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Contents

SUMMARY. 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. Based on an identification scheme reproducing essential CB characteristics, we propose a SVAR which confirms the endogeneity of main Bulgarian monetary aggregates to shocks on the ECB interest rate, with different reactions to shocks on the FED interest rate or the Bulgarian Leva (BGL) to USD exchange rate.

JEL Classification: E42, E52

Keywords: Currency Board, monetary policy, SVAR, Bulgaria

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1. Introduction

Understanding monetary policy is without any doubt a traditional yet very active research field in economics. 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. We denote by monetary policy instruments different monetary exogenous or controlled variables, that a policy–maker can control and change in a discretionary way (*i.e.* the refinancing interest rate or money supply).

In line with EFN (2004, pp. 100–101), changes in monetary policy instruments are expected to affect the economy mainly through four channels: the direct interest rates channel, the exchange rate channel, the domestic asset prices channel and the credit channel. The present study focuses mainly on the direct interest rate channel, and to a lesser extent, due to particularities of the monetary system in Bulgaria, on the exchange rate channel.

As Taylor (1995) emphasizes, traditional IS–LM Keynesian–based macroeconomic theory in a country with complete autonomy of monetary policy suggests that tightened monetary policy, i.e. a discretionary exogenous raise in the interest rate or a diminish of the money supply, should diminish prices 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 assets demand relatively to the demand in the rest–of–the–world assets).

To find empirical evidence of the existence of such effects, most studies use Structural Vector AutoRegressive (hereafter SVAR) models.[1] This approach consists in augmenting VAR models with some "structural" or economic–based constraints, in order to identify "pure" monetary policy shocks. Once these shocks defined, it is possible to simulate the impact of an exogenous change in the monetary instrument on different economic variables. In the present study, we estimate several SVARs in order to try to better understand how exogenously changes in the interest rate and the exchange rate affect a set of key macroeconomic variables in Bulgaria.

[1] Alternatively, see the narrative method used by Friedman & Schwarz (1963) or Romer & Romer (1989, 2004).

The presence of a particular monetary system (a Currency Board, hereafter CB) implies the lack of Bulgarian controlled monetary instruments, since domestic money supply and interest rate are endogenous. Consequently, we study two types of shocks: changes in the ECB interest rate and changes in the FED interest rate (connected with variations in the BGL/USD exchange rate).

Results in our estimations confirm that Bulgarian interest rate and money supply are endogenous. In particular, the domestic interest rate is rather disconnected from the ECB interest rate in the short run, which produces new evidence on the CB functioning. Furthermore, we find that changes in the FED interest rate affect Bulgarian main variables with a lag, while their adjustment is rather different with respect to a shock on the ECB rate.

The rest of our paper is organized as follows. Section two contains an extended survey on monetary policy transmission, upon the degree of monetary autonomy. Section three proposes an overview of the main characteristics of the CB system in Bulgaria, while in section four we build a SVAR model in order to estimate the reactions of some Bulgarian economic aggregates to external monetary shocks. Finally, section five explores some possible extensions and concludes.

2. Monetary policy and SVARs: a survey of the existing literature

SVAR analysis has been used in rather heterogeneous fields.[2] For example, Blanchard & Perotti (2002) perform a SVAR analysis to search for macroeconomic effects of fiscal policy, L'Horty & Rault (2003) propose a study of the labor market, while Parent & Rault (2004) use it to obtain evidence on the bimetallism over the 1850–1870 period. Nevertheless, a vast majority of articles involving SVAR analysis deal with monetary policy issues, as SVARs are considered a powerful and useful tool in addressing this kind of topic.[3]

Within the monetary policy frame, most of studies have focused on the monetary policy shocks transmission to different key macroeconomic

[2]For a presentation of the SVAR method, see Hamilton (1994) textbook or Stock & Watson (2001).

[3]Gavin & Kemme (2004, p.18), remark that the SVAR method "*...is widely used to study the effect of monetary policy shocks*", while Morsink & Bayoumi (2001) confirm that they use the SVAR technique because it allows placing minimal restrictions. Leeper et al. (1996), Rudebusch (1998), Sims (1998) and Stock & Watson (2001) try to assess the robustness of SVARs.

variables,[4] as suggested by the impressive literature review proposed by Christiano et al. (2000).To better fit the goal of the present study, we split the literature upon the *degree of autonomy* of the monetary policy. Indeed, as recalled in *Introduction* and developed below, the CB system adopted by Bulgaria has the main characteristic of heavily restricting (one might say to zero) autonomy of Bulgarian monetary policy.

The first subsection is dedicated to countries with autonomous monetary policy, including the United States, other developed countries and the former Acceding Countries (that integrated the European Union in 2004). Considering this latter group of countries enriches our analysis with some evidence on countries with only partially autonomous monetary policy.[5]

Monetary policy effects in countries with autonomous monetary policy

It makes no doubt that most of articles that use SVAR analysis to quantify the effects of monetary policy focus on the US economy.[6] In a very popular contribution, Sims (1992) estimates a monthly data SVAR with six variables, namely industrial production, prices, the interest rate, a monetary aggregate, the exchange rate and commodity prices. Similar to previous analysis in Evans (1989) or Blanchard & Quah (1989), but in a rather different context,[7] Sims (1992) finds that output (or industrial production as a *proxy*, to benefit of monthly data) response to monetary shocks follows a hump–shape (or a U shape), with maximum after several periods.

In a comment on this article, Eichenbaum (1992) finds that a positive shock on money M1 increases the federal funds rate and decreases output, which is rather counter–intuitive, but the result that really puzzled economists

[4]Other studies in monetary policy, but in different directions, include Crowder & Wohar (2003) who investigate the wealth effect on consumption, or Quah & Vahey (1995) and Jacquinot (1998) who measure core (structural or long-term) inflation in the UK and France respectively. Mojon *et al.* (2002) build a SVAR to find evidence on the link between monetary policy and investment in the Euro Area.

[5]Beside, it is highly probably that these countries could produce information in an environment that is characterized by nominal convergence, similar to the period that Bulgaria knew in recent years, as part of the integration process in the European Union (officially achieved in January 2007). Corricelli et al. (2006) propose a survey on the monetary transmission mechanism in Central and Eastern Europe.

[6]See, for example, Bernanke & Blinder (1992), Christiano & Eichenbaum (1992), Gordon & Leeper (1994), Eichenbaum & Evans (1995) or Christiano et al. (1996).

[7]Evans (1989) and Blanchard & Quah (1989) find hump-shaped effects on output but in a quarterly data SVAR with only real variables (US unemployment and real output growth). Second, contrary to Sims (1992), theirs identification schemes include long-run restrictions to split between supply (permanent) and demand (temporary) shocks.

was the rise in prices. Eichenbaum (1992) pretends that this effect is sufficiently robust and important to be named as the "price puzzle", and since then an important literature focused on explaining this effect (see, *e.g.* Leeper & Roush, 2003, Hanson, 2004, or Giordani, 2004). One of the most accepted explanations of the price puzzle is the one proposed by Sims (1992): the monetary policy tightening purpose is to diminish *future* inflation, while a simple VAR would only measure the effect on *current* inflation. To overcome this shortcoming, Sims (1992) proposes to include a variable that would capture enough additional information about *future* inflation (precisely, about the persistency of future inflation), and he selects the *commodity world prices*.[8] Further evidence in Christiano *et al.* (2000) or Boivin & Giannoni (2002), confirm that specifying commodity world prices performs rather well in solving the price puzzle.[9]

Except few articles using identification schemes based on signs (Castelnuovo & Surico, 2005, or Peersman, 2005), two types of constraints are generally used: short-term constraints and long term constraints (see Gali, 1992, for an example of both identification schemes). In this paper we focus exclusively on short-term constraints.

The literature emphasizes two broadly used types of contemporaneous constraints. First, in a pioneer work, Sims (1982) estimates a SVAR model with M1 and output by considering that money supply M1 is predetermined and policy innovations are exogenous with respect to the non–policy innovations (*i.e.* the policy variable M1 does not contemporaneously respond to output shocks, because of information lags in formulating policies). Results are similar to Cochrane (1994), who shows that, following a shock on money supply M2, M2 positively responds on impact and federal funds rate initially diminish, while both public spending and output follow a hump–shaped curve.

Alternatively, Bernanke & Blinder (1992), Leeper *et al.* (1996), Bernanke & Mihov (1998) and Christiano *et al.* (2000) consider a reversed scheme, in which policy shocks have no contemporaneous effect on output, because of some stickiness in the reaction of output to monetary shocks. This hypothesis is generally accepted when data are monthly, but it is considered to be less

[8]Barth & Ramey (2001) propose a different interpretation of the price puzzle, based on the cost channel, i.e. higher interest rates raise the cost of holding inventories and, as a consequence, act as a positive cost shock. In fine this negative supply effect transits to prices, which rise.

[9]However, recent evidence on US quarterly data proposed by Castelnuovo & Surico (2005) suggests that using production price index of industrial commodities (which is close to commodity world prices variable) does not allow purging the price puzzle, a problem that appears also in our estimations.

plausible when model is estimated on annual data. In the same article mentioned above, Cochrane (1994) proposes a second SVAR in which he studies response of ordered variables (output, prices, commodities price index, M1 and federal funds rate) to an exogenous shock on the federal funds rate. An increase in the federal funds rate has the traditional short-term negative effect on the consumption variable, output and M1. However, including commodities price index does not allow solving the price puzzle, as prices increase in the short-run. Similar results are derived in a quarterly data SVAR with three variables, ordered output, inflation and federal funds rate, by Castelnuovo & Surico (2005). Following a shock on the federal funds rate, output negatively reacts and follows the traditional hump-shaped curve, while prices exhibit the price puzzle (in the absence of any correction variable).

Compared to the impressive amount of articles analyzing monetary transmission in the United States, there exist few papers addressing this question in other countries. Morsink & Bayoumi (2001) is a classical contribution for Japan; Sims (1992) provides evidence for France, Germany, Japan and United Kingdom (besides the evidence for the US, described above), while Dedola & Lippi (2005) focus on five OECD countries. An impressive study is proposed by Frankel *et al.* (2002), who analyze transmission of interest rates in 46 countries, divided between 18 industrial and 28 developing (but neither Central or Eastern Europe), using the currency regime as the main classification criterion. An important contribution is also Angeloni *et al.* (2003), who recense the most significant results of a common study (called *Monetary Transmission Networks*) realised by the ECB and 12 national Central Banks.

To close this section on countries with monetary policy autonomy, we split the eight former Acceding Countries in three groups. In the *first class* we include countries that follow inflation targeting (Czech Republic, Hungary and Poland), and have (among the former Acceding Countries) the highest degree of monetary policy autonomy. A very recent study on the Czech Republic by Arnostova & Hurnik (2005) builds on a SVAR model and finds that tightened monetary policy shock temporarily decreases output, while prices react more persistently and fall with a peak in 6 quarters after the monetary policy shock. A close study is EFN (2004) who finds that following a shock on the interest rate, output temporary declines, while prices, money and the exchange rate temporarily increase, then decline. The authors conclude that these findings are close to those for the Euro Area, as confirmed by Orlowski (2000). Finally, Lavrac (2004) concludes to the existence of important effects of an exchange rate shock, but his result is questioned by Coricelli *et al.* (2003).

Evidence on Poland in Garbuza (2003) suggests that both interest rate and exchange rate shocks have clear effects on output and inflation. However, as for the Czech Republic, the importance of exchange rate shocks is still to be discussed, as Korhonen (2003) and Coricelli *et al.* (2003) present opposite results. Moreover, EFN (2004) finds that changes in the interest rate have no short-term effect on output and money (with both declining in the following periods), while prices exhibit the price puzzle.

Finally, contrary to their results for the other two countries, Coricelli *et al.* (2003) isolate important effects of exchange rate shocks in Hungary. EFN (2004) completes these results for Hungary showing that output, prices and money all follow hump-shaped curves, with negative reaction in the short run.

The *second group* of Acceding Countries concerns those with managed floating regime, thus with lower autonomy of monetary policy (Slovak Republic and Slovenia). In a study on the Slovak Republic, Korhonen (2002) finds that exchange rate shocks have an impact on output, but however inferior to output response following changes in the interest rate. However, Kuijs (2002) and Ganev *et al.* (2002) support that variations in the exchange rate produce important effects, while broad money and interest rate changes have modest impact on the economy. To search for the robustness of these results, EFN (2004) builds a SVAR with variables ordered output, prices, exchange rate, money, and interest rate, and find that tightened interest rate shocks decrease prices and money, but increase output. Nevertheless, further investigation of this last counterintuitive effect on monthly data confirms that raising the interest rate is output decreasing in the short run.

Building on Delakorda (1999) and Ganev *et al.* (2002), Coricelli *et al.* (2003) find evidence of the presence of an important exchange rate pass–through in Slovenia. Concerning the reaction of the economy to shocks in the interest rate, EFN (2004) concludes that prices and money decrease, but output increases in the short run which is rather counterintuitive.

Finally, the *third* and, in the perspective of our analysis, most important class regroups Latvia (which has established a fixed peg with a basket of currencies), Lithuania (with a Currency Board and fixed nominal exchange rate with the USD, then with the EURO) and Estonia (also a Currency Board with fixed nominal exchange with the ECU, then the EURO). This last group of countries is included in a subsection below. However, before reviewing some of the main results, let us develop the main characteristics of the monetary policy in Bulgaria.

3. Overview of the monetary policy in Bulgaria

Starting July the 1st 1997, Bulgaria has decided to introduce a Currency Board (CB), in order to stabilize the domestic economy after the important crisis of 1996-1997 (see Berlemann & Nenovsky, 2004, for a description of the Bulgarian crisis). In so doing, Bulgaria joins Estonia and Lithuania who 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).[10] As we argued before, this type of organizing the monetary authority is a *sine-qua-non* condition to consider, if one tries to study monetary policy transmission in Bulgaria.

Pikkani (2000, p.6) resumes 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, in order to supply foreign currency on demand, a CB implies for 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 100% backing of domestic currency implies 100% technical or non–political credibility, as the 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 automatic sterilization of excess liquidity.[11] 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) explains, 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) emphasizes, "...[the CB should be seen as] a *long-run relationship between monetary conditions and not as a rapid current account adjustment mechanism*".

Yankov (2004) offers some additional insights on the CBs, explaining that under pegged exchange regimes (as the CB), domestic interest rate should

[10]Among other countries that used CB monetary system, we recall Argentina or Hong Kong.

[11]Niggle (1991) proposes a discussion on different theories on the endogeneity of the money stock.

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) argues that the velocity of the convergence process (to the anchor interest rate value) essentially depends on the degree of integration of financial markets, because financial assets are better substitutes and capital tends 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 resume,[12] neither monetary aggregates, nor the domestic interest rate can be considered as pure monetary instruments and used accordingly. In fact, under a CB as the one in Bulgaria, the use of monetary policy is restricted to excess reserves above the monetary base. 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 shocks transmission on the Bulgarian economy, we are left with mainly three types of shocks that can be considered as exogenous. The first one, and more 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.

Second, 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 is fixed against the EURO, while most of 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.

Third, we can eventually try to use the required reserves 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 an index which would reflect changes in both the level and the base on which this ratio is interfering.

[12]The few (very rare) theoretical models reproducing the CB functioning include Pikkani (2000), Desquilbet & Nenovsky (2003) or Blessing (2007).

Finally, in Bulgaria (as well as in Lithuania), 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 reserves accountancy. Thus, anytime 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 definetely 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, it is hard to admit that Government proceeds 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.[13]

Evidence from former Acceding Countries with monetary system close to Bulgaria

Recall that from all former Acceding Countries, Estonia, Lithuania and Latvia have little (zero) autonomous monetary policy and are therefore of high importance with respect to our analysis in Bulgaria.

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

Lithuania was the second country in the Central and Eastern Europe who introduced a CB monetary system, in 1994. The domestic money was first anchored to the USD, then to the EURO since 2002. Recent evidence from Vetlov (2003) suggests that the high degree of openness of the Lithuanian economy makes it rather vulnerable to the external environment (for example, shocks on the ECB interest rate). Furthermore, EFN (2004) finds that

[13]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 paradoxally, 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).

an increase in the ECB interest rate positively changes the domestic interest rate, with money deacreasing, price 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) identifies important effects of the exchange rate.

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

4. Evidence from monetary policy transmission in Bulgaria

The above evidence about monetary policy transmission in other CBs countries suggests that *i*) effects are short-lasting and rather weak, *ii*) money may have some cyclical behavior and *iii*) price exhibit the price puzzle. To investigate if these results apply to the Bulgarian economy, we develop in this section a SVAR model. The first subsection presents the data, subsection two discusses a benchmark case, in subsection three we check for the robustness of results, while in subsection four we propose an extension of the benchmark SVAR.

Data

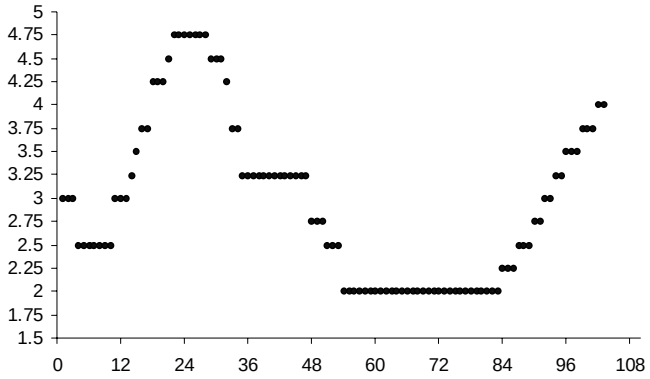
All data used in the benchmark analysis are quarterly, cover the period Q3 1999 until Q1 2007, leading to 31 observations. Even if Bulgaria introduced the CB on July the 1st 1997, we use data starting only the 3rd quarter of 1999 to allow for variables to "stabilize" after this important shock. For example, changes in consumer prices (*i.e.* inflation) highly 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).

The most important feature of the CB in Bulgaria is that domestic usual monetary variables are not controlled by the National Bank. Consequently, as stressed before, we consider in our benchmark model that monetary shocks come from the ECB refinancing interest rate. However, as illustrated by Figure 1, changes in the ECB refinancing rate are too rare to produce the necessary amount of variability in our analysis.

Figure 1

THE ECB MONTHLY MAIN REFINANCING RATE

(103 monthly data for the period 1999:1 – 2007:7, source BNB)

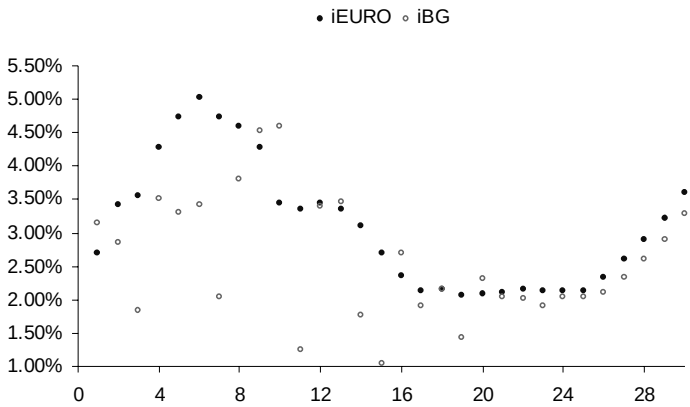


Thus, in line with other studies (for example, EFN, 2004), we use the LIBOR 3 months interest rate as the exogenous variable in our analysis.

Figure 2

THE ECB LIBOR EUR 3 MONTHS AND THE BULGARIAN MONEY MARKET RATE

(quarterly data for the period 1999:Q3 – 2007 Q1, source BNB)

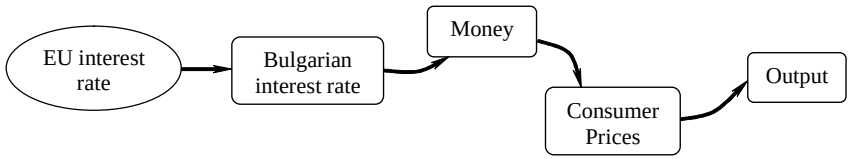


In our benchmark case, we study the impact of the i^{EU} on four variables. First, on the Bulgarian interest rate (i^{BG}), defined as the "money market rate". Second, we consider a broad money indicator M3, namely the annual (quarter to quarter) growth rate in M3. To capture the effect on prices, we use the annual (quarter to quarter) growth rate of consumer prices (inflation π).[14] Finally, to look for some real economy effects, we consider Y as the annual (quarter to quarter) growth rate of real output (GDP).[15] All these variables, as well as the LIBOR 3 months interest rate, come from the BNB dataset. All variables are considered to be stationary.[16]

In our benchmark case, we consider the transmission mechanism described in the Figure 3.

Figure 3

TRANSMISSION MECHANISM OF A SHOCK ON THE ECB INTEREST RATE



Arrows denote the transmission mechanism in our benchmark case.[17] An ECB interest rate shock has first an impact on the Bulgarian interest rate (i^{EU}) . Changes in interest rate (i^{BG}) (*i.e.* money prices) are supposed to affect money M3. Changes in money M3 further impact on consumer prices *(π)*. Finally, real activity *Y* (output) reacts last to initial changes in the ECB interest rate.

[15]Of course, one might compute (for example) quarterly growth for GDP, i.e. relative GDP change in one quarter with respect to the previous one. However, this might introduce some seasonality in our data. Money growth and GDP growth are own computations.

[16] ADF tests on the Bulgarian interest rate and on money growth reject the presence of a unit root, while ECB interest rate, inflation and output growth are found to be first-order integrated processes. However, due to the small size of our data, one should be careful in considering those series as non-stationary, as emphasized by Wu & Zhang (1997) for the interest rate (which is our solely exogenous monetary policy variable), in a panel of countries.

[17]As the most important trade partner of Bulgaria is the EU, we do not include in the benchmark case an exchange rate. However, evidence below discusses movements in the BGL to USD exchange rate, as the USD Zone is the second important trade partner of Bulgaria.

To reproduce the benchmark case in a SVAR, we consider the following assumptions. First, to capture the transmission mechanism i^{BG}- $M3 - \pi - Y$, we order the variables in this same order. With recursive identification, 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.[18] The second fact that we want to reproduce is that i^{EU} changes are the most exogenous. To capture this feature in a recursive SVAR, we order i^{EU} in the first position, implying that changes in other variables do not contemporaneously affect the ECB interest rate.

The benchmark model

We report that all SVAR were identified using the Cholesky decomposition upon a lower triangular matrix, which corresponds to a recursive SVAR with contemporaneous constraints. 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 by bootstrap.

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

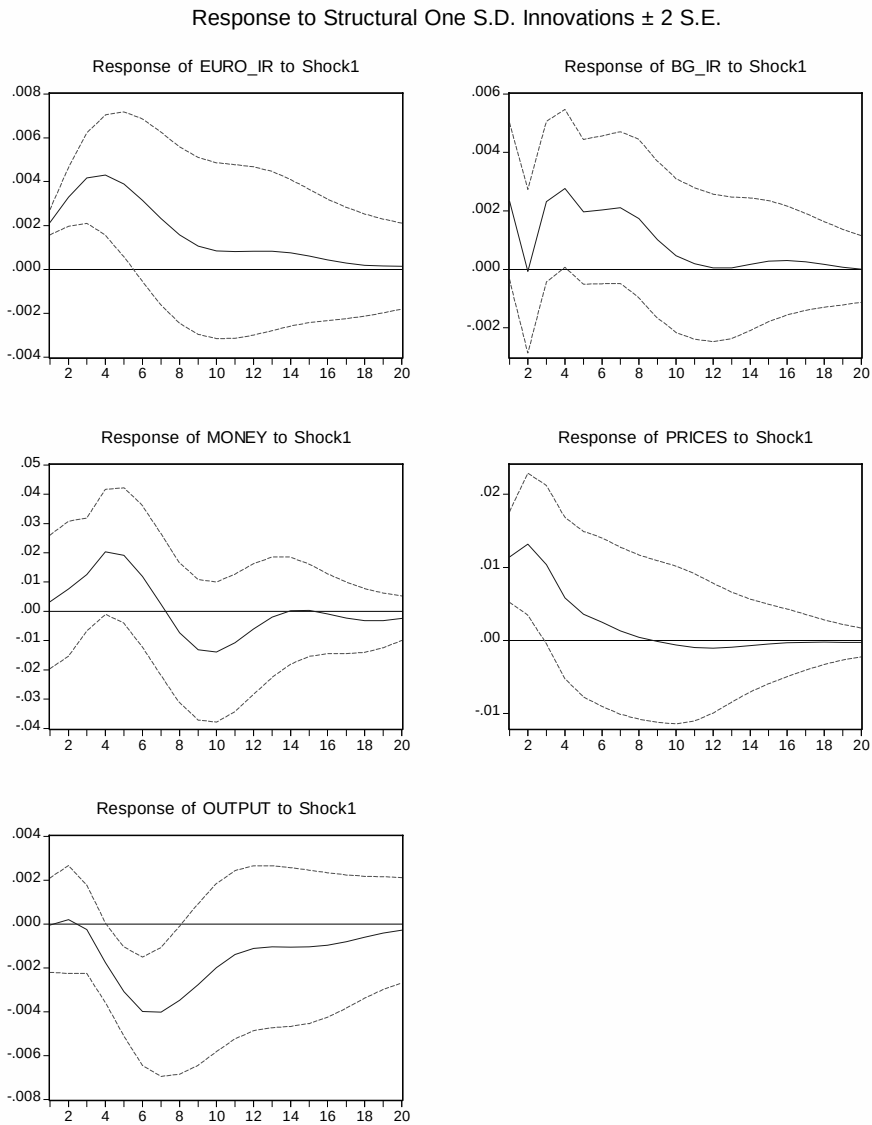
Lag	LR	FPE	AIC	SC	HQ
0	NA	6.30e-19	-27.71989	-27.47992	-27.64853
1	118.7921	1.46e-20	-31.52480	-30.08499*	-31.09667
2	38.68064*	1.02e-20*	-32.09049	-29.45082	-31.30558*
3	22.42913	1.61e-20	-32.27765*	-28.43814	-31.13596

[18]Of course, variables influence each other in lags. See the SVAR structure in the related literature.

Since three out of four information criteria prefer the lag 2 to the lag 1, 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. Figure 4 reports impulse response functions in our benchmark model.

Figure 4

REACTION OF BULGARIAN VARIABLES IN THE BENCHMARK



Observe first that an exogenous increase in the ECB interest rate initially increases the Bulgarian interest rate. However, the Bulgarian interest rate adjustment in the short-run is far from smooth (rather irregular). Money positively responds in the short-run, which is also counterfactual, but in accordance with EFN (2004). However, what is more important is that money adjustment is cyclical.

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 lack of smoothness in their short-run adjustment may suggest that adjustment in both aggregates take 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 or 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 of 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 the monetary system involves the presence of a Currency Board. In particular, remark that real data described in Figure 2 confirm that for a certain period of time, the ECB and the Bulgarian interest rate were rather disconnected.

Another point that could sustain these interpretations is that domestic interest rate adjustment is more rapid, compared to evidence in EFN (2004) for former acceding countries with some autonomous degree for monetary policy (Czech Republic, 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 usually defended in a CB monetary system as the one in Bulgaria (see, e.g. Babich, 2001, Bems, 2001, or Vetlov, 2003).

Building on this interpretation for the behavior of monetary aggregates, we can withdraw very interesting information about output reaction. 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 for 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 explain it, we turn back to the irregular adjustments in the 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 rapidly compared to economies with higher monetary autonomy, but in line with results for countries under CB.

To resume, 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 behavior of these two variables would somehow be constrained by some institutional interference. In this case, both domestic interest rate and money present an irregular adjustment, a result supported by real data in Figure 2, showing that domestic interest rate has been deconected from the evolution of the ECB interest rate, for quite an important period of time. However, notice that this adjustment takes less time compared to more autonomous economies, a result that comes close to the evidence that CBs economies adjust very quickly. In this case, output lacks reaction in the initial periods, which can be also considered 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 adjustment takes less time, reproducing the idea that external monetary shocks have short–lasting impacts on real activity in a CB.

Robustness

i) exogenous variables

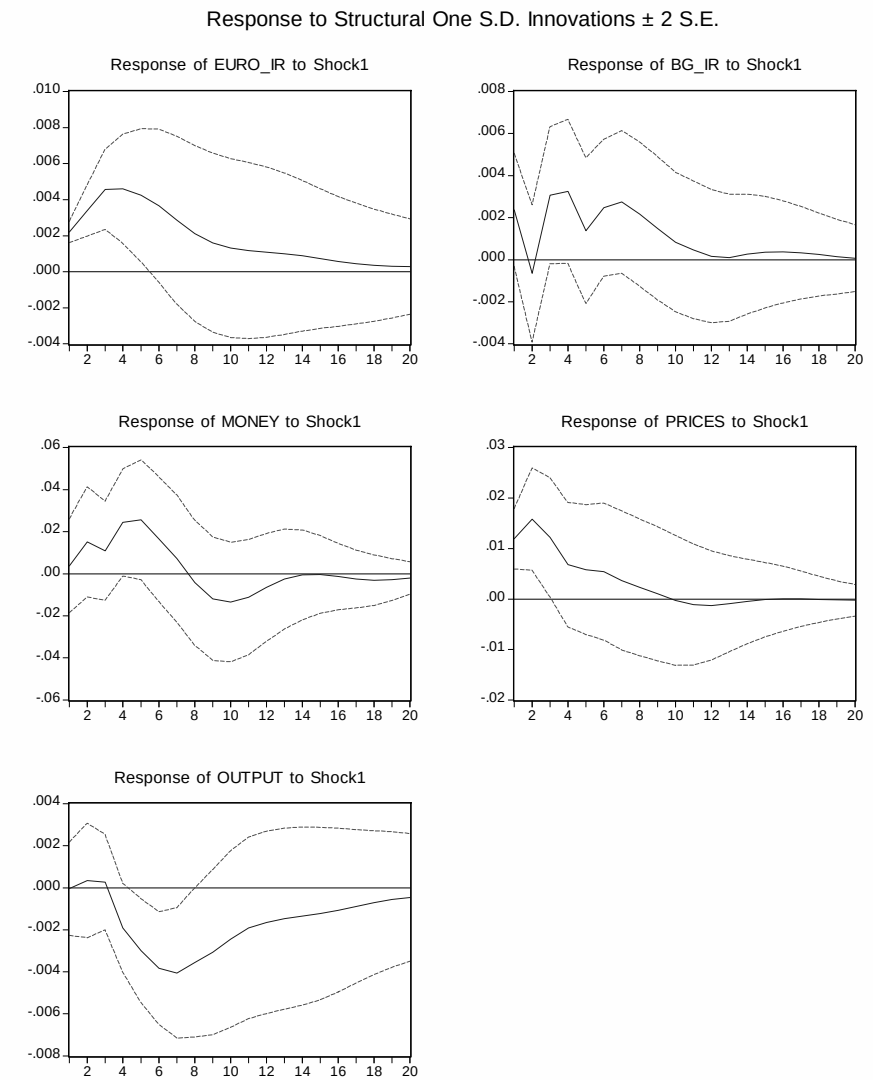
In this sub-section we consider some experiments to check for the robustness of our benchmark model. To do so, we estimate a SVAR model including other variables as exogenous (outside the SVAR structure).

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 did not allow to unambiguously conclude to the absence of the 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.

Second, we give interest to the presence of other exogenous variables. As in EFM (2004), we introduce several *fiscal variables* as exogenous, to prove that our benchmark result still holds. First, we consider the *ratio of public deficit to GDP*, in quarter-to-quarter growth rate. Results are described in Figure 5.

Figure 5

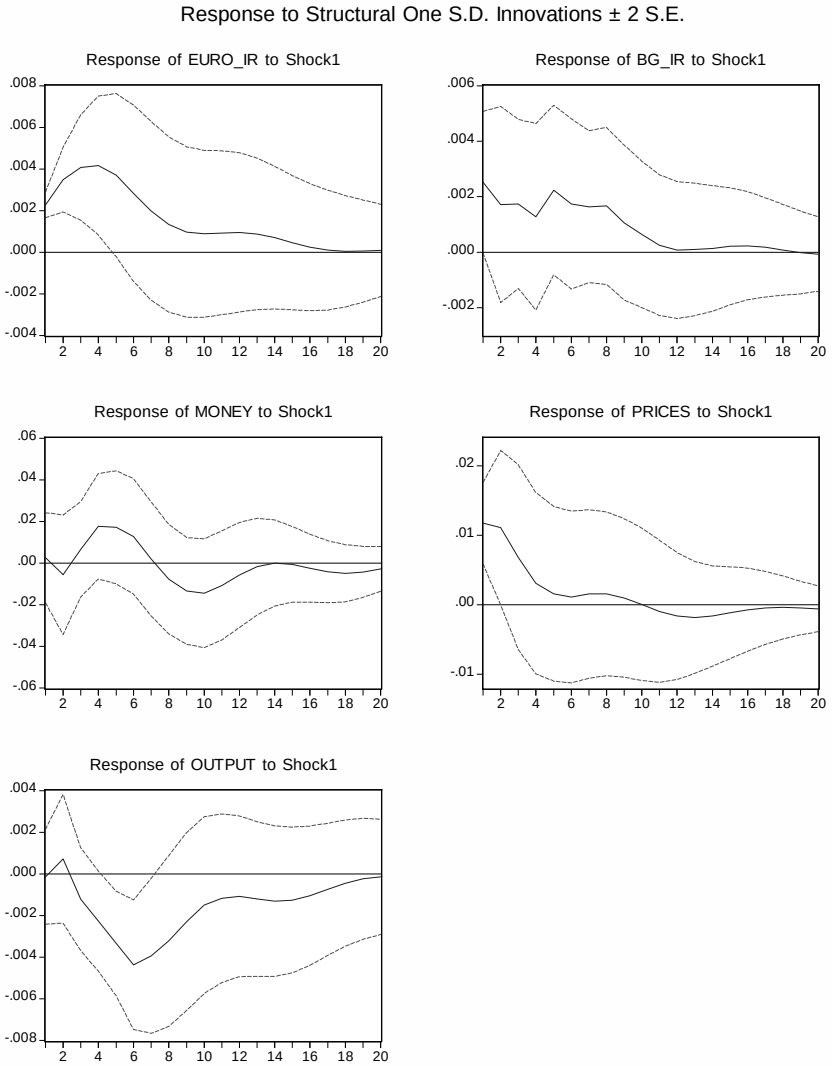
THE BENCHMARK SVAR WHEN CORRECTING FOR DEFICIT/GDP



Second, we correct for the variation of the *public debt to GDP ratio*. Indeed, Bulgaria knew during this period a significantly reduction in the public debt to GDP ratio, which exhibits a very pronounced negative slope. Thus, to correct the non-stationarity problem that unit root tests exhibit, we use the first order difference of the ratio (cf. Figure 6).

Figure 6

THE BENCHMARK SVAR WHEN CORRECTING FOR (DEBT/GDP)



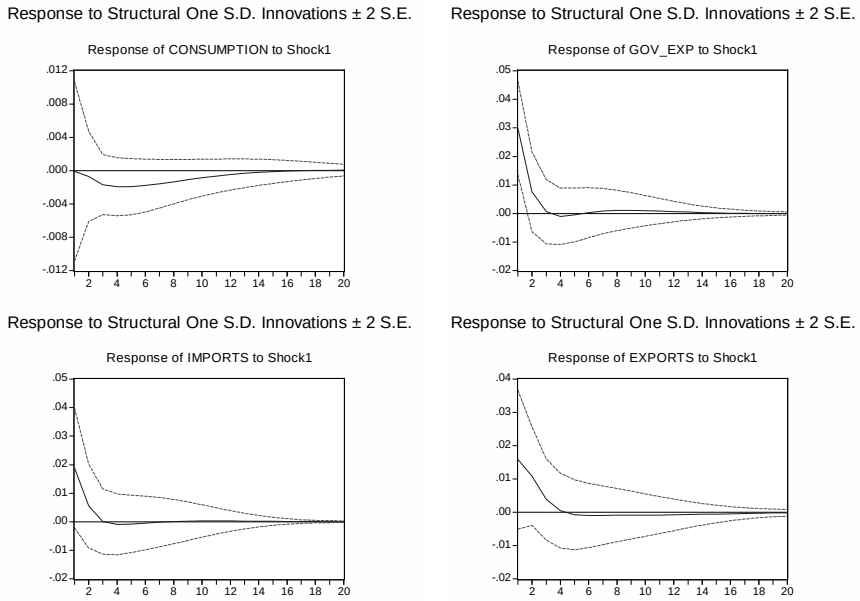
As Figures 5 and 6 confirm, our results are qualitatively unchanged when correcting for these two fiscal variables, notably concerning the adjustment of Bulgarian interest rate, money supply and output. Finally, similar to EFN (2004), correcting for these fiscal variables does not allow solving the price puzzle.

ii) 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.

Figure 7

Responses of several real variables to an ECB interest rate shock



In accordance to Figure 7, following a positive shock on the ECB interest rate, private consumption decreases less that output, confirming that consumption adjusts smoother than output.[19] 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 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, one explanation is that these variables are highly coordinated in Bulgaria, since a major share of exported goods are produced with imported goods.

Further analysis

While the analysis up to this point is dedicated to the interest rate channel, we focus in this subsection on the exchange rate channel. Of course, the CB in Bulgaria implies that the exchange rate with the anchor (the EURO) is constant, which is why this analysis is impossible. However, Bulgaria still has important relations with countries like Turkey, Russia etc, and these countries are heavily linked to the United States Dollar (USD). Therefore, we believe that changes in the FED policy, as well as in the BGL/USD exchange rate, may have some influence on the Bulgarian economy.

To do so, we consider a SVAR in which we replace the ECB interest rate with the US interest rate and place the BGL/USD exchange rate second.[20] The information criteria (including Schwarz) and the LR test suggest the adoption of lag 1. Figure 8 illustrates the response of variables to a shock in the FED interest rate.

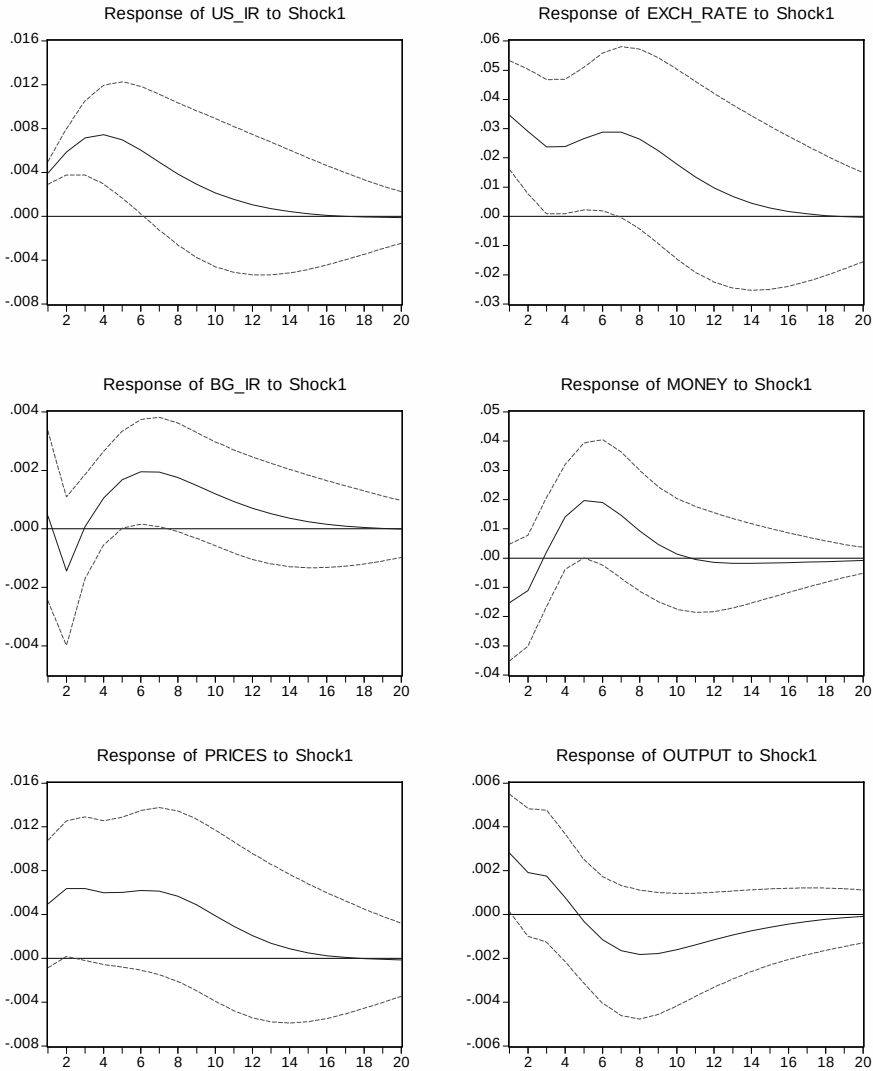
[19]To find if investment is more volatile than output, we have performed several estimations using the gross fix capital formation (GFCF). Unfortunately, the GFCF is extremely volatile in the first quarters of the sample and our attempts to shorten the sample by disregarding these initial values did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

[20]As we show in an Appendix available on request, results are qualitatively unchanged when abstracting from introducing the exchange rate in this SVAR.

Figure 8

EFFECTS OF A CHANGE IN THE US INTEREST RATE, INCLUDING EXCHANGE RATE EFFECTS

Response to Structural One S.D. Innovations ± 2 S.E.



With respect to our benchmark model, we remark several important changes. First, it is obviously that domestic interest rate responds very differently to changes in the FED interest rate, since the Bulgarian interest rate follows the raise in the FED rate with a certain lag. This result may receive a typical interpretation: domestic rate responds to higher returns on capitals outside the EURO area in order to preserve domestic capitals inside Bulgaria. Besides, according to traditional macroeconomic textbooks, an increase in the FED interest rate depreciates the BGL/USD exchange rate.

Further, money initially decreases then increases, following its reaction in the benchmark model, as soon as domestic interest rate increases. Raising US interest rates (or, more precisely, interest rates in the USD zone, which includes some important trade partners of Bulgaria) has a positive effect on Bulgaria's competitivity (through the exchange rate channel), which explains the initial raise in output. However, in the medium term, Bulgarian interest rate must positively adjust to follow the raise in the US rate, which offsets output.

Overall, we observe an important adjustment bias of the Bulgarian economy following a shock on the FED rate, compared to a shock on the ECB rate. Indeed, domestic interest rate follows the US rate with some lag and the adjustment period is more important. Both money and prices respond more vigorous and especially the persistence of the shock is significantly larger, while the medium–term negative effect of output is less strong, confirming that Bulgaria is financially more integrated with the Euro Area, than with the USD Area.

To resume, compared to a change in the ECB interest rate, a positive shock on the US interest rate followed by the depreciation of the BGL generates rather different effects. First, Bulgarian interest rate converges to the US interest rate with a certain lag. Because domestic interest rate adjusts only after some periods, output benefits from the BGL depreciation and initially increases. However, output declines once domestic interest rate follows the FED interest rate expansion.

5. Conclusion and extensions

The purpose of this study is to propose some new insights on monetary policy transmission in Bulgaria, using estimations based on the SVAR method.

An important literature survey proposes extensive evidence from previous studies. In Bulgaria, the main characteristic of the Currency Board in place is the lost of autonomy for monetary policy, concerning the two main (traditional) instruments, the interest rate and money supply. For this reason, we split the litterature review upon the degree of autonomy of the monetary

policy. Countries with complete autonomy include the United States, the Euro Area, while we present some evidence on several developed countries.

Insights from the former Acceding Countries allow illustrating monetary policy transmission in economies where monetary policy is autonomous up to a certain degree, as for example in Czech Republic, Poland, Hungary, Slovak Republik and Slovenia. However, we consider as the most important the evidence for countries with no monetary policy autonomy (Lithuania, Latvia and Estonia), as their monetary system is identical or close to the CB in Bulgaria.

The presence of a particular monetary system (a CB) is a determining factor in analyzing monetary policy in Bulgaria. Consequently, an entire section is devoted to Bulgaria's CB and the implications generated by adopting such a monetary system, and particularly in explaining how an exogenous monetary shock may be defined.

Our benchmark SVAR model concludes that both the domestic interest rate and money follow the ECB dynamics only in the medium-long-run. In the short–run however, both aggregates' responses are irregular, 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 is why firms and households may take decisions which diverge from decisions that would have been taken by an autonomous Central Bank (as confirmed by our Figure 2). Even though output does not react in the short-run, our hypothesis in our SVAR excludes output stickiness, implying that this result can only be explained by an identical "time-to-built" interpretation, namely that the economy needs time to collect enough information about future adjustments of monetary aggregates. These results remain robust when we control for some exogenous fiscal (public deficit or public debt) or real variables (private consumption, public expenditure, exports or imports).

We add to this evidence concerning the ECB interest rate effect, an analysis focused on two other elements. Precisely, we study Bulgarian variables reaction to a change in the FED interest rate (which affects important trade partners of Bulgaria that mainly use USD), while controlling for the BGL/USD exchange rate. We show that an increase in the FED interest rate, followed by a (standard) depreciation of the BGL, generates an increase (with a certain lag) in the Bulgarian interest rate, while output positively responds in the short run.

It is our intimate conviction that further analysis is needed to complete our results. A first development, in line with Boivin & Giannoni (2002) or Castelnuovo & Surico (2005), should allow replacing the output growth rate

by a detrended series (by using, *e.g.* the Hodrick–Prescott filter, the Beveridge-Nelson decomposition or the Unobserved Components decomposition). A second extension should give interest to the use of different identification schemes (for example, a non-triangular contemporaneous identification in which money and prices would contemporaneously influence each other in response to changes in the ECB interest rate).

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