Some New Insights into Currency Boards: Evidence from Bulgaria

Alexandru Minea [$] *and Christophe Rault* [+#]

[$] Université d'Orléans, LEO, CNRS UMR 6221, Rue de Blois, B.P.6739, 45067 Orléans Cedex 2, France;
CRP Tudor and STATEC, Luxemburg
email: alexandru.minea@univ-orleans.fr.

[+] Université d'Orléans, LEO, CNRS, UMR 6221, Rue de Blois-B.P.6739, 45067 Orléans Cedex 2, France; IZA, Germany ; and William Davidson Institute at the University of Michigan, Ann Arbor, Michigan, United States,
web-site: http://membres.lycos.fr/chrault/

January 08

Abstract

The presence of a Currency Board (CB) monetary system in Bulgaria is a key factor in assessing monetary policy transmission, since a CB implies no monetary autonomy. Using the SVAR technique according to the statistical properties of macroeconomic time series, we propose evidence sustaining the endogeneity of main Bulgarian monetary aggregates to shocks on the ECB interest rate. These results shed a new perspective over CB functioning.

Keywords: Currency Board, monetary policy, SVAR, Bulgaria.

JEL Classification Numbers: E42, E52.

[#] *Corresponding author:* chrault@hotmail.com, christophe.rault@univ-orleans.fr.
Some parts of the paper were written while the former author was a research guest at the Bulgarian National Bank (BNB). We would like to thank Petar Chobanov, Kalina Dimitrova, Nikolay Nenovsky and Patrick Villieu for their vital feedback on the CB topic. Financial assistance from BNB has been a stability factor in carrying out this research project. The opinions expressed in this study are those of the authors and do not necessarily reflect the positions of the Bulgarian National Bank, the CRP Tudor or the STATEC. Of course, all remaining errors are solely ours.

Contents

Non-technical summary 3

1. Introduction 4

2. Monetary system and monetary policy in Bulgaria 6

3. Evidence from monetary policy transmission in Bulgaria 9

3.1 Macroeconomic Data 9

3.2 The benchmark model 11

3.3 Robustness Tests 16

3.3.1 The inverted model 16

3.3.2 Exogenous variables 17

3.3.3 Effects on other variables from the real economy 17

4. Conclusion 18

References 19

Appendix 1 – Checking robustness with respect to the public deficit to GDP ratio 22

Appendix 2 – Responses of several real variables to an ECB interest rate shock 22

Non-technical summary

The aim of this paper is to offer some new insights into monetary policy transmission in Bulgaria. The presence of a particular monetary (a CB) system is a determining factor in analyzing monetary policy in Bulgaria. Consequently, we explore CB functioning in Bulgaria and the implications generated by adopting such a monetary system. In particular, we concentrate on explaining how an exogenous monetary shock may be defined.

We study in detail the economic hypothesis that allows for the SVAR identification and define a benchmark model. The estimations of our benchmark model conclude that both domestic interest rate and money follow the ECB dynamics in the medium-long-run only. In the short-run however, both aggregates exhibit a rather irregular response, and a possible explanation may involve their endogeneity. Effectively, under the CB in Bulgaria, these two aggregates are not "driven" by some institutional behaviour, which could elucidate why firms and households may take decisions which diverge from decisions that would have been taken in the presence of an autonomous Central Bank, as highlighted by *Figure 2* and evidence from former Acceding Countries with no monetary policy autonomy (Lithuania, Latvia and Estonia).

Moreover, even though output does not react in the short-run, our hypothesis in our SVAR excludes output stickiness. Consequently, this result can only be explained by an identical "time-to-build" interpretation, namely that agents influencing the real economy need time to collect enough information about future adjustments of monetary aggregates. Notice that our results remain highly robust when we control exogenous fiscal variables (public deficit or public debt) or when replacing output with real variables (private consumption, public expenditure, exports or imports).

1. Introduction

Understanding monetary policy is without any doubt a traditional yet very active research field in economics. As it is generally accepted that monetary policy has deep effects on economy, it becomes clear how important it is to acquire the necessary amount of information on them. This kind of analysis is synthesized in what is called the *monetary policy transmission mechanism*.

Empirical and theoretical studies address the problem of monetary policy transmission, by trying to describe the different channels through which policy-makers 'decisions on monetary policy *instruments* propagate in the economy, as well as their impact on key economic variables (see, *inter alii* the classical contributions from Sims, 1982, 1992, Cochrane, 1994, Gordon & Leeper, 1994, Christiano, Eichenbaum & Evans, 1996, Leeper, Sims & Zha, 1996, Bernanke & Mihov, 1998, or Bernanke & Blinder, 2002). We denote by monetary policy *instruments* different monetary *exogenous* or *controlled* variables, that a policy-maker can control and change in a discretionary way. For instance, the European Central Bank (ECB) controls and changes the refinancing *interest rate*, in order to (hope to) direct the economy on the desired path (for example, the ECB might raise the interest rate whenever anticipated inflation is too high, to induce a downward revision of these expectations)[1].

As Taylor (1995) emphasized, traditional IS-LM Keynesian-based macroeconomic theory in a country with complete autonomy of monetary policy suggests that a tightened monetary policy, *i.e.* a discretionary exogenous raise in the interest rate or a decrease of money supply (growth rate), should diminish price growth (lower inflation), negatively affect output growth (*via* the negative effect on investment, thus on aggregate demand) and lead to an appreciation of the exchange rate (as higher interest rates increase domestic asset demand relatively to the demand in the rest-of-the-world assets).

However, little is known about monetary policy transmission in countries with a Currency Board (CB) monetary system. Indeed, in a CB, which implies a fixed exchange rate with an anchor-country, monetary authorities control neither the interest rate nor the money supply. Consequently, this raises a serious question in properly defining a monetary policy instrument. Thus, our first aim is to deal with this question using evidence from the CB

[1] The actual evidence supporting the interest rate as the main monetary instrument must not obstruct the reader from knowing that for a long time *monetary aggregates* were used as the main monetary instrument. Furthermore, a recent study by Peersman & Smets (2001) confirmed the prominence assigned to monetary aggregates by an important number of Central Banks.

functioning in Bulgaria. Following this discussion, we emphasize some results derived from countries with monetary systems close to that of Bulgaria, *i.e.* with highly restricted monetary policy autonomy, namely Estonia, Lithuania and Latvia. Using these results as a background, we focus next on monetary policy transmission in Bulgaria.

Since the Bulgarian interest rate is not controlled by the National Bank, we must focus on a different source for monetary shocks. Following a discussion of this point, we select the anchor-country interest rate, namely the European Central Bank (ECB) interest rate in the case of Bulgaria, as the main source of monetary policy shocks (as in EFN, 2004) Furthermore, we study domestic monetary (the Bulgarian interest rate and money supply) and real (output) variable responses to shocks on the ECB rate, in a Structural VAR (SVAR) model in accordance with the statistical properties of our macroeconomic series.

Our results are twofold. Firstly, monetary variables responses are rather irregular (cyclical), which is in line with previous evidence on the CB functioning. Thus, in the absence of monetary policy autonomy, "traditional" domestic monetary instruments exhibit an *endogenous* behaviour relative to the anchor-country interest rate. Precisely, the Bulgarian interest rate follows the ECB interest rate in the medium-long-run only, while the two interest rates are rather disconnected in the short run, with money supply following a cyclical adjustment.

Secondly, our estimations imply that the real economy (output growth) exhibits little reaction to ECB interest rate shocks. However, this result is rather puzzling in the SVAR we propose, since *ex-ante* we suppose output lacks stickiness. Therefore, we conclude that this behaviour is also a characteristic of CB functioning, with the same explanation based on the incapacity or undesirability of agents (influencing real economy) to formulate short-run decisions in the absence of autonomous domestic monetary policymakers.

Further estimations investigate the robustness of our results, both including exogenous variables and different SVARs. Monetary variables conserve their above-described behaviour when controlling for fiscal variables, as the deficit or debt to GDP ratios. Furthermore, replacing output by other real variables in several SVARs yields traditional responses of these real variables, while monetary aggregates conserve their irregular response to ECB interest rate shocks.

The rest of the paper is organized as follows. In section two we present the CB monetary system in Bulgaria and focus on the definition of an exogenous monetary instrument, and then we present some evidence from countries with little monetary policy autonomy. Section three presents the data, our main results and checks for robustness, while section four concludes.

2. Monetary system and monetary policy in Bulgaria

On July 1st ,1997, Bulgaria decided to introduce a Currency Board (CB), in order to stabilize the domestic economy after the important crisis of 1996-1997 (see, Berleman & Nenovsky, 2004, for a discussion on the Bulgarian crisis). In so doing, Bulgaria joined Estonia and Lithuania which introduced CBs anchored on ECU and USD in 1992 and 1994 respectively, and to some extent Latvia, where the national currency is in a fixed peg with the SDR (a basket of currencies)[2]. In accordance with evidence in the first section, this is definitely a feature to consider, if one tries to assess monetary policy effects in Bulgaria.

Pikkani (2000, page 6) summarized that "*An orthodox CB Arrangement is an exchange rate arrangement whereby the monetary authority stands ready to exchange local currency for another (anchor) currency at a fixed exchange rate without any quantitative limits*". To be more precise, to supply foreign currency on demand, a CB implies a 100% backing of emitted domestic currency with foreign exchange reserves.

Consequently, the CB in Bulgaria was very efficient in fighting the 1996-1997 crises, since a 100% backing of the domestic currency implies a 100% technical or non-political credibility, as monetary authorities cannot run out of reserves. In turn, full backing of the domestic base money and full convertibility at a fixed exchange rate assures a totally endogenous base money supply, with the automatic sterilization of excess liquidity[3]. Indeed, any *ceteris paribus* change in money demand will induce changes in base money and the corresponding changes in foreign exchange reserves.

As Lattemae (2003) explained, in a joint study on the CB systems of Estonia and Lithuania, in a CB there is *no active monetary policy*. Consequently, changes in the interest rate or monetary aggregates must not be defined as exogenous, as they mainly reflect endogenous development of the two indicators, subject to *i*) economic development, *ii*) external financing constraints and *iii*) different arbitrage conditions. Further, the CB can be understood as an automatic stabilizer, or, as Lattemae (2003) emphasized, "… [the CB should be seen as] *a long-run relationship between monetary conditions and not as a rapid current account adjustment mechanism*".

---

[2] Among other countries that used CB monetary system, we recall Argentina or Hong Kong.
[3] Niggle (1991) proposed a discussion on different theories analyzing the money stock endogeneity.

Yankov (2004) offered some additional insights into CBs, explaining that under pegged exchange regimes (as the CB) domestic interest rate should track closely the interest rate of the country whose money is used as anchor, *i.e.* the ECB interest rate for Bulgaria. However, Fase (1999) argued that the velocity of the convergence process (to the anchor interest rate value) essentially depended on the degree of integration of financial markets, because financial assets were better substitutes and capital tended to seek out the highest risk-adjusted returns. Obviously, if there is a premium risk on the domestic economy, then the domestic interest rate should converge to the anchor interest rate plus the premium.

To sum up[4], neither monetary aggregates, nor the domestic interest rate can be considered as pure monetary instruments and used accordingly. In fact, under a CB as that of Bulgaria, the use of monetary policy is restricted to excess reserves exceeding the monetary base. The Central Bank can use the required reserve ratio, which of course impacts the economy through increased costs of financial intermediation. Overall, in terms of our future modeling, this implies that studying exogenous changes in either domestic interest rate or money aggregates, which is econometrically computable, has no coherent interpretation and should therefore be avoided.

Thus, as our main interest is to study *exogenous* monetary shock transmission on the Bulgarian economy, we are left with mainly three types of shocks that can be considered as exogenous. The first, and most important, corresponds to exogenous changes in the ECB interest rate. As documented above, these changes should transmit to the Bulgarian domestic interest rate and further to all key macroeconomic variables. In our empirical analysis, we consider this experiment as the benchmark and most important.

Secondly, remark that pegging against an anchor does not completely eliminate fluctuations, since the anchor can float against other trade partners' currencies. A striking example is Lithuania, where starting 2002 the anchor was fixed against the EURO, while most trade is done with Russia. In this case, studying exogenous changes in the currency of an important trade partner (different from the "anchor currency" partner) might produce some interesting insights.

Thirdly, we can try to use the required reserve ratio as an exogenous instrument, but variability in this indicator becomes econometrically interesting only in the last few periods. However, for countries as Estonia, there is an attempt by Nenovsky et *al.* (2001) to compose

[4] For further evidence on the CB functioning, the reader is encouraged to consult the few (rather rare) theoretical models, including Pikkani (2000), Desquilbet & Nenovsky (2003) or Blessing (2007).

an index which will reflect changes in both the level and *the base* on which this ratio is interfering.

Finally, in Bulgaria (as well as in Lithuania), the Government has an account (that may include, for example, revenues from taxes and/or privatizations) with the Central Bank, and resources in this account enter the official reserve accountancy. Thus, anytime the Government makes important deposits or withdrawals from this account, it implicitly changes the amount of official reserves, with potential effects on the economy. However, there is a definitely open discussion if changes in Government Account with the Central Bank should be considered as "monetary" shocks. In our view, they are clearly not monetary shocks, since, even if these changes affect first monetary conditions, and it is hardly conceivable that the Government should proceed to this kind of changes for *monetary objectives* (for example, to lower inflation expectations). For this reason, we abstain from considering this kind of shock as linked to monetary transmission issues, even if one could probably withdraw some interesting information from its analysis[5].

Evidence from former Acceding Countries with monetary system close to Bulgaria

From all former Acceding Countries, Estonia, Lithuania and Latvia have little (zero) autonomous monetary policy. Since their monetary systems are close to that of Bulgaria, former empirical evidence from these countries may therefore provide interesting insights with respect to our analysis in Bulgaria.

Since 1992, Estonia has introduced a CB system anchored first on ECU, then on the EURO. Concerning monetary transmission, Lattemae (2003) found that external shocks in financial conditions, like ECB interest rate, were rapidly transmitted, in accordance to our previous evidence on the CBs. Following Bems (2001) and Ganev et *al.* (2002), Lattemae & Pikkani (2001) extended this analysis, as they concluded that effects on the real economy were small and short lived. Finally, evidence in EFN (2004) suggested that following a shock on the ECB interest rate, domestic interest rate increases, money decreased initially and had a cyclical movement afterwards, while output initially increased.

Lithuania was the second country in Central and Eastern Europe that introduced a CB monetary system, in 1994. The domestic money was first anchored to the USD, then to the

[5] Similarly, we think that this shock can hardly be considered as a "pure" fiscal shock, since its changes influence monetary conditions first, before the real economy. As we have stressed before, we see this as an open discussion. Furthermore, quite paradoxically, it seems that this kind of shock is the most studied compared to the other three, as reflected by very interesting evidence in Nenovsky et *al.* (2001) or Nenovsky & Hristov (2002).

EURO in 2002. Recent evidence from Vetlov (2003) suggested that the high degree of openness of the Lithuanian economy made it rather vulnerable to the external environment (for example, shocks on the ECB interest rate). In a SVAR, EFN (2004) found that an increase in the ECB interest rate positively changed the domestic interest rate, with money decreasing, price exhibit prize puzzle and a counterintuitive short-term increase in output. In addition to the effects of the ECB interest rate and as stressed above, Vetlov (2001) identified important effects of the exchange rate.

Finally, since 1994, Latvia has adopted a fixed peg on the SDR with very narrow bands ($\pm 1\%$), which in terms of exchange rate regime comes rather close to a CB. Evidence from Babich (2001) implied that changes in the ECB interest rate, contrary to variations in the exchange rate, had some impact on the real activity. However, these effects seem to be weak or non-existent.

3. Evidence from monetary policy transmission in Bulgaria

The above evidence about monetary policy transmission in other CB countries suggests that *i*) effects are short-lasting and rather weak, *ii*) money may have some cyclical behaviour and *iii*) price exhibits the price puzzle. To investigate whether these results hold or not for the Bulgarian economy, we propose in this section a Structural VAR (SVAR) model on the series taken in level, since all series turn out to be integrated of order zero (*cf. supra*). Subsection one describes the data, subsection two discusses the benchmark case, while in subsection three we investigate the robustness of our results.

3.1 Macroeconomic Data

Data are quarterly and cover the period Q3:1999 until Q1:2007, leading to 31 observations[6]. Even if Bulgaria introduced CB on July 1st, 1997, we use data starting from the 3rd quarter of 1999 to allow for variables to “stabilize” after this important shock. For example, changes in consumer prices (*i.e.* inflation) greatly oscillate between high values (*i.e.* 65.7% change in Q1:1998 relative to Q1:1997) and negative values (*i.e.* -0.9% change in Q2:1999 with respect to Q2:1998).

[6] Data for Q2:2007, Q3:2007 and Q4:2007 are only estimations. Therefore we did not include them in our analysis. However, we report that including these values does not qualitatively alter our results.

The most important feature of the CB in Bulgaria is that domestic usual monetary variables are not exogenous. Consequently, as stressed before, we consider in our benchmark model that monetary shocks come from the ECB refinancing interest rate. However, changes in the ECB refinancing rate are too rare to produce the necessary amount of variability in our analysis. Therefore, in line with other studies (see, *e.g.* Peersman & Straub, 2004, or Reynard, 2007), we use the *LIBOR 3 months* interest rate $\left(i^{EU}\right)$, as the exogenous variable in our analysis.

In our *benchmark case*, we study the impact of the i^{EU} on four variables. First, on the Bulgarian interest rate $\left(i^{BG}\right)$, defined as the "money market rate". Secondly, we consider a broad money indicator M3, namely the annual (quarter to quarter) growth rate in M3. To capture the effects on prices, we use the annual (quarter to quarter) growth rate of consumer prices (inflation π)[7]. Finally, to look for some real economy effects, we consider Y as the annual (quarter to quarter) growth rate of real output (GDP)[8]. All these variables, as well as the *LIBOR 3 months* interest rate, come from the BNB dataset.

The first step of the analysis is to look at the macroeconomic data univariate properties and to determine their degree of integration. Indeed, investigating the stationarity of the series is a crucial step to determine the correct multivariate econometric specification to implement. Theoretically, a process is either I(0), I(1) or I(2). Nevertheless, in practice many variables or variable combinations are borderline cases, so that distinguishing between a strongly autoregressive I(0) or I(1) process (interest rates are a typical example), or between a strongly autoregressive I(1) or I(2) process (nominal prices are a typical example) is far from easy. As many unit root tests are now available in literature, we have chosen to rely on the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test (1992), to investigate which of the I(0), I(1), I(2) assumptions is most likely to hold. It is now well known that this test considers the null hypothesis of stationarity against the alternative unit root hypothesis and is more powerful than the Augmented Dickey-Fuller (ADF) test.

The results of the KPSS tests are not reported here because of limited space[9], but they can easily be summarized as follows, since clear patterns emerge from them. Indeed, the null stationarity hypothesis around a constant and around a linear trend root cannot be rejected at

[7] Lavrac (2004) analyzed the role of inflation targeting in the Czech Republic, Hungary and Poland, and concluded that the best measure for inflation was "headline inflation rate", *i.e.* the rate of change of consumer price index, and not inflation net of regulated prices.
[8] Of course, one might compute (for example the quarterly growth for GDP, *i.e. the* relative GDP change in one quarter with respect to the previous one. However, this might introduce some seasonality in our data. Series of Money growth and GDP growth are our own computations.
[9] They are available upon request.

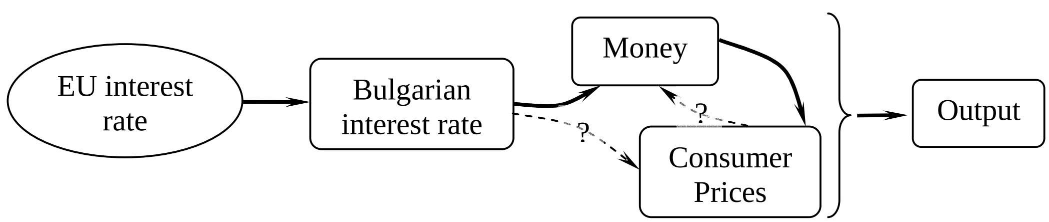
the 1% significance level for all macroeconomic series under consideration. This leads us to conclude that all our series are properly characterized as an I(0) process[10].

3.2 The benchmark model

Hereafter, we implement an impulse analysis by calculating the impulse response functions (IRFs) to shocks, in a SVAR[11] on the series taken in level, since all series turn out to be integrated of order zero[12].

In our *benchmark case,* we consider the transmission mechanism described in *Figure 1* below.

Figure 1 – Transmission mechanism of a shock on the ECB interest rate



The *continuous* arrows denote the transmission mechanism in our *benchmark* case[13]. A EU interest rate $\left(i^{EU}\right)$ shock is considered to impact first the Bulgarian interest rate $\left(i^{BG}\right)$. Changes in interest rate i^{BG} (*i.e.* money prices) are supposed to affect money M3. Changes in money M3 further transit to consumer prices (π). Finally, real activity Y (output) reacts last to initial changes in the ECB interest rate.

[10] Note that this result must be taken with some caution given the small number of observations used for implementing unit-root tests (31). Indeed, attempts to conclusively prove the existence of such unit-roots usually require a great number of observations (over 100). In spite of this restriction, we think however that these tests, which we only apply for purely descriptive purposes, can propose a first indication on the statistical properties of the data.

[11] VARs were introduced by Sims (1980), while Hamilton (1994) textbook or Watson (1994) provided intensive evidence on the VAR technique. While the SVAR technique has recently been used for rather heterogeneous topics (Blanchard & Perotti, 2002, for fiscal policy, L'Horty & Rault, 2003, for the labour market, or Parent & Rault, 2004, in economic history), its application concerns mainly monetary policy effects (on consumption in Crowder & Wohar, 2003, on core inflation in Quah & Vahey, 1995, or on investment in Mojon et *al.*, 2002), and in particular monetary policy transmission. This latter analysis appears in the seminal contributions from Sims (1982, 1992) or Blanchard & Quah (1989), as emphasized in a survey by Christiano et *al.* (2000).

[12] Furthermore, since all series of our database are integrated of order zero, the question of cointegration testing between those series is of course not relevant and hence do not emerge in this paper.

[13] Since the most important trade partner of Bulgaria is the EU, we disregard exchange rate effects.

To reproduce the benchmark case, we use these constraints to achieve SVAR identification[14]. First, to capture the transmission mechanism $i^{BG} \rightarrow M3 \rightarrow \pi \rightarrow Y$, we order the variables in this same order. Using a recursive identification (see Stock & Watson, 2001), this implies that shocks in i^{BG} (more precisely, responses of i^{BG} to changes in i^{EU}) contemporaneously affect i^{BG}, $M3$, π and Y, changes in $M3$ contemporaneously affect $M3$, π and Y, changes in π contemporaneously affect π and Y, while changes in Y contemporaneously affect only Y[15]. The second fact we want to reproduce is that i^{UE} changes are most exogenous. To capture this feature in a recursive SVAR, we order i^{UE} in the first position, implying that changes in other variables do not contemporaneously affect the ECB interest rate.

Selecting this order entails a short comment. Remark that dashed curves in the *Figure 1* above denote our conviction that some uncertainty exists in the transmission mechanism from the Bulgarian interest rate onward, as one might suggest that transmission to $M3$ and π may be inverted. To test this assumption we also propose what we call the *inverted* SVAR, with these two variables in inverted order.

We identify our SVAR using the Cholesky decomposition upon a lower triangular matrix. Impulse response functions were computed following a one-period shock equal to one standard deviation in the ECB interest rate in each SVAR. Confidence bands for impulse response functions were computed using the bootstrap method by carrying out 1000 simulations.

Consider first the *benchmark* case. To select the *lag*, *Table 1* below reports the LR log likelihood test (column 1), and four information criteria: FPE final prediction error (column 2), Akaike information criterion (column 3), Schwarz information criterion (column 4), Hannan-Quinn information criterion (column 5).

Table 1 – Lag selection in our benchmark SVAR model

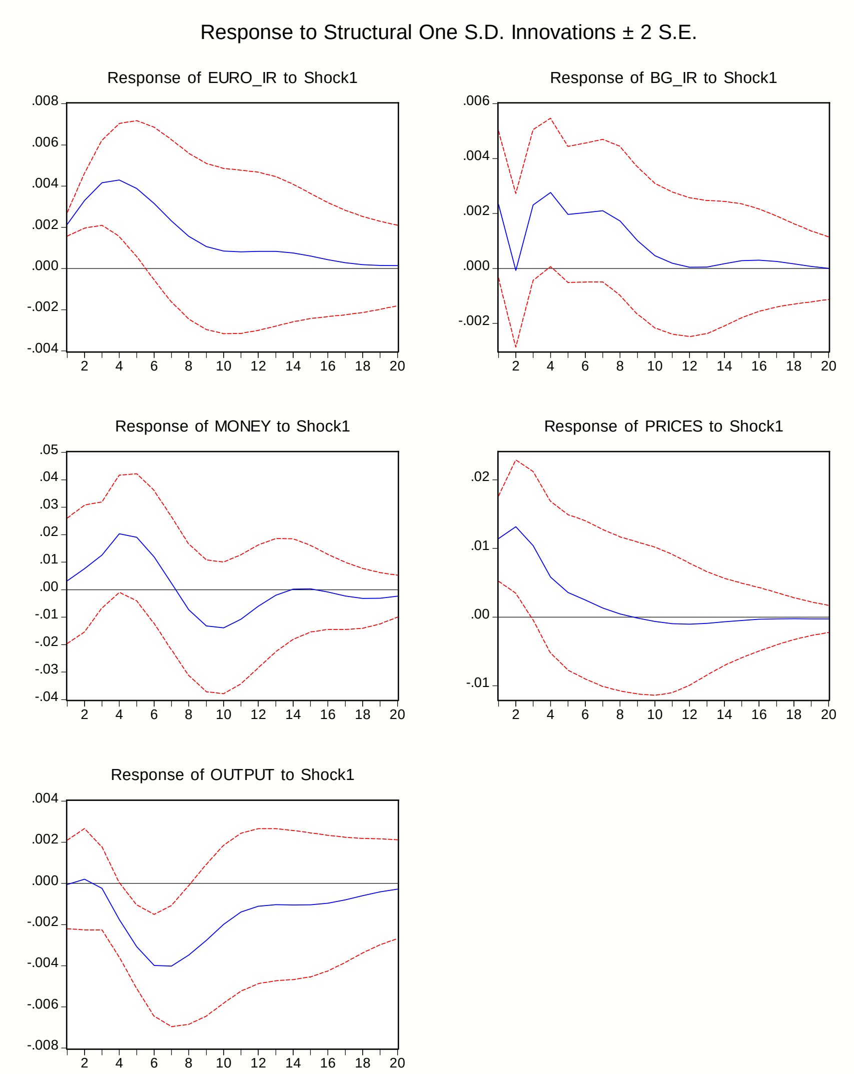
Lag	LR	FPE	AIC	SC	HQ
0	NA	6.30e-19	-27.71989	-27.47992	-27.64853
1	118.7921	1.46e-20	-31.52480	-30.08499*	-31.09667
2	38.68064*	1.02e-20*	-32.09049	-29.45082	-31.30558*
3	22.42913	1.61e-20	-32.27765*	-28.43814	-31.13596

[14] In a survey, Stock & Watson (2001) recalled the mechanism used for SVAR identification.
[15] Of course, the SVAR technique implies that variables influence each other in *lags*.

As illustrated by *Table 1*, three out of four information criteria prefer the *lag 2* to the *lag 1*, thus we choose a *lag 2* order for our benchmark model. Besides, our decision is also supported by the LR test, clearly suggesting the adoption of a *lag 2* SVAR. Moreover, several test statistics have been calculated in order to check the quality of the multivariate estimation (Lagrange Multiplicator test (LM) and Ljung-Box test for serial correlation of order 16, ARCH tests (Autoregressive Conditional Heteroscedasticity), Jarque-Bera normality test). The tests constitute a good way to detect the possible failing of some hypotheses made during the system estimation. In order not to make the presentation cumbersome, the results of these tests are not reported here, but they indicate that the SVAR model is well behaved and not subject to misspecification, since the usual hypotheses concerning the residuals of each equations are verified[16]. Finally, the re-estimation of the SVAR by recursive least squares and the implementation of Chow tests confirm the stability of the parameters for the estimation period. *Figure 2* below reports impulse response functions for our benchmark model.

[16] The residuals of the VAR model equations exhibit good overall properties: except for some minor normality problems, no sign of serial correlation exists and they are not of ARCH type

Figure 2 – Reaction of Bulgarian variables in the benchmark model

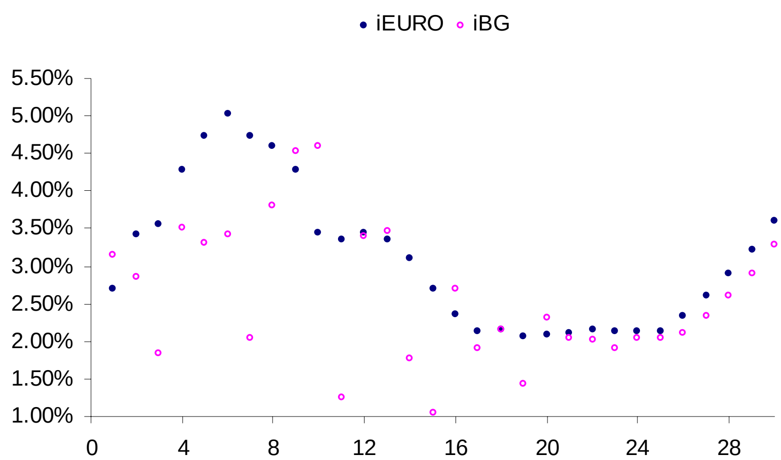


We observe first that an exogenous increase in the ECB interest rate initially increases the Bulgarian interest rate. However, the Bulgarian interest rate adjustment is very irregular. Money positively responds in the short-run, which is also counterfactual, but in accordance with EFN (2004). Instead, what is more important is that money adjustment is irregular (cyclical), similar to the adjustment of the domestic interest rate.

Our interpretation of these two results is in line with the idea that both Bulgarian interest rate and money are *endogenous* with respect to external monetary shocks. Thus, the irregularities in their adjustment may be seen as a proof that adjustment in both aggregates takes time to stabilize, because, compared to the countries with some degree of autonomous monetary policy, the BNB has no *stricto sensu* institutional impact on neither the domestic interest rate nor money. Lacking the information that this kind of institutional anchor is usually supplying, firms and households need more time to form expectations, and even their expectations might differ from those that would have been made in the presence of a Central Bank, which can explain the irregular movement in both the interest rate and money. Notice that our results are highly supported by empirical evidence in EFN (2004) for Estonia, a country where also the monetary system involves the presence of a Currency Board.

Moreover, we represent in *Figure 3* below the ECB Libor EUR 3 months interest rate $\left(i^{EU}\right)$, as well as the Bulgarian money market rate $\left(i^{BG}\right)$, both in quarterly data for the period 1999:Q3 – 2007:Q1.

Figure 3 – The ECB Libor EUR 3 months and the Bulgarian money market rate



In accordance with our results in the SVAR benchmark, we remark that data described in *Figure 3* confirm that for a certain period of time, the ECB and the Bulgarian interest rate were rather disconnected.

Another point that could sustain our results is that the domestic interest rate adjustment is more rapid, compared to evidence in EFN (2004) for former acceding countries with some autonomous degree for monetary policy (the Czech Republic, the Slovak Republic or Slovenia). This can be a proof of rapid (however intense) absorption of foreign shocks by the domestic rate, which is also a feature that is usually defended in a CB monetary system as that of Bulgaria (see, *e.g.* Babich, 2001, Bems, 2001, or Vetlov, 2003).

Building on this interpretation for the behaviour of monetary aggregates, we can withdraw very interesting information about output behaviour. Notice that output does not significantly respond for around 3 quarters, which is again a very important result. Indeed, in our identification scheme, putting output *last* involves that we implicitly assume the *lack of stickiness* of output reaction, with respect to monetary shocks (changes in i^{EU}). Thus, output lack of reaction in our SVAR cannot come from a stickiness *hypothesis*, but is rather a stickiness *result*. To account for it, we turn back to the irregular adjustments in monetary variables. Because of this type of adjustment for monetary variables, real economy also reacts with some *delay*, because further information about the evolution of endogenous adjustments of monetary variables is needed. Thus, after a period close to 3 quarters, our estimations exhibit the usual decrease in output growth, but however this negative effect is absorbed more quickly compared to economies with higher monetary autonomy, but in line with results for countries under CB.

To sum up, our results suggest that, as monetary variables are not controlled by the BNB (they are endogenous), firms and households may lack some information compared to the case where the behaviour of these two variables would somehow be constrained by some institutional interference. In this case, both domestic interest rate and money have an irregular adjustment, a result supported by real data in *Figure 3*, showing that domestic interest rate is disconnected from the evolution of the ECB interest rate. However, notice that this adjustment takes less time compared to more autonomous economies, a result that comes close to the evidence that CB economies adjust very quickly. In this case, output lacks reaction in the initial periods, which can be considered also as a “time-to-build-information” period for households and firms, concerning the evolution of endogenous monetary variables. Finally, output decrease is important, but its adjustments takes less time, reproducing the idea that external monetary shocks have short-lasting impacts on real activity in a CB.

3.3 Robustness Tests

3.3.1 The inverted model

With respect to the benchmark model, we have also considered the *inverted* model. In the inverted model we suppose that changes in the Bulgarian interest rate affect first prices and then money, thus variables are ordered $i^{EU}, i^{BG}, \pi, M3, Y$. We report that considering the inverted SVAR does not qualitatively change our results.

3.3.2 Exogenous variables

In this sub-section we consider some experiments to check the robustness of our benchmark model. To do so, we estimate some SVAR models that include other variables as exogenous (outside the SVAR structure).

First, we wish to investigate if introducing a world price variable may solve the *price puzzle*. Different simulations with either the variable *external prices* (defined as an average of oil, metal, non-food and food prices) or the variable *world commodity prices* do not allow to unambiguously conclude to the absence of price puzzle. In turn, we report that introducing these variables as exogenous does not change the impulse response functions following a shock in the ECB interest rate, compared to our benchmark model.

Secondly, we explore the sensitivity of our benchmark results with respect to the presence of some (exogenous) *fiscal variables*. First, we consider the *ratio* of *public deficit to GDP*, in quarter-to-quarter growth rate. Secondly, we correct the *variation* of the *public debt to GDP ratio*. Indeed, Bulgaria knew during this period a significant reduction in the public debt to GDP ratio, which exhibits a very pronounced negative slope. Thus, to correct the possible non-stationarity problems, we employ the first order difference of this ratio. As *Appendix 1* confirms, our results are qualitatively unchanged when correcting these two fiscal variables[17].

3.3.3 Effects on other variables from the real economy

We consider next several SVAR models in which we replace output by other variables from the real economy. Precisely, we focus on private consumption, gross fix capital formation, public expenditure, imports and exports, all in quarter-to-quarter growth rate, all extracted from the BNB database. We report that our benchmark results are unchanged, therefore we represent exclusively the *new* variable introduced in the SVAR, which replaces output. For coherence, we consider the same order as in the benchmark SVAR.

[17] Our results join evidence in EFN (2004), in the way that correcting for these fiscal variables does not allow to solve the price puzzle, except for Hungary and Poland but for none of the three countries with monetary system close to Bulgaria.

In accordance with evidence in *Appendix 2*, following a positive shock on the ECB interest rate, private consumption decreases less than output, confirming that consumption adjusts smoother than output[18]. Concerning public expenditure, we observe that following a raise in the ECB interest rate, government reacts counter-cyclically by positively adjusting public spending starting from the impact, in order to partially counterbalance the negative effect in output. Although the public spending raise is vigorous on impact, its persistence is rather reduced in time. Finally, imports and exports both positively react on the impact, which is somehow counter-intuitive. However, this result may be explained by the fact that these variables are highly coordinated in Bulgaria, since a major share of exported goods are produced with imported goods.

4. Conclusion

The purpose of this study is to offer some new insights into monetary policy transmission in Bulgaria. The presence of a particular monetary (a CB) system is a determining factor in analyzing monetary policy in Bulgaria. Consequently, we explore CB functioning in Bulgaria and the implications generated by adopting such a monetary system. In particular, we concentrate on explaining how an exogenous monetary shock may be defined.

We study in detail the economic hypothesis that allows for the SVAR identification and define a benchmark model. The estimations of our benchmark model conclude that both domestic interest rate and money follow the ECB dynamics in the medium-long-run only. In the short-run however, both aggregates exhibit a rather irregular response, and a possible explanation may involve their endogeneity. Effectively, under the CB in Bulgaria, these two aggregates are not “driven” by some institutional behaviour, which could elucidate why firms and households may take decisions which diverge from decisions that would have been taken in the presence of an autonomous Central Bank, as highlighted by *Figure 2* and evidence from former Acceding Countries with no monetary policy autonomy (Lithuania, Latvia and Estonia).

Moreover, even though output does not react in the short-run, our hypothesis in our SVAR excludes output stickiness. Consequently, this result can only be explained by an

[18] To find if investment is more volatile than output, we performed several estimations using the gross fix capital formation (GFCF). Unfortunately, GFCF is extremely volatile in the first quarters of the sample and our attempts to shorten the sample by disregarding these initial values did not produce conclusive results.

identical “time-to-build” interpretation, namely that agents influencing the real economy need time to collect enough information about future adjustments of monetary aggregates. Notice that our results remain highly robust when we control exogenous fiscal variables (public deficit or public debt) or when replacing output with real variables (private consumption, public expenditure, exports or imports).

References

- Babich, V. (2001), “Monetary Transmission in Latvia”, *Baltic Economic Trends* 2, 16-27.

- Bems, R. (2001), “The Monetary Transmission Mechanisms in the Baltic States: Introduction”, *Baltic Economic Trends* 2, 3-6

- Berlemann, M. and N. Nenovsky, (2004), “Lending of First versus Lending of Last Resort: The Bulgarian Financial Crisis of 1996/1997”, *Comparative Economic Studies* 46, 245-271

- Bernanke, B. and A. Blinder, (1992), “The Federal Fund Rate and the Channels of Monetary Transmission”, *American Economic Review* 82, 901-921

- Bernanke, B. and I. Mihov, (1998), “Measuring Monetary Policy”, *Quarterly Journal of Economics* 113, 869–902

- Blanchard, O. and R. Perotti, (2002), “An Empirical Characterization Of The Dynamic Effects Of Changes In Government Spending And Taxes On Output”, *Quarterly Journal of Economics* 117, 1329-1368

- Blanchard, O. and D. Quah, (1989), “The Dynamic Effects of Aggregate Demand and Supply Disturbances”, *American Economic Review* 79, 655-673

- Blessing, J. (2007), “The Bulgarian Economy on Its Way to the EMU: Economic Policy Results from a Small-scale Dynamic Stochastic General Equilibrium Framework*”, BNB wp. No. 60*

- *Bulgarian National Bank Database*

- Christiano, L., M. Eichenbaum and C. Evans, (1996), “The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds”, *Review of Economics and Statistics* 78, 16-34

- Christiano, L., Eichenbaum, M. and C. Evans, (2000), “Monetary policy shocks: What have we learned and to what end?”, in Taylor, J. and Woodford, M. (eds), *Handbook of Macroeconomics*, North-Holland, Amsterdam

- Cochrane, J. (1994), “Shocks”, *Carnegie Rochester Conference on Public Policy* 41, 295-364

- Crowder, W. and M. Wohar, (2003), “A Cointegrated Structural VAR Model of the Canadian Economy”, *Bank of Canada wp*

- Desquilbet, J-B. and N. Nenovsky, (2003), “Exploring the Currency Board Mechanism: a Basic Formal Model”, *BNB wp. No. 35*

- EFN (European Forecasting Network), (2004), “*The Euro Area and the Acceding Countries, Annex 4*”, Reports, Spring

- Fase, M. (1999), *On Interest Rates and Asset Prices in Europe. The selected Essays of Martin M. G. Fase*; Edward Elgar Publishing Limited, UK

- Ganev, G., Molnar, K., Rybinski, K. and P. Wozniak, (2002), “Transmission of Monetary Policy in Central and Eastern Europe”, *CASE reports 52*

- Gordon, D. and E. Leeper, (1994), “The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification”, *Journal of Political Economy* 102, 1228-1247

- Hamilton, J. (1994), “*Time Series Analysis*”, Princeton University Press

- Kwiatowski, D., Phillips, P., Schmidt, P. & Y. Shin, (1992), “Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root: How Sure Are We That Economic Time Series Have a Unit Root ?”, *Journal of Econometrics* 54, 159-178

- Lättemäe, R. (2003), “EMU accession issues in Baltic countries”, *Ezoneplus Working Paper 17A*

- Lättemäe, R. and R. Pikkani. (2001), “The Monetary Transmission Mechanism in Estonia”, *Baltic Economic Trends* 2, 7-15

- Lavrac, V. (2004), “Fulfillment of Maastricht Convergence Criteria and the Acceding Countries”, *Ezoneplus wp. No. 21*

- Leeper, E., Sims, C. and T. Zha, (1996), “What Does Monetary Policy Do?”, *Brookings Papers on Economic Activity* 2, 1-63

- L’Horty, Y. and C. Rault, (2003), “*Inflation, Minimum Wage and Other Wages: An Econometric Study of French Macroeconomic Data*”, *Applied Economics* 36, n°4.

- Mojon, B., Smets, F. & P. Vermeulen, (2002), “Investment and monetary policy in the euro area”, *Journal of Banking & Finance* 26, 2111-2129

- Nenovsky, N. and K. Hristov, (2002), “The New Currency Boards and Discretion: Empirical Evidence from Bulgaria”, *Economic Systems* 26, 55-72

- Nenovsky, N., Hristov, K. and M. Mihaylov, (2001), “A Simple Test of Currency Board Automatic Mechanism in Bulgaria, Estonia and Lithuania”, *Journal des Economistes et des Etudes Humaines* 11, 575-616

- Niggle, C., (1991), "The Endogenous Money Supply Theory: An Institutionalist Appraisal", *Journal of Economic Issues* 25, 137-151

- Parent, A. and C. Rault, (2004), "The influences affecting French assets abroad prior to 1914", *Journal of Economic History* 64, n°2.

- Peersman, G. and F. Smets, (2001), "The monetary transmission mechanism in the Euro Area: More evidence from VAR analysis", *ECB Working Paper 91*

- Peersman, G. and R. Straub, (2004), "Technology Shocks and Robust Sign Restrictions in a Euro Area SVAR", *ECB Working Paper 373*

- Pikkani, R. (2000), "The Monetary Sector under a Currency Board Arrangement: Specification and Estimation of a Model with Estonian Data", *Bank of Finland wp. No. 10*

- Quah, D. and S. Vahey, (1995), "Measuring Core Inflation", *Economic Journal* 105, 1130-1144

- Reynard, S. (2007), "Maintaining Low Inflation: Money, Interest Rates and Policy Stance", *Journal of Monetary Economics* 54, 1441-1471

- Sims, C. (1980), "Macroeconomics and Reality", *Econometrica* 48, 1-48

- Sims, C. (1982), "Policy Analysis With Econometric Models." *Brookings Papers on Economic Activity* 1, 107–152

- Sims, C. (1992), "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy", *European Economic Review* 36, 975-1000

- Stock, J. and M. Watson, (2001), "Vector Autoregressions", *Journal of Economic Perspectives* 15, 101-115

- Taylor, J. (1995), "The monetary transmission mechanism: An empirical framework", *Journal of Economic Perspectives* 9, 11-26

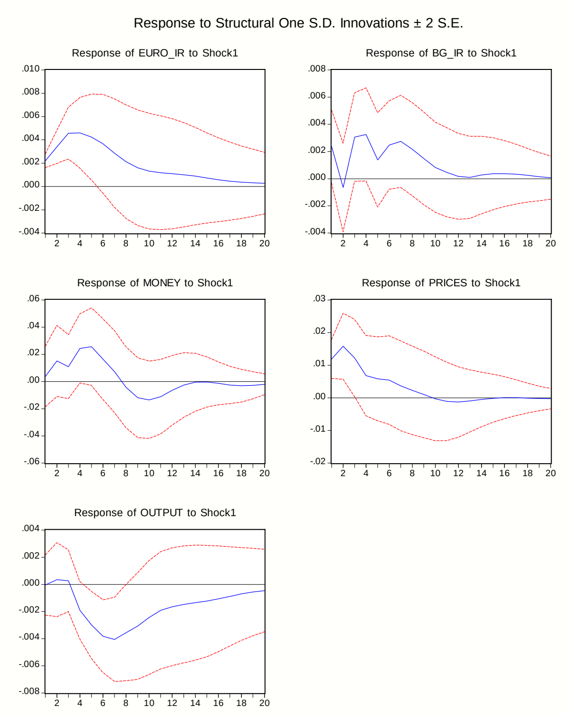
- Vetlov, I. (2001), "Aspects of Monetary Policy and the Monetary Transmission Mechanism in Lithuania', *Baltic Economic Trends* 2, 28-36

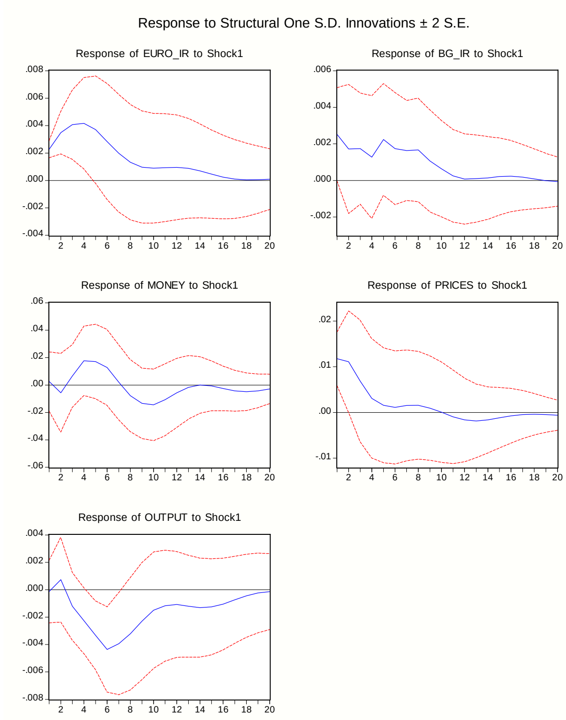
- Vetlov, I. (2003), "Monetary transmission mechanism in Lithuania", *Bank of Lithuania manuscript*

- Yankov, V. (2004), "*Endogeneity of the Money Supply Process in a Currency Board Economy and the Monetary Transmission Mechanism within a Monetary Business Cycle Model*", PhD dissertation

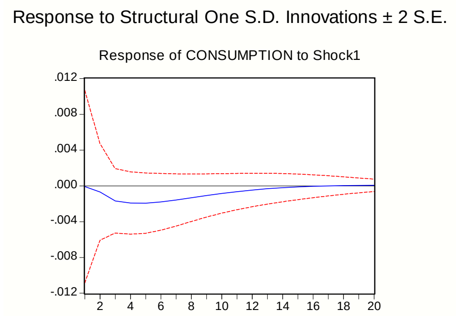
- Watson, M. (1994), "Vector Autoregressions and Cointegration" in *Handbook of Econometrics, Volume IV*, R. Engle and D. Mc-Fadden, eds. Amsterdam: Elsevier Science Ltd., 2844–2915

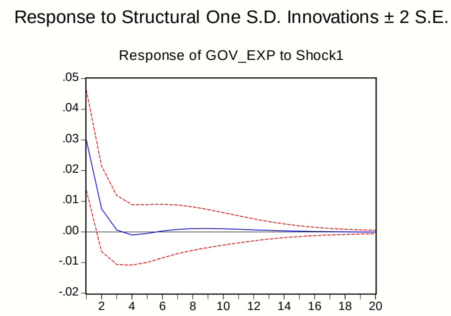
Appendix 1 – Checking robustness with respect to the public deficit to GDP ratio (the left column) and the public debt to GDP ratio (the right column)

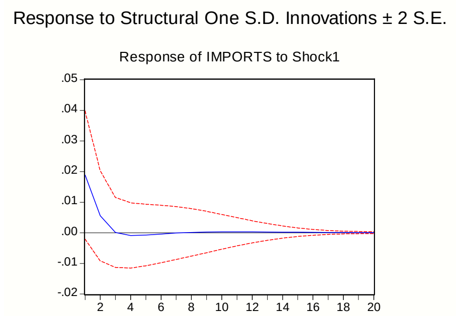


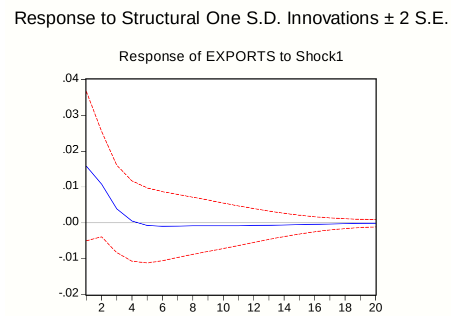


Appendix 2 – Responses of several real variables to an ECB interest rate shock









Notes:

- The 5 % confidence interval of each of the impulse response functions (IRFs) (represented by the two dotted lines on each graph) has been calculated using the bootstrap method by carrying out 1000 simulations.
- The response of a variable of the system following a shock to another is given by the full line on each graph.
- The fact that IRFs to shocks stabilize and come back towards zero indicates on the one hand, that the VAR model is correctly specified and on the other, that all macroeconomic series are integrated of order zero.