spending on GDP and its components. As before, we will begin by first documenting the empirical evidence on this issue with the fiscal SVAR augmented with a linear time trend.

The response of consumption in the first part of the sample is significantly positive, while in the second part of the sample, it is not different from 0 (see Figure 6). As for the response of investment, it is slightly negative on impact in the first part of the sample. In the second part, the decrease of investment following a government spending shock is more marked (Figure 7). This echoes to the "crowding out effect" found by Blanchard & Perotti (2002). The response of output is only significantly positive for the first part of the sample if we consider 90% confidence bands. We are forced to retain the same confidence interval for the same analysis with the SVAR in differences because the loss in information is even more pronounced if we estimate on a smaller sample. With this in mind, the only signifiicant result is the rise in consumption following a government spending shock in the first part of the sample (Figure 8). To sum up, both specifications seem to imply that the dynamic effects of fiscal policy have tended to fade away in the second part of the sample. The first specification even exhibits a strong crowding-out effect of government spending on investment. We will now try to respond to the same questions, but this time using our FAVAR framework. Since we split the sample in two, we cannot estimate exactly the VAR in differences augmented with factors, as the dimension of the VAR will be too high in relation to the time dimension (64 observations for the first part of the sample and 113 for the second). Therefore, we will estimate a VAR in differences without the inflation and interest rate, which will be replaced by the first three factors. The motive for adding the third factor is that it will proxy for the missing information contained in the interest and inflation rate, since it is largely correlated with the price series in the dataset used by Ludvigson & Ng (2009).

While the effect on GDP and consumption is still positive (Figures 10 and 11), the only response that is significantly different from zero at the 95% treshold is the one for consumption for the first part of the sample. As for the second part of the sample, the response is never negative, but is more close to zero impact instead. While the fiscal SVAR (with linear trend) estimates that fiscal policy through government spending has had a negative effect in the second part of the sample, our FAVAR model estimates that this kind of policy has had, instead, no clear-cut effect on GDP and its components. This is in line with the results obtained with the VAR estimated in differences. We can try to explain those results by looking at the shape of the IRF of government spending to a government spending shock across the two sub samples. By looking at Figure (1), we see that the rise in government spending following a government spending shock is more pronounced in the first part of the sample. It is more protracted in the second part of the sample and better estimated (the confidence band intervals are narrower) because we have more data for this subsample.

1960Q1:1979Q1 sample 1979Q1:2007Q1 sample

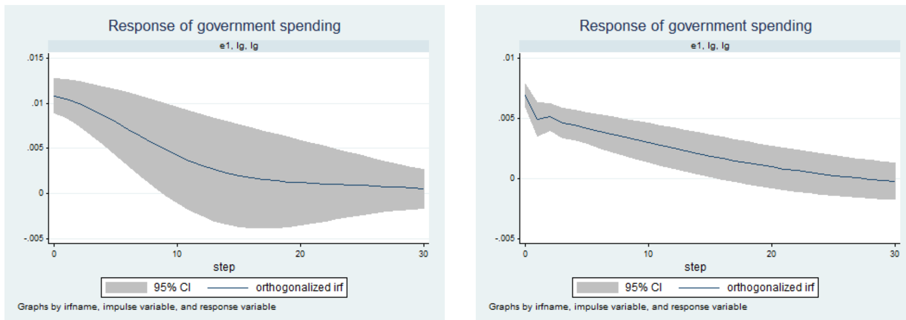

Figure 1: Effects of government spending shock on consumption : VAR in levels with linear trend

5 Conclusion

Our initial objective was to study the dynamic effects of government spending using the FAVAR framework. Our results confirm largely what has already been documented in the literature. The government spending shock has a positive effect on consumption and output (only in the FAVAR and the SVAR without linear trend for output), which is largely due to the first part of the sample. Therefore, government spending shocks have had a decreasing effect on key macroeconomic variables over the last few decades. There is nevertheless room to make substantial improvements to our work. First of all, we were not able to gather data on taxes. While we are able to control for a monetary policy shock by including inflation and interest rates in the VAR, we cannot control for a shock on taxes. Furthermore, due to the trending nature of our variables (even though the nature of this trend is not known for sure), we must estimate a FAVAR model in first differences since the factors have been estimated on stationary data. Thus, the gain in information from the inclusion of the factors comes after a loss of information due to first differencing the data; this implies that the beneficial role of adding the factors into the VAR is not clear cut.

One solution to this problem would be to estimate I(1) factors on a large data set and estimating a Factor Augmented Error Correction Model, as in

Banerjee et al. (2010). This will surely minimize the loss of formation we have experienced here. To check that the estimated government spending shock is not anticipated, we can carry out an orthogonality test as in Forni & Gambetti (2010) : if the estimated shock is orthogonal to the *Survey of Professional Forecasters* Government spending forecast, then we can say that the government spending shock is a truly structural shock. As for the inclusion of taxes, I will have to consider another identification scheme for the shocks, since the method used in this paper only permits to estimate one shock. In particular, I will have to look at Mountford & Uhlig (2009) or Blanchard & Perotti (2002) identification schemes. Those will be subjects I would like to investigate during a PhD thesis.

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A Statistical properties of the series

Table 2: Test statistics for the KPSS test

lags	G_t	C_t	Y_t	I_t
0	3.32	0.72	0.30	1.02
1	1.69	0.37	0.16	0.53
2	1.15	0.25	0.11	0.37
3	0.87	0.19	0.09	0.29
4	0.71	0.16	0.07	0.24
5	0.6	0.14	0.06	0.21
6	0.52	0.13	0.06	0.19
7	0.47	0.11	0.05	0.18
8	0.42	0.10	0.05	0.17
9	0.39	0.09	0.05	0.16
10	0.36	0.09	0.05	0.15
11	0.34	0.09	0.05	0.15
12	0.32	0.09	0.05	0.14
13	0.29	0.08	0.05	0.14

The null hypothesis for the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test is : the series is trend stationary. The 5% critical value of the test is equal to 0.146. If the test statistic is greater than this value, then we reject the null hypothesis at the 5% treshold.

Table 3: P-values for the ADF and Phillips-Perron tests

	Phillips-Perron	Augmented Dickey-Fuller
G_t	0.0674	0.0265
C_t	0.1832	0.0021
Y_t	0.0250	0.0032
I_t	0.0585	0.0380

For the two tests, the null hypothesis is the presence of a unit root in the data. Both models have been estimated with a deterministic trend.

B Impulse Response Functions

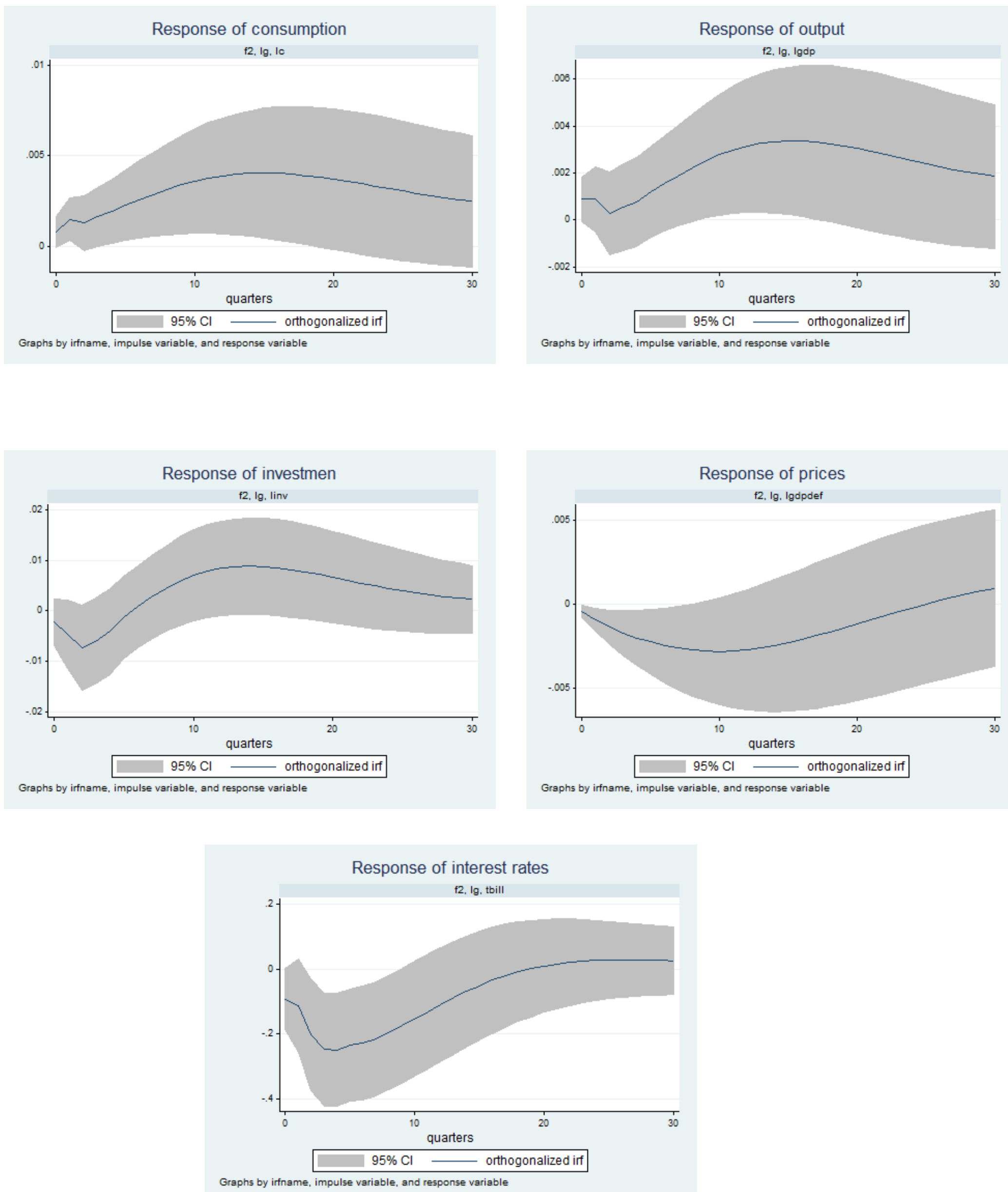

Figure 2: Responses to an increase in government spending. SVAR in levels

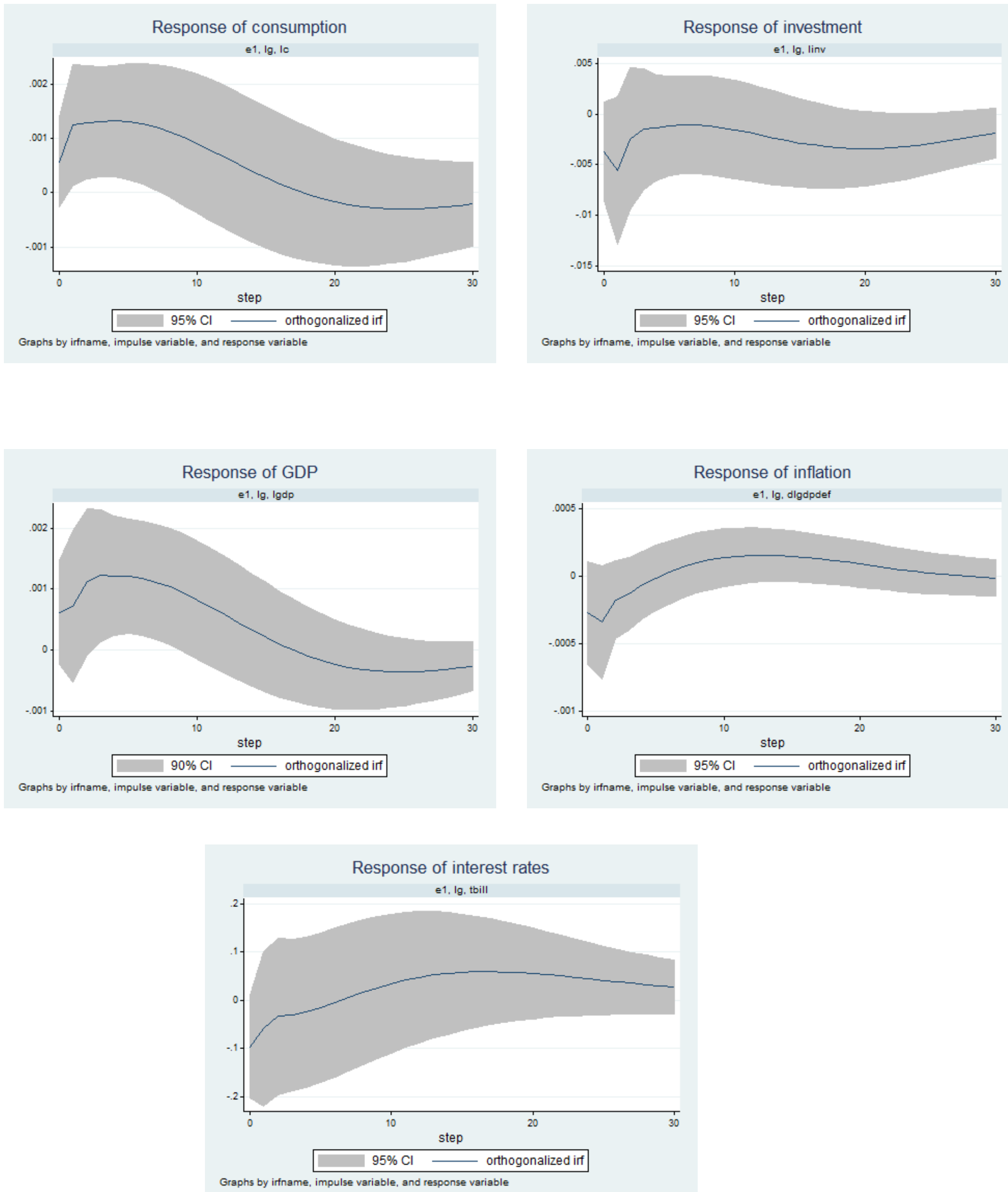

Figure 3: Responses to an increase in government spending. SVAR in levels with linear trend

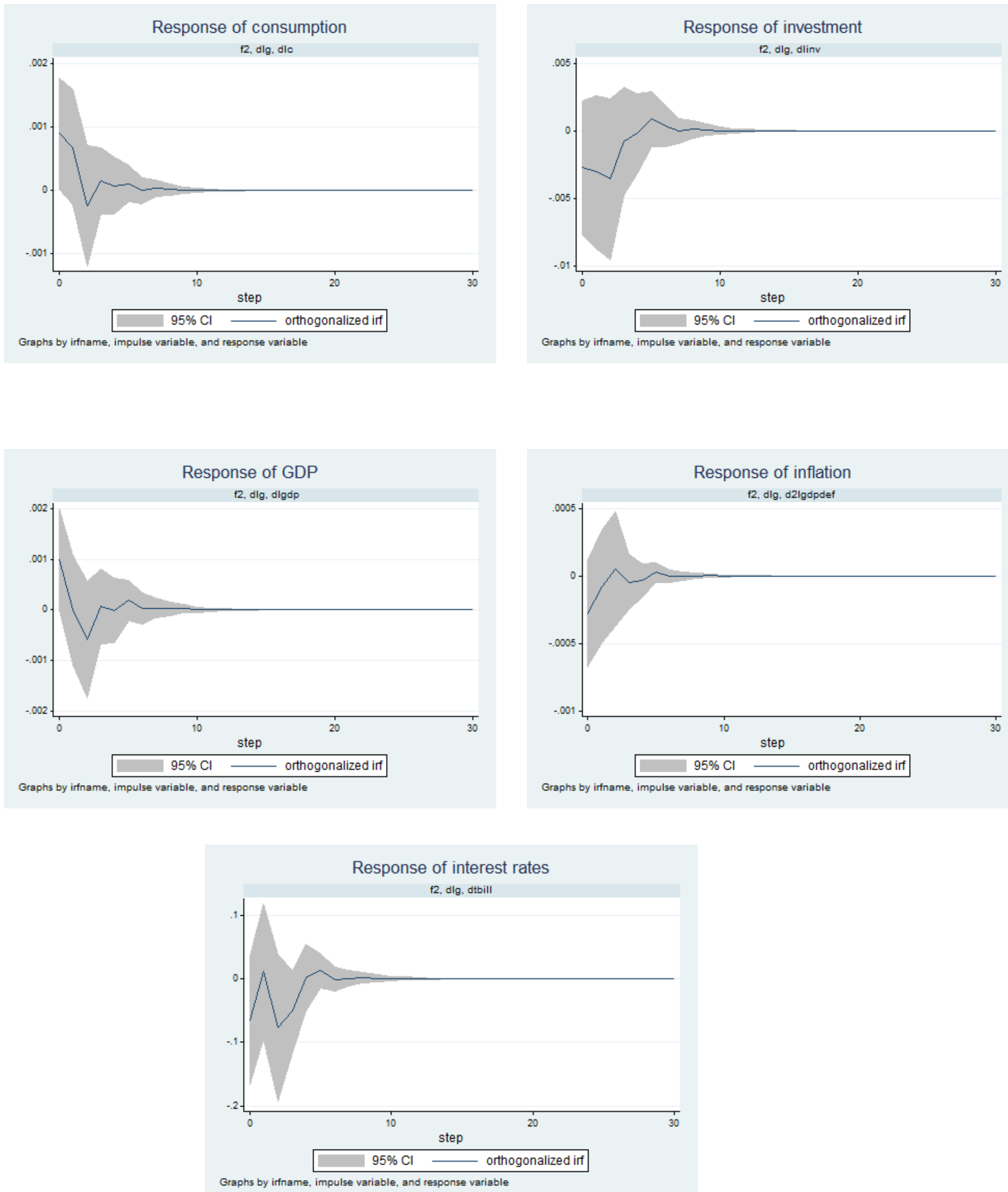

Figure 4: Responses to an increase in government spending. SVAR in first differences

Table 4: Estimation results2 : FAVAR

Variable	**Coefficient** (Std. Err.)
Equation 5 : GDP Deflator	
L.factor1	-0.001* (0.001)
L2.factor1	0.000 (0.000)
L.factor2	-0.001* (0.000)
L2.factor2	0.000 (0.000)
Equation 6 : Treasury Bill	
L.factor1	-0.628** (0.130)
L2.factor1	0.288* (0.127)
L.factor2	0.022 (0.127)
L2.factor2	0.015 (0.124)

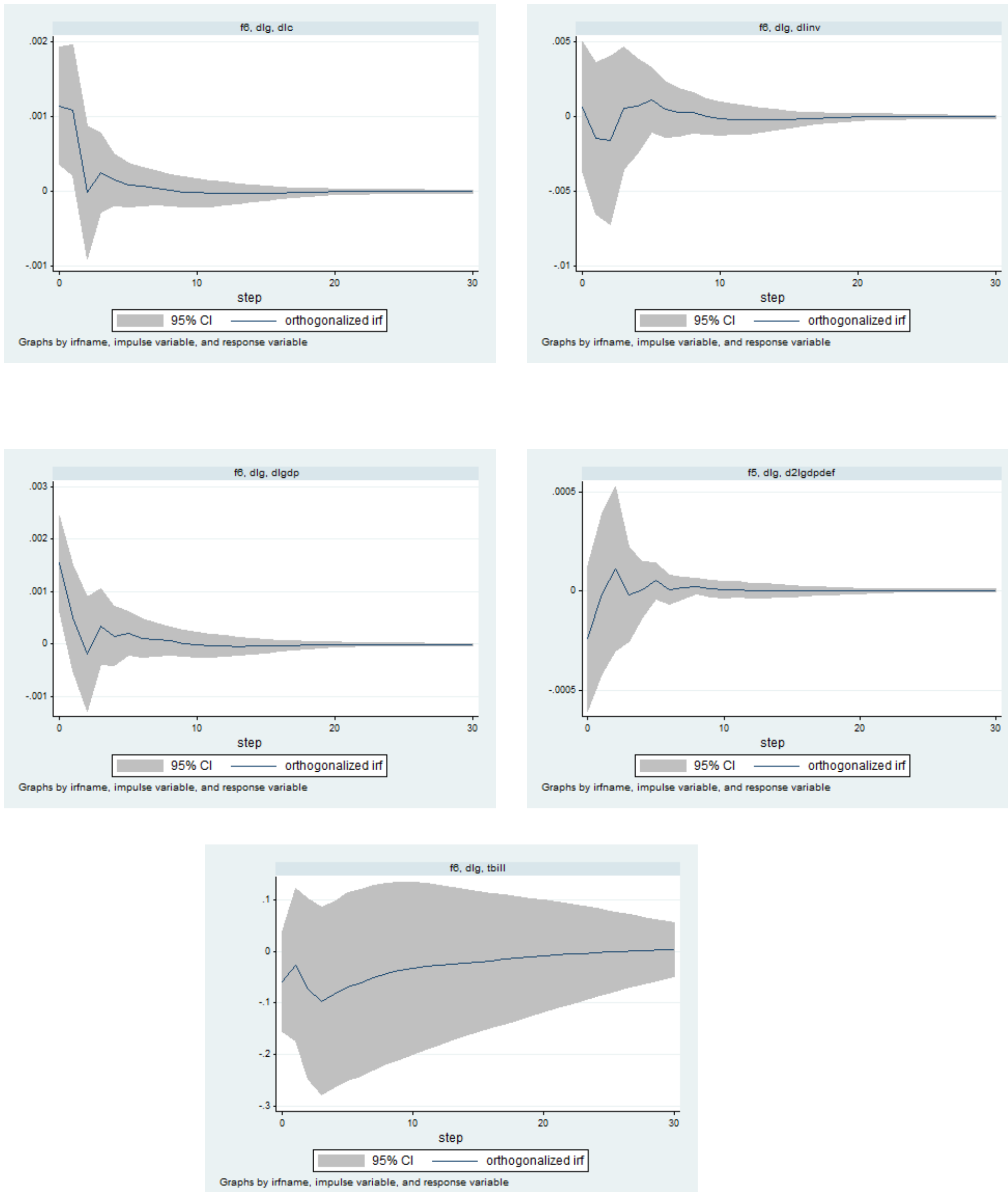

Figure 5: Responses to an increase in government spending. Factor-Augmented VAR

1960Q1:1979Q1 sample 1979Q1:2007Q1 sample

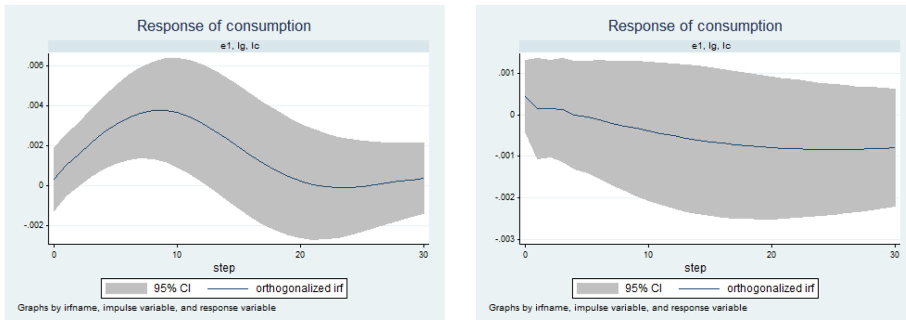

Figure 6: Effects of government spending shock on consumption : VAR in levels with linear trend

1960Q1:1979Q1 sample 1979Q1:2007Q1 sample

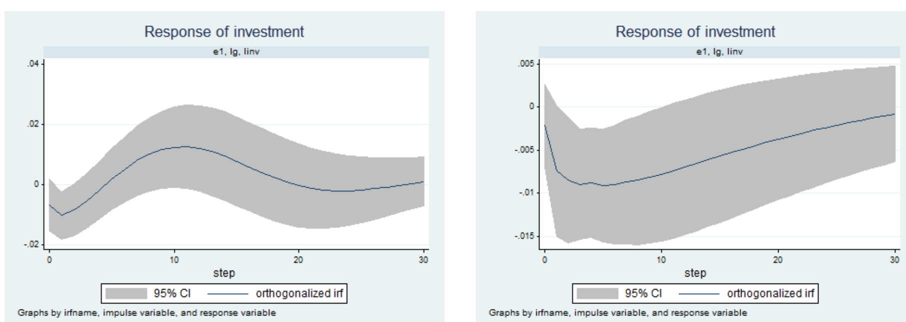

Figure 7: Effects of government spending shock on investment : VAR in levels with linear trend

1960Q1:1979Q1 sample 1979Q1:2007Q1 sample

Figure 8: Effects of government spending shock on consumption : VAR in differences

1960Q1:1979Q1 sample 1979Q1:2007Q1 sample

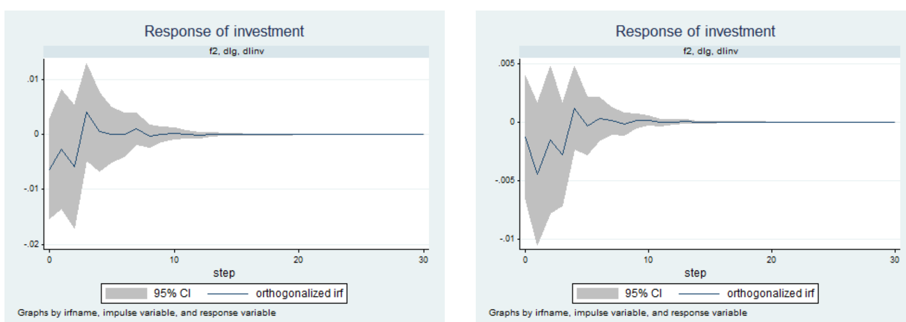

Figure 9: Effects of government spending shock on investment : VAR in differences

1960Q1:1979Q1 sample 1979Q1:2007Q1 sample

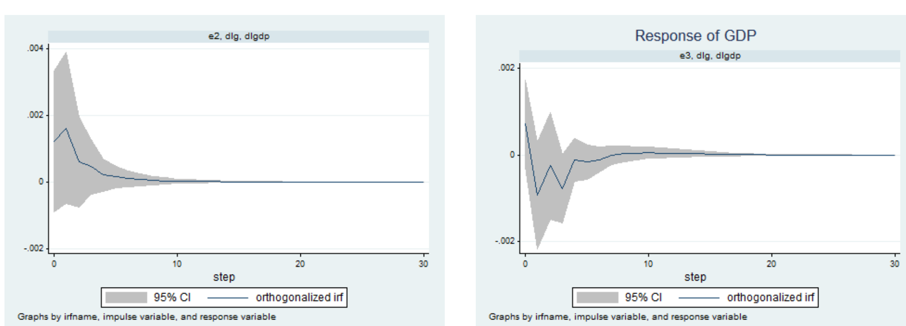

Figure 10: Effects of government spending shock on GDP : FAVAR specification

1960Q1:1979Q1 sample 1979Q1:2007Q1 sample

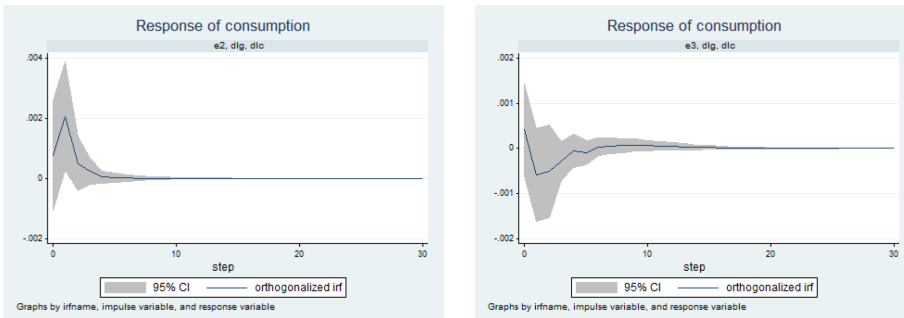

Figure 11: Effects of government spending shock on consumption : FAVAR specification

1960Q1:1979Q1 sample 1979Q1:2007Q1 sample

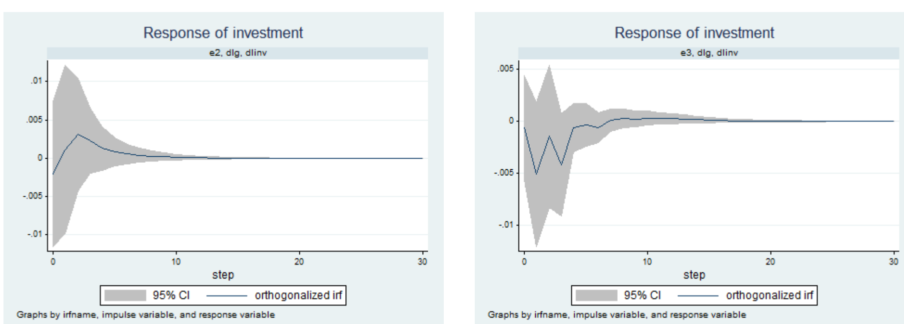

Figure 12: Effects of government spending shock on investment : FAVAR specification