Monetary Policy in a Small Open Economy with Fixed Exchange Rate: The Case of Macedonia

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Abstract

This paper empirically applies the New Keynesian model for monetary policy analysis in a small open economy with a fixed exchange rate. Official reserves are included in the interest-rate rule to account for the constraint that these impose on monetary policy when the exchange rate is fixed. Also, the foreign interest rate is included in order to reflect the necessity of following the foreign monetary policy. The model is applied to Macedonian data from the period 1997-2011. In general, results indicate that monetary policy has been focused on domestic objectives during this period, despite the fixed currency. In addition, there seems to have been significant differences in the conduct of the monetary policy in the first half and the second half of this period. The response to inflation has been more aggressive in the earlier period, at a time when reserves appear less important, while the output gap is found to be important only in the latter period, possibly due to the stronger monetary policy transimission. Finally, results indicate that the monetary policy has likely moved from adaptive in the first period, to rational in the second period.

Keywords: New Keynesian model, monetary policy, fixed exchange rate, Macedonia

JEL classification: E12, E43, E52

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1. Introduction

In recent years, the New Keynesian framework has become the dominant framework for analyzing monetary policy. It incorporates advances of macroeconomic modelling from the real business cycle theory – the dynamic general equilibrium techniques (hence, New) into a model that explicitly recognizes the existence of nominal price rigidities, which gives rise to non-neutral effects of monetary policy (hence, Keynesian). The simplest model arising from this framework is the New Keynesian model (NKM). NKM consists of three equations - IS curve, which defines output; Phillips curve, which defines inflation; and interest-rate rule, which defines monetary-policy conduct.

A large strand of literature applies the New Keynesian framework to analyse monetary policy; an indicative list includes: Clarida *et al.* (1998; 2000); McCallum and Nelson (1998); Ireland (2001); Smets and Wouters (2003; 2007); Lubik and Schorfheide (2004); Giordani (2004); Christiano, Eichenbaum and Evans (2005), Gerdesmeier *et al.* (2007); Lee (2009). However, all empirical works have been done for countries that target inflation, explicitly or implicitly. In this framework, monetary policy is designed to react to the deviations of inflation and output from their targets. Still, this is hardly applicable for a small open economy exposed to external supply-side shocks and targeting the nominal exchange rate. In such circumstances, the main guidance for the monetary-policy conduct likely stems from the developments on the foreign exchange market, i.e. the need to maintain the chosen exchange-rate parity. Hence, the central bank might be tightening when the economy goes down, in order to sustain the rumours for devaluation, which is apparently not a prediction of the New Keynesian model. The present study aims to modify the New Keynesian framework for the case of a small open economy with a fixed exchange rate and to analyze to what extent the peg affected the monetary policy conduct.

In theory, economies with fixed exchange rates can still have an independent monetary policy, as long as they have limited capital mobility, which can occur, for instance, due to the maintenance of some capital controls or due to the underdeveloped financial markets. Nevertheless, the fixed exchange rate largely constrains monetary policy - if the level of reserves is too low, monetary authorities might be precluded from targeting inflation or output, since this might peril the maintenance of the chosen parity. Moreover, significant differences in the interest rates in the domestic country and the country to which the exchange rate has been fixed can result in arbitrage opportunities, which can endanger the parity as well. To account for these two issues, the standard NKM is modified by including official reserves in the interest-rate rule, to account for the constraint that reserves impose onto monetary policy when the exchange rate is fixed, and by including the foreign interest rate, to capture the subordination of the policy when the exchange rate is fixed. The model is then applied to the case of Macedonia, for the period 1997-2011, to investigate whether our conjecture about the importance of the reserves for the monetary policy holds, and whether monetary policy has been dedicated to domestic goals.

The policy implications that emerge from this study are related to the choice of the optimal exchange rate regime for small open economies and to the conduct of monetary policy in countries with fixed regimes. Namely, it is usually considered that by fixing the exchange rate, countries lose their monetary policy. This consideration has been one of the factors that have lead many small open economies to choose a floating regime. Hence, the findings of this study about the actual behavior of the monetary policy in Macedonia can serve as a useful argument in this debate - finding that the monetary policy has responded to movements in inflation or economic activity would imply that it has been dedicated to domestic goals, i.e. that monetary policy can be independent, despite the peg. On the other hand, finding significant coefficients in front of the foreign interest rate and the international reserves would imply that monetary policy, though independent, has still been constrained, i.e. that optimal monetary policy should closely follow the movement of international reserves.

The organization of the paper is as follows. The next section briefly introduces the New Keynesian model and suggests a variant to accommodate the case study of a small open economy with a fixed exchange rate. In section 3, the data and the research methodology are presented. Section 4 reports results, conducts robustness checks, and discusses. Section 5 concludes.

2. Applied New Keynesian Model for a Small Open Economy with a Fixed Exchange Rate

2.1. Brief Theoretical Overview

The New Keynesian Model (NKM) consists of three types of agents - households, firms and the government (the central bank). Agents maximize some objective function, subject to constraints. The model assumes differentiated goods and monopolistic competition, which allows firms to set prices. It further assumes sticky price adjustment - only a certain fraction of firms can adjust prices each period, which makes monetary policy non-neutral. The model is well established in the literature and Gali (2008) is followed herein; for a thorough elaboration refer to Gali (2008, Chapter 3), Woodford (2003, Chapter 3), Walsh (2003, Chapter 5).

The economy is composed of a continuum of households and firms. The representative household consumes a basket of goods and supplies labour to imperfectly competitive firms. The objective of each household is to maximize its utility, which is the difference between the utility from consumption and the disutility from working:

$$\max E\ [\sum_{i=0}^{\infty}\beta^{i}(\frac{C_{t+i}^{1-\gamma}}{1-\gamma}-\frac{\mathrm{N}_{t+i}^{1-\phi}}{1-\phi})] \tag{1}$$

whereby E denotes the expectations operator, N_t is the number of hours worked, C_t is the basket of goods consumed consisting of differentiated products produced by monopolistically competitive firms, β is the discount factor, γ is the coefficient of relative risk aversion (the inverse of the elasticity of intertemporal substitution) and ϕ is the inverse of the Frisch elasticity of labour supply. The basket of goods and their prices are represented in a Dixit-Stiglitz (1977) manner:

$$C_t=[\int_0^1 c_{jt}^{(\sigma-1)/\sigma}dj]^{\sigma/(\sigma-1)} \tag{2}$$

$$P_t=[\int_0^1 p_{jt}^{1-\sigma}dj]^{1/(1-\sigma)} \tag{3}$$

whereby c_{jt} and p_{jt} denote goods produced by and prices of individual firms and $\sigma>0$ is the price elasticity of demand for the individual goods.

Households maximize utility subject to the following budget constraint:

$$\int_0^1 p_{jt}c_{jt}dj + B_t = W_t N_t + (1+i_{t-1})B_{t-1} + T_t \tag{4}$$

Whereby: W_t is the nominal wage per hour, B_t is the quantity of nominal one-period bonds paying interest i_t, T_t is the nominal lump-sum transfers and $\int_0^1 p_{jt}c_{jt}dj$ represents the total nominal expenditure of consumption goods, the sum of expenditures on all indivudal goods, $p_{jt}c_{jt}$. Equation (4) suggests that what households get as wages, interest from bonds (i.e. savings) and transfers, they spend on purchasing goods and buying bonds (i.e. saving).

Transfers are the redistribution of firms' profits. One way to think about this is that firms are owned by the government (or that the tax rate is 100 percent). The role of the government in this simple model is then to redistribute the profits and to issue bonds (by which households distribute income inter-temporally), where the interest rate on bonds is determined by the government. There is no government consumption/investment in this model, and therefore the two functions of the government are separated. Although there is only one authority in the model, this does not imply that monetary policy is not independent. Independence in this type of models is usually associated with the *commitment* of the authority, which eliminates the inflation bias (i.e. the rules vs. discretion debate; see Kydland and Prescott, 1980 or Clarida et al. 1999).

Firms produce differentiated consumption goods (c_{jt}), according to identical exogenous production technology Z_t with only one factor of production - labour (N_t):

$$c_{jt} = N_{jt}Z_t \tag{5}$$

Not all firms can change their price every turn, i.e. in each turn, a fraction of 1-ω of the firms adjust their price, which is then readjusted each turn with a probability of ω (Calvo pricing). Firms maximize profits subject to three constraints: the production function (eq. 5); the demand curve they face (eq. 2) and the Calvo pricing condition. Firms' problem, thus, becomes choosing the price for their product (p_{jt}) in order to maximize the profit:

$$\max E \sum_{k=0}^{\infty} \omega^k \beta^k \left(\frac{C_{t+k}}{C_t}\right)^{-\gamma} \left(\frac{p_{jt}}{P_{t+k}} c_{jt+k} - \frac{W_{t+k}}{P_{t+k}} \frac{c_{jt+k}}{Z_{t+k}}\right) \tag{6}$$

The profit in period *t+k*, $(\frac{p_{jt}}{P_{t+k}} c_{jt+k} - \frac{W_{t+k}}{P_{t+k}} \frac{c_{jt+k}}{Z_{t+k}})$, multiplied by the probability that the price has not changed between *t* and *t+k*, (ω^k), is discounted by the stochastic discount factor $(\beta^k (\frac{C_{t+k}}{C_t})^{-\gamma})$.

Maximizing the above objective functions, then log-linearizing the first-order conditions around the steady-state, and some additional algebraic manipulations, yields the following two equations:

$$y_t = Ey_{t+1} - \frac{1}{\gamma}(i_t - E\pi_{t+1}) \tag{7}$$

$$\pi_t = \beta E\pi_{t+1} + \alpha y_t \tag{8}$$

Equation (7) is the IS curve, which describes aggregate demand, i.e. the output gap ($y_{t,}$) as a function of the expected output gap and the real interest rate; equation (8) is the Phillips curve, which describes aggregate supply, i.e. inflation (π_t) as a function of expected inflation and the output gap.

However, the model specifies two equations with three unknowns - inflation, output gap and real interest rate. Hence, interest-rate function is needed to close the model. The interest rate is modelled as a Taylor-type (1993; 1999) rule[1]:

$$\Delta i_t = a(E\pi_{t+1} - \pi^*) + bEy_{t+1} \tag{9}$$

which states that the monetary authority adjusts the nominal interest rate (i_t) in order to minimize deviations of expected inflation ($E\pi_{t+1}$) from the target (π^*) and deviations of expected output from the potential. It should be noted that the Taylor rule is not optimal in this simple model (see Gali, 2008, Chapter 4). Optimal monetary policy in this model cares only about stabilizing inflation, and output is then stabilized indirectly (the "divine coincidence"). Since the paper is positivistic in nature, we opted for the more standard Taylor-type rule, since it is more likely to represent reality.

The NKM, thus, consists of three equations: (7), (8) and (9). The constructed model: i) has clear micro-foundations in individual optimization; ii) has forward-looking expectations; and iii) is less susceptible to the Lucas critique - expectations are rational and change with changes in policy. Moreover, the model focuses on interest-rate policy which is in contrast to the traditional focus on changes in base money. This is in accord with the current practice, whereby central-bank policymakers mainly discuss changes in the nominal overnight interbank interest-rate target and leave the handling of the base money to trading specialists to achieve those targets. Monetary policy in the model affects output directly, through the real interest rate, and inflation indirectly, through output.

2.2. Adaptation of the New Keynesian Model

Small open economies are very exposed to external shocks which easily transmit onto the real economy. Under a fixed exchange rate, the intensity with which an external shock is transmitted onto the output becomes even higher, which puts pressure on monetary policy - to preserve the chosen exchange-rate parity, the central bank must intervene on the foreign exchange market through sterilised interventions, which affects the level of official foreign reserves. Hence, the pressures on the foreign exchange market are the major driving force of monetary policy in a small open economy with a fixed exchange rate. To capture the monetary policy setup in a small open economy, the interest-rate rule (9) is accommodated in the following way. At the outset, official reserves are added, because of two arguments: firstly, given the fixed exchange rate, official reserves might impose a constraint on monetary policy since insufficient reserves might preclude the central bank from targeting inflation or output in a situation when there are pressures on the exchange rate[2]; secondly, reserves' movements contain important information for the external-sector developments, as well as for the whole economy, and monetary authorities observe data on foreign reserves in real time.

[1] Although the original Taylor rule is defined in terms of current inflation and output gap, nowadays it is more common to see it in this variant, with expected inflation and expected output gap. See further in Clarida *et al.* (2000).

[2] Insufficient reserves can preclude the central bank from targeting inflation or output gap even under flexible exchange rate, but to a much lesser extent.

Secondly, the interest rate of the country to which the currency is pegged is included in the interest rate rule, too. Substantial differences in the domestic and the anchor-country's interest rates can lead to arbitrage opportunities, and as a result monetary policy in the anchor country can be an important factor for the domestic monetary policy.

In contrast to some other studies arguing in favour of the role of the exchange rate for developing economies (e.g. Frankel, 1979; Mohanty and Klau, 2005; De Mello and Moccero, 2008), its role is not empirically investigated here. The exchange rate is usually included to capture pressures on the foreign exchange market, which might prevent monetary policy from targeting other variables. However, when the exchange rate is fixed, these pressures are not felt by the *nominal bilateral rate* or are felt only little, and they are better captured by the official reserves. This argument does not hold, though, for the *nominal effective exchange rate* (NEER), since it is not constant even when the exchange rate is fixed. However, the dynamics of NEER are completely driven by the movements of other currencies, relative to the anchor currency, which are clearly out of the central bank's influence. Therefore, since the central bank could not target NEER, its inclusion within the policy rule is weakly justified. One may argue to include the real effective exchange rate (REER) - one compelling argument being its effects on trade. However, given that REER is simply NEER corrected for the difference between domestic and foreign inflation, and, given that, in turn, NEER and foreign inflation are exogenous, it follows that the central bank can affect REER only through the domestic inflation. As domestic inflation already enters the interest-rate rule, the inclusion of REER would imply including inflation twice, which is again methodologically incorrect.

The other two equations of the NKM (IS and Philips curve) should be modified as well to capture the specificity of the small open economies, as in Gali and Monacelli (2005). The most important difference between the closed- and open-economy NKM is that in the open-economy model, the growth rate of the foreign GDP appears in the IS curve, as well.[3] Hence, by estimating the closed-economy NKM, foreign economic activity is treated as a shock to the IS curve instead of being explicitly included in the equation. However, as long as foreign GDP growth is independently and identically distributed (i.e., has a constant mean and variance and is not serially correlated), which is very likely to be the case, its non-inclusion does not impose methodological difficulties.

Given this discussion, the modified New Keynesian model that is estimated in this paper is:

$$y_t = \alpha_0 + \alpha_1 y_{t+1} - \alpha_2 i\_real_{t+1} \tag{10}$$

$$\pi_t = \beta_0 + \beta_1 \pi_{t+1} + \beta_2 y_t \tag{11}$$

$$i_t = \gamma_0 + \gamma_1 i_{t-1} + \gamma_2 i\_ecb_t + \gamma_3 \pi_{t+1} + \gamma_4 y_{t+1} + \gamma_5 reserves_{t+1} \tag{12}$$

whereby *i_real* denotes the real interest rate (what was denoted by $i_t - E\pi_{t+1}$ in the previous section), *i_ecb* is the European Central Bank/Bundesbank interest rate, *reserves* denote official international reserves, and the remaining variables are as before. As seen in Section 3.2, some of these variables are non-stationary and hence their deviations from trends are included in the model.

[3] There are some differences in the interpretation of the reduced-form coefficients, as well.

2.3. Short Discussion about Macedonian Monetary Policy

Macedonia gained monetary independence in April 1992. In the first years, the National Bank of the Republic of Macedonia (NBRM) followed a strategy of monetary targeting. Faced with hyperinflation, a consequence of the break-up of the socialist system, this strategy seems to have been a reasonable choice. It aimed at limiting money supply and along with the fiscal consolidation and wage and price controls, at halting the spending and, hence, inflation. The strategy proved successful in curbing hyperinflation, but could not bring price growth to a reasonably low digit, mainly due to the unstable relationship between money supply and the level of spending (velocity of circulation), as in almost all countries that abandoned this regime (see Mishkin, 2001). Hence, in November 1995 NBRM switched to pegging the national currency to the German mark. The peg has been established in the form of a conventional peg, i.e. with only minor margins allowed: in the period 1999:M1-2011:M5, the average value of the nominal exchange rate denar/euro was 61.1, the minimal was 60.4 (1.2% lower than the average), while the maximal was 62.3 (1.8% higher than the average). In general, it was considered that fixing the exchange rate would be an optimal solution, given the small size of the economy, the high degree of openness and the high level of currency substitution. Consequently, inflation declined to 3% in 1996, but without significant results in the real sector. Authorities perceived that the high current-account deficits resulted in subdued price competitiveness, i.e. overvalued currency, and devalued the denar by 16% in July 1997. Since then, no changes have been made in the exchange-rate regime or the parity. The parity has been endangered by the two political shocks: the Kosovo refugee crisis in 1999 and the domestic conflict in 2001, but pressures were successfully resisted by interest-rate soaring.

Until 2000, the financial sector in Macedonia has been characterized by a structural deficit of liquidity, so NBRM has been providing liquidity to the system. In the first years following monetary independence until 1994, NBRM implemented its strategy mainly through refinancing commercial-bank credits (i.e. selective credits). With this, NBRM directly provided money to certain priority sectors of the economy. Afterwards, until its end in 1999, the main instrument was the interest rate on the auctions of uncollateralized credits, although credit ceilings proved to be powerful instruments in this period too. However, the financial system switched to a phase of liquidity surpluses after 2000 and the interest rate on central-bank bills became the main instrument for conducting monetary policy, i.e. for withdrawing liquidity from the system.Some existing studies on Macedonian monetary policy, for the interested reader, are: Stavreski (1997); Naumovska *et al.* (2002); Petkovski and Bishev (2003); Bishev (2004); Petrevski (2005); Vrboska (2006), Eliskovski (2009); Georgievska (2009); Besimi (2009); Velickovski (2010).

3. Methodology

3.1. Econometric Procedure

The model is estimated using the Generalized Method of Moments (GMM), developed by Hansen (1982), as at least three variables in our model are endogenously determined, which would cause inconsistency in the usual Ordinary Least Squares estimates. Although models of this type are nowadays commonly estimated using Bayesian techniques, it is not inappropriate to use the GMM method (e.g., see Christiano and Eichenbaum, 1992). The model is estimated as a system of three equations instead of estimating it equation by equation, because system estimation exploits cross-equation dependencies and is expected to result in more efficient coefficients, which is very important, bearing in mind the rather limited sample considered (14 years). The risk associated with a system estimator is that a misspecification of one equation translates into a misspecification of all the equations in the system. Thus, the modelling is cautious and the results of each of the equations are carefully examined.

A note on the instrumentation. As usual in the literature on NKMs and interest-rate rules, the set of instruments consists of lagged values of the regressors. For instance, Clarida *et al.* (1998, p.1044) use an extended set of lagged values of the regressors to instrument the expected values of inflation and output in the interest rate rule for Germany, Japan and the US. This type of instrumentation is justified as long as the error term in the equations is not correlated with the past values of the regressors (which could cause weak identification). Whereas this seems plausible enough in the case of inflation and output gap, in the case of the interest-rate rule, this assumption implies that monetary policy decisions are rational, i.e. that central banks' decisions incorporate all information that is available at the time when decisions are made, as a result forecast errors are uncorrelated with the available information (Boivin, 2006; Clarida *et al.* 2000). Seven lags of the regressors are included as instruments and their validity is checked through the J test.

3.2. Data

Since GMM is a large-sample technique, monthly data are used to provide a rich dataset. Additionally, since monetary-policy decisions in Macedonia are made at a fortnightly frequency, monthly data are more relevant for reflecting monetary-policy conduct. The sample period is 1997:1 – 2011:5.

The dataset consists of five variables: inflation, output gap, NBRM interest rate, official reserves and the ECB interest rate. Output gap is proxied by the cycle of the log of the industrial-production, obtained by the Hodrick-Prescott filter. The reserves are included in the same way – as the HP cycle of the logged reserves. The month-on-month percentage change in the CPI index is used to measure inflation. Month-on-month, not year-on-year inflation is considered because price pressures are reflected first in the month-on-month inflation, and later in the year-on-year inflation, due to the base effect (i.e. the price level a year ago). The CPI and the industrial production series were seasonally adjusted, using the Census X12 method, assuming multiplicative seasonal effects.

The data on the industrial production and the CPI index are collected from the State Statistical Office of Macedonia. For the NBRM interest rate, the interest rate on auctions of deposits is used for the period before 2000, since this was the monetary instrument in that period and the interest rate on the central-bank bills afterwards. The data on NBRM interest rates and reserves are from NBRM, while the data on ECB interest rates (the Bundesbank interest rate prior to 2001) are from the Bundesbank statistics. Two dummies are also included in the regressions to capture the two political shocks of this period – the Kosovo crisis in April and May 1999 and the internal military conflict in July, August and September 2001.

Since GMM requires stationary data, integration properties of the data are investigated before proceeding to estimation[4]. The unit-root analysis, given in Table 1, suggests that the hypothesis that domestic interest rate, ECB interest rate and reserves contain unit root cannot be rejected. Hence, the gap (cycle) of these variables is used, obtained by a

[4] Technically speaking, GMM can be used even with non-stationary data, but in that case the trend needs to be estimated together with the parameters (see Hamilton, 1994, p. 424).

Hodrick-Prescott filter. After filtering, these variables became stationary and as such they enter the model (equations 10-12).

Table 1: Unit-root Tests

Variable	ADF test	DF-GLS test	PP test	NG-Peron test	Decision
Industrial gap	<0.01	>0.10	<0.01	>0.10	Probably stationary
Inflation	<0.01	<0.01	<0.01	<0.01	Stationary
Interest rate	<0.10	<0.01	>0.10	<0.10	Probably non-stationary
Interest rate gap	<0.01	<0.01	<0.01	<0.01	Stationary
Reserves	>0.10	>0.10	>0.10	>0.10	Non-stationary
Reserves gap	<0.05	<0.01	<0.05	<0.01	Stationary
ECB interest rate	>0.10	>0.10	>0.10	>0.10	Non-stationary
ECB interest rate gap	<0.05	<0.05	>0.10	<0.01	Stationary

Notes:
H_0: Series is non-stationary. Text in the cells shows whether the p-value of the test is higher or lower than the level of significance. For instance, <0.01 means that the p-value is lower than 0.01, i.e. that H_0 can be rejected on 1%.

Source: Authors' estimations

4. Results and Discussion

4.1. Results

The model explained in section 2.2 along with the considerations in section 3.2 is applied to the case of Macedonia, for the period 1997-2011. We explore the interest-rate behaviour by adding and omitting the above-mentioned variables, leaving the first two equations unchanged. Furthermore, we also check whether monetary policy reacts to past or future values of the variables, i.e. whether monetary-policy conduct has been backward- (adaptive) or forward-looking (rational).

We turn to discussing results now. To save space, results of the finally-chosen specification (Table 2) are presented only. The intermediate specifications test backward- versus forward-looking specifications of the model by looking at results' significance and are available on request.

Table 2: Results of the finally-chosen specification

IS curve **Output gap**		**Phillips curve** **Inflation**		**Interest rate rule** **Interest rate gap**	
Constant	0.00	Constant	0.00***	Constant	-0.002***
Output gap(+1)	0.58***	Inflation(+1)	0.25***	Interest rate gap(-1)	0.75***
Real int. rate gap(+1)	-0.32***	Output gap	0.03**	Inflation(-1)	0.63***
				Reserves gap	-0.02**
				dum99	0.05***
				dum01	0.05***
Adjusted R²	0.18		0		0.82
J test p-value		0.90			
H_0: instruments are valid					

Notes:
***, ** and * indicate significance at 1%, 5% and 10%, respectively.
The dependent variable in each equation is given in the heading row.

Source: Authors' estimations

Coefficients on the explanatory variables appear with the expected signs in the first two equations, so that monetary-policy decisions correctly transmit onto real economy. Coefficients in the *IS curve* suggest that the current output gap depends positively on the expected output gap, and negatively on the expected real interest rate, while the *Phillips* *curve* coefficients suggest that current inflation depends positively on expected inflation and expected output gap. The coefficient on the real interest rate in the IS curve suggests a relatively strong effect of the monetary policy on economic activity; in the long run, output increases by about 0.8 percent (relative to the potential) when the interest rate declines by 1 percentage point (p.p.)[5]. However, the effect of an increase in the output gap by 0.8 percent on the inflation is significant, but fairly weak, 0.03 p.p. (0.8 times the long-run effect of a unitary increase in the output gap on the inflation, which is 0.04). The latter result implies that inflation in Macedonia is mostly imported, a finding consistent with the fixed exchange-rate regime.

The *interest-rate rule* is discussed next. The lag of NBRM interest rate is significant and positive, 0.75, suggesting a considerable interest-rate smoothing. The first important finding is the statistically significant inflation effect, which implies that monetary policy in Macedonia in the observed period has been, at least partially, dedicated to domestic goals, likely due to the still-existing constraints with respect to capital mobility, mainly in the form of underdeveloped capital market. The size of the inflation coefficient points out that the interest rate is increasing by 2.5 p.p. when inflation rises by 1 p.p. Additionally, since inflation appears with a lag, the reaction of the central-bank to inflation has been backward-looking.

Reserves are significant, suggesting that they constrained monetary policy (or, that monetary authorities "targeted" reserves). The long-run coefficient suggests that a decrease of reserves, relative to their trend, by 1 percent increases the interest rate by 0.1 p.p., which is not very strong. Output gap and the ECB interest rate turned out to be insignificant and negative and were therefore excluded from the final regression; the insignificance of the ECB interest rate indeed comes as a surprise. The two dummy variables included to control for the two exogenous non-economic shocks in the observed period (the Kosovo crisis in 1999 and the internal military conflict in 2001) are highly significant, both statistically and economically, pointing out that the two conflicts increased the interest rates by around 5 p.p., ceteris paribus.

The 14 years considered in the analysis, although fairly short, have been rich in terms of economic developments, in addition to the military conflicts that were already mentioned. Firstly, the anemic economic performances during the politically challenging times of the late 1990s and early 2000s were succeeded by a stable macroeconomic period accompanied by supported economic activity in mid-to-late 2000s, and ended with the global crisis towards the end of 2000s. Secondly, in the first half of the period, monetary policy was possibly constrained by the strict arrangements that the country had with the IMF[6]. Thirdly, two different governors were in office during this period, each one spanning over half of the period. It is questionable therefore if one can assume same monetary policy behaviour in such different times. The potential structural instability within the observed period might not only obscure the real picture, but also lead to wrongly-estimated coefficients. The insignificance of

[5] Given that lag/leads of the dependent variables appear as regressors in all the equations, the interpretation of the coefficients refers to the long-run effects. The *long-run coefficients* are obtained as the respective coefficient divided by (one minus the coefficient on the lag/lead of the dependent variable).

[6] Since 1994, Macedonia has had eight arrangements with the IMF: STF arrangement in 1994, Stand-by arrangement in 1995, ESAF arrangement in 1997, CCFF arrangement in 1999, EFF and PRGF arrangement in 2000, Stand-by arrangement in 2003 and Stand-by arrangement in 2005. The last arrangement was terminated in August 2008. Even though the arrangements were present nearly throughout the whole period of our analysis, the conditions of the earlier arrangements were, arguably, much more rigid.

the ECB-interest-rate coefficient is the first indicator for this. For this reason, the analysis proceeds by applying the model to two distinctive subperiods: 1997:1-2004:3 and 2004:4–2011:5. The obtained coefficients would imply the policy design given the distinct domestic and external economic conditions as well as the distinct policymaker preferences, without claiming which of the two is more important. This type of analysis, by subperiods, is well established in the literature (e.g. see Clarida *et al.* 2000; Benati and Mumtaz, 2007; Primiceri, 2005; Canova and Gambetti, 2004).

Results for the first subperiod are presented in Table 3.

Table 3: Results of the model for the first subperiod (1997:1-2004:3)

IS curve Output gap		Phillips curve Inflation		Interest rate rule Interest rate gap	
Constant	0.00	Constant	0.00***	Constant	-0.005***
Output gap(+1)	0.33***	Inflation(+1)	0.07	ECB interest rate gap	0.53**
Real int. rate gap(+1)	-0.43***	Output gap	0.00	Interest rate gap(-1)	0.78**
				Inflation(-1)	0.95***
				Reserves gap	-0.01
				dum99	0.06***
				dum01	0.04***
Adjusted R²	0.18		0		0.78
J test p-value		0.90			
H_0: instruments are valid					

Notes:
***, ** and * indicate significance at 1%, 5% and 10%, respectively.
. The dependent variable in each equation is given in the heading row.

Source: Authors' estimations

The long-run response of the output gap to the real interest rate remains the same as in the whole period. On the other hand, the Philips curve coefficients are insignificant, suggesting that inflation was not driven by domestic factors, which might be due to the lower utilisation of the factors of production in this early period. The coefficient on the ECB interest rate in the monetary policy rule is now significant, both statistically and economically, suggesting that domestic monetary policy was indeed following the monetary policy of the anchor country. The coefficient on inflation is significant and is slightly higher than for the whole period (around 4 p.p.). The output gap is insignificant, which is not strange - in these years, macroeconomic stability has been perceived to be much more important than output growth. Furthermore, many existing studies (Jovanovski *et al*. 2005, Velickovski, 2006, Vrboska, 2006) indicate a very weak monetary transmission mechanism through the interest-rates channel, which is an additional argument for not considering the business cycle when making monetary-policy decisions. Finally, as mentioned before, for most of this period Macedonia has been under strict arrangements with the IMF, which, arguably, constrained monetary policy from considering output in the monetary-policy decisions. The coefficient on reserves is also insignificant, which may be unexpected[7]. One reason for this may be the higher level of capital closedness of the economy during this period. Another may be the fact that reserves in this period were, to a large extent, driven by non-economic factors, like big privatisations. Finally, under the IMF arrangements the country was allowed to

[7] The coefficient of the reserves becomes significant when the two dummies are excluded from the regression, but still relatively small. Since these two dummies capture short-time exogenous shocks (military conflicts), we decide to retain them in the specification, despite the insignificant reserves.

withdraw funds whenever the external balance was endangered, as a result the authorities might have neglected reserves in the monetary-policy decisions.

On the other hand, coefficients on the interest-rate smoothing and the two crisis dummies are roughly the same as before. The two conflicts that the two dummies capture resulted in capital outflows and speculations for denar devaluation, as a result the central bank responded with an interest-rate increase to stabilize expectations. As capital outflows and speculations resulted in declining reserves, and these appear insignificant in the policy rule, the inclusion of the dummies is well justified.

The results for the second subperiod are analysed next (Table 4).

Table 4: Results of the model for the second sub-period (2004:4-2011:5)

IS curve Output gap		**Phillips curve Inflation**		**Interest rate rule Interest rate gap**	
Constant	0.00	Constant	0.00***	Constant	0.00*
Output gap(+1)	0.75***	Inflation(+1)	0.62***	ECB interest rate gap	0.29***
Real int. rate gap(+1)	-0.18**	Output gap	0.04**	Interest rate gap(-1)	0.92***
				Inflation(+1)	0.07***
				Output gap(+1)	0.01***
				Reserves gap	-0.03***
Adjusted R^2	0.23		0		0.93
J test p value	0.90				
H_0: instruments are valid					

Notes:
***, ** and * indicate significance at 1%, 5% and 10%, respectively.
The dependent variable in each equation is given in the heading row.

Source: Authors' estimations

Important differences can be identified between the results for this second subperiod and the preceding results, which signifies a structural change in the monetary policy and renders estimation of a single model for the whole period as problematic. Firstly, though unitary increase in the real interest rate affects the output gap with roughly the same magnitude as before, this increase further causes inflation to decline by 0.08 p.p. The significance of this effect can be explained by the arguably higher utilisation of capacities in the second sub-period, while its small size is still consistent with the exchange rate peg. The coefficient on the interest-rate lag in the monetray policy rule in this subperiod is slightly higher than in the first subperiod, which accords well with the evidence about the improved monetary transmission from the first two equations and from Velickovski (2006). Also, both inflation and output gap in this second subperiod appear significant in the interest-rate rule, and they appear with the lead, implying that monetary policy has been forward-looking. This implies a likely transition of the monetary-policy conduct from adaptive to rational between the two sub-periods. Still, reactions to inflation and output are rather weak - increase in inflation by 1 p.p. leads to increase in the interest rate by 0.9 p.p, while one percent increase of output over potential has been followed by a 0.15 p.p. rise of interest rate. The coefficient on ECB's interest rate halved compared to the first subperiod, but is still significant, reflecting some degree of "follow the leader" behaviour, due to the fixed currency. Finally, the coefficient on reserves gains both significance and size, suggesting a 0.35 p.p. interest-rate increase when reserves decline by one percent. Such a high reaction supports the previous discussion about the importance of reserves for the monetary policy in a small open economy with a fixed exchange rate. In addition, it is consistent with the evidence about Macedonian monetary policy contained in the regular reports of the Macedonian central bank, which regularly stress the role of the reserves for the monetary policy.

In summary, the main finding from this analysis is that despite the fixed currency, the central bank had room to conduct an independent monetary policy. This can be mainly attributed to the existence of capital controls, hence still satisfying the impossible trinity rule whereby only two of the following three can hold: fixed currency, capital freedom and independent monetary policy. Furthermore, inflation appears significant at the 1% level in both sub-periods, which provides some evidence that NBRM targeted inflation in tandem with the fixed exchange-rate regime. Similar examples of targeting inflation without formally having an inflation-targeting regime were Germany and Switzerland until the late 1990s, who were not exchange-rate targeters, but monetary targeters. Many observers and empirical studies (see, e.g., Bernanke and Mihov, 1997; Bernanke and Mishkin, 1997) suggest that monetary policies in these countries were driven in the medium and long term primarily by inflation goals, and that the distinction between inflation and money targeting, in general, has been overstated. An additional argument in support of this claim for the case of Macedonia is the observation that inflation developments receive prominent attention in the regular reports of NBRM. The reports are not classical inflation reports, but are similar in content, just as in the case of the central banks of Switzerland and Germany.

4.2. Robustness Analysis

As there seems to exist a clear structural break in monetary policy across the two subperiods, the robustness of the results for each subperiod is investigated next. The robustness is examined with respect to the sample length, the choice of instruments and the type of estimation (i.e. system or equations). Table 5 reports the results for the first subperiod (1997:1-2004:3), Table 6 for the second (2004:4-2011:5). Only the interest-rate rule estimates are reported. In the *sample-length exercise*, in column 2 the first and the last year are excluded, in column 3 the first two years are exluded and in column 4 the last two years are excluded. In the *instrument exercise*, the model is estimated using five and nine lags as instruments (column 5 and 6, respectively). In the final robustness exercise, we investigate whether results differ when the policy rule is estimated *as a single equation, not as a system* (column 7).

The results of these checks seem to suggest that the previous results are pretty robust.

Table 5: Results of the robustness checks for the first subperiod (1997-2004)

	Results of the final model	**Shorter sample (without first and last year)**	**Shorter sample (without first two years)**	**Shorter sample (without last two years)**	**5 lags as instrum ents**	**9 lags as instrumen ts**	**equation estimate**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Constant	0***	0***	0***	0***	0***	0***	0***
Interest rate gap (-1)	0.79***	0.81***	0.86***	0.76***	0.78***	0.81***	0.67***
ECB interest rate gap	0.59**	0.69***	1.02***	0.49**	0.22	0.77***	-1.23**
Inflation(-1)	0.95***	0.81***	0.56***	0.30***	1.06***	0.43***	1***
Reserves gap	-0.01	-0.01**	0.01***	-0.01*	0.01	0	0.03**
dum1999	0.06***	0.05***	0.06***	0.04***	0.07***	0.05***	0.05**
dum2001	0.04***	0.03***	0.01***	0.04***	0.04***	0.02***	0.06***

Notes: ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

Source: Authors' estimations

Table 6: Results of the robustness checks for the second subperiod (2004-2011)

	Results of the final model	Shorter sample (without first and last year)	Shorter sample (without first two years)	Shorter sample (without last two years)	5 lags as instruments	9 lags as instruments	equation estimate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0***	0***	0***	0***	0***	0***	0***
Interest rate gap(-1)	0.92***	0.89***	0.95***	0.86***	0.92	0.91***	0.97***
ECB interest rate gap	0.28***	0.14***	0.23***	0.19***	0.26***	0.28***	0.29***
Output gap(+1)	0.01***	0.01***	0.01***	0.00*	0.02***	0.01***	0.02***
Inflation(+1)	0.06***	-0.01	0.06***	0.04***	-0.02	0.08***	-0.02
Reserves gap	-0.03***	-0.02***	-0.02***	-0.03***	-0.03***	-0.03***	-0.02***

Notes: ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

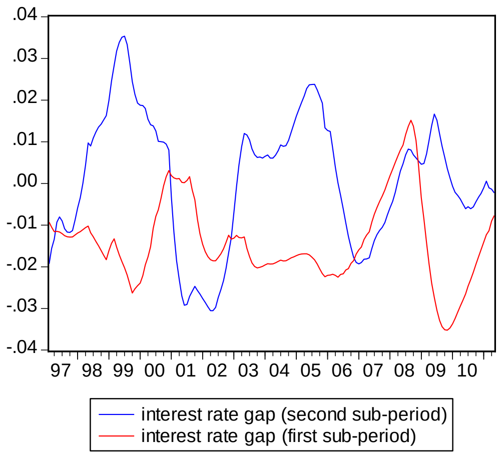
Source: Authors' estimations

4.3. Further Discussion

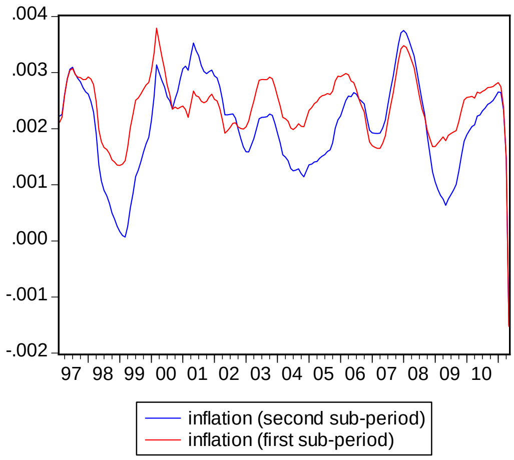
In the final section, implications of the different monetary policy in the two subperiods for the overall macroeconomic performance are investigated. In the manner of Benati and Mumtaz (2007), regimes of the two governors are imposed over the entire period and outcomes for the interest rate, inflation and the output gap are compared. To limit the effect of the differences in the transimission mechanism during the two sub-periods on the results, we fix the coefficients in the IS and Philips curve to the coefficients that were obtained for the whole period. Comparisons are given on Figure 1 and in Table 7.

Figure 1: Comparison of the interest rate gap, output gap and inflation when the monetary policy of the two subperiods is imposed over the whole period

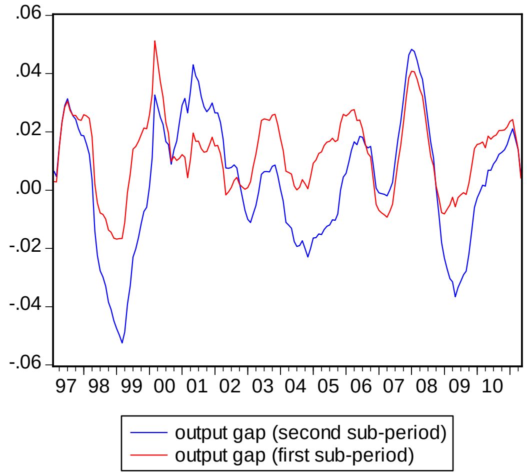
Interest rate gap



Inflation



Output gap



Source: State Statistical Office of the Republic of Macedonia, National Bank of the Republic of Macedonia and authors' estimations

Notes: The vertical axes all represent percentages. Interest rate and output are plotted as deviations from the trend, while the inflation rate is the month-on-month percentage change of the CPI.

Table 7: Summary statistics for the interest rate, output gap and inflation when the monetary policy of the two subperiods is imposed over the whole period

	Interest rate gap		Inflation		Output gap	
	First subperiod imposed	Second subperiod imposed	First subperiod imposed	Second subperiod imposed	First subperiod imposed	Second subperiod imposed
Mean	-0.014	0.001	0.0024	0.0020	0.12	0.03
Standard deviation	0.010	0.016	0.0006	0.0009	0.01	0.02

Source: Authors' estimations

The comparison of outcomes for the three endogenous variables, when the two "regimes" are imposed over the whole period, gives some interesting insights. Imposing the regime of the first subperiod onto the entire period (meaning, roughly, what would outcomes have looked like had the economic environment or policymakers' preferences in the second sub-period not changed), results, on average, in lower interest rates, than compared to imposing the second subperiod's regime. Consequently, the first regime produces a more positive output gap. As interest rates are lower and output gap is more positive, the first regime results in higher inflation as well. This might sound odd, since it was found earlier that monetary policy in the first subperiod responded more to inflation than in the second subperiod. The explanation is that in the second subperiod monetary policy was pursuing its stabilization role mainly through the output gap, which seems to have shown effective in keeping inflation low. Finally, if the two regimes are compared in terms of the standard deviations of the inflation and the output gap (see Woodford, 2003, Chapter 6), we arrive at the conclusion that the regime of the first subperiod resulted in less volatile inflation and output gap. All the mentioned differences were statistically significant at 1%.

5. Conclusion

This paper discusses how the New Keynesian model can be modified in order to analyze monetary policy in a small open economy with a fixed exchange rate, and then applies this modified model to the case of Macedonia. As a major factor influencing monetary policy in such economies are developments in the external sector, the interest rate rule incorporates the official foreign reserves in order to capture pressures on the foreign exchange market. In addition, the rule includes the interest rate of the anchor country in order to capture the need to follow the anchor-country monetary policy and to avoid arbitrage opportunities. The model is then estimated using the GMM method, on monthly Macedonian data, for the period 1997:1-2011:5. Results for the two sub-periods (1997:1-2004:3 and 2004:4-2011:5), which coincide with the two governors' mandates, reveal that monetary policy has indeed had some room for reaction to domestic inflation, with a stronger response in the earlier period. Furthermore, reserves appear less important in this first sub-period, likely due to the fact that their movement in this period was driven by various external factors, like privatizations, as well as due to the many arrangements the country had with the IMF during this period, which allowed it to borrow whenever it needed. Finally, the output gap is found to be important only in the latter period, while monetary policy has likely moved from adaptive to rational between the periods. These findings have important implications for the policymakers. They basically break down the misconception that small open economies with fixed exchange rates cannot have independent monetary policy. The results also point out that monetary policy in such economies should pay attention to developments in the external sector (i.e. international reserves) in addition to inflation and the business cycle.

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