BANKA SLOVENIJE

MONETARY POLICY IN A SMALL-SCALE ECONOMIC MODEL

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Abstract

For the purpose of building and implementing monetary policy, central banks deploy economic models of different scope and size. Comparatively low level of familiarity with the transmission mechanisms of monetary policy will undoubtedly be the reason why the architects of monetary policy in Slovenia seldom reach for econometric models as aids in the decision-making process. The simple macroeconomic model described herein embodies equations commonly used in the modelling process. The model consists of three main blocks; namely, GDP block, supply-side block and monetary block. A key place in the model is reserved for the reaction function of monetary policy that serves to simulate how by steering exchange rate, monetary policy strives to mend the deviation of actual inflation from the inflation target set by the Government. Aided by the model, policy-makers are better equipped to foresee the way in which the economy reacts to changing values of exogenous variables. Simulations have affirmed that the scope of the reaction is largely commensurate to the nature and scope of response given by monetary policy. A conclusion in line with these findings is that mission-critical steps should be plotted and executed with utmost caution. Although criticism against the application of small-scale models in forecasting has often been voiced, it has been demonstrated that in the case of predicting the intermediate monetary policy target of the Bank of Slovenia, a small-scale model produces results at par *to those obtained by applying other methods.*

Key words: Monetary policy, Models, Simulations, and Forecasting.

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FOREWORD

The general idea behind the development of economic modelling tools is to create a playground and simulate the game where economic issues are key players, while regulators act as coaches whose plan of the game is referred to as economic policy. Given the complexity of economic models and the scope of recent changes in Slovenia's economy, it does not come as a surprise that snapshots or full-scope scrutinise of economic models have rarely appeared in Slovenian professional magazines. Another plausible explanation for the small number of works in this field is that there is sometimes a lack of representative periods or there are no historical records at all (the most notorious example is national accounts statistics), while a relatively high portion of missing information could be accounted for by conditions usually associated with economies in transition (abnormal behaviour of economic agents, statistic breaks, institutional changes, etc.), in which the economy functioned and still does. Attempts at building models of monetary policy functioning have been even rarer. There have certainly been more reasons for such lack than mentioned before, despite the fact that, as a rule, it is models that make one of the foundations for the decision-making process. One of the most important reasons for such a situation is undoubtedly relatively poor understanding of the impact/effects of transmission mechanisms in Slovenia. Nevertheless, this area of economics is slowly gaining recognition it most certainly deserves. That the situation has improved may also been seen by the number of works published over the past few years (e.g. Bole (1999), Čufer (1997), Drenovec (1999), Košak M. (1999), Košak T. (1999), Mencinger (1997), Strojan (1999)) which mainly focus on specific properties of channels (interest rate, credit, exchange rate), through which monetary policy may affect economy.

On the view to outline the economy by means of appropriate assumed or in some other way defined (calibrated) equations that are eventually put together in an operating model with converging properties, the purpose of the model shall be determined in advance. Equations that approximate economic models would make the most appropriate representations of economy. Economic models may be deployed to make forecasts related to future movements in endogenous variables of the model on the basis of changes in exogenous variables or to simulate reaction of the economy to economic policy and other exogenous variables (*ex-post*) that appear in the model by means of alternative values of instrumental variables in the model. In the case of structural models, their application is usually determined by their scope. Small-scale models are generally developed for *ex-post* simulations, while large-scale models that comprise more variables that in turn incorporate more information are better suited to forecasting. Attempts made over the last decade at assessing models for Slovenia built upon macroeconomic aggregates that could be classified as large-scale models in terms of their scope and the number of equations built-in have been rare (e.g. Cimperman et al. (1995), Kuzmin (1997) or Kračun (1999)). The main advantage of large-scale models is that such models enable a relatively thorough insight into the structure of functioning of economy. On the other hand, their flaw lies in being rather difficult to manage and therefore non-transparent; hence opportunity cost for maintaining data base for such a model is high and that the application of such models is often not so intense as its architects (and patrons) would like it to be. In this analysis we will use a small-scale model for *ex-post* simulation as well as for extrapolation of future developments; hence interpretation of results obtained in such a way shall be done with utmost caution.

For the purpose of policy-making related to measures within the framework of the monetary policy, central banks usually deploy several models[1]. These models are not only different in type and scale, but also in the scope of application. Large-scale – medium-scale - macroeconomic model serves to forecast movements in more important variables in the national economy and makes a direct

[1] As for the importance of models for guiding and implementing the monetary policy and the applications of different types of models, see e.g. Bank of England (1999).

fundamental for decisions within the framework of the monetary policy; small-scale models provide a more specialised angle and are better suited to individual areas that monetary policy has to take into consideration during the decision-making process. Among small-scale models the most popular are small-scale structural macroeconomic models, as well as vector autoregression models and optimising models.

Attention will be focused on the presentation of a simple model of Slovenia's economy and possibilities for its application. Since the stress is on examining a model that is both by its contents and by its size more similar to small-scale macroeconomic models, the first step will be to examine its architecture and its strengths. The first part also presents individual equations of a quarterly model of the national economy that is being dealt with in this excercise. To give a better insight, each equation will be accompanied by a brief comment and alternative possibilities will be presented to write the respective equations, which could be taken into account for the purpose of upgrading the model and the database. As it has already been mentioned in the foreword, it should serve to forecast and analyse economy reaction to economic policy measures. Later on the focus will be on some results achieved by model simulations when adjusted exogenous variables and in particular of the variables that are completely or only partly determined by monetary policy, are used. Moreover, we will use simulations to draw attention to changes in the behaviour of macroeconomic aggregates, should monetary policy respond to exogenous shocks by changing parameters in its reaction function. Towards the end of the section we will indicate the possibility for using the model as a tool for setting the monetary target. In conclusion, outcome, findings, and proposals for eventual (possible) extensions and improvements of the model will be offered.

1. PROPERTIES OF THE MODEL AND ITS BUILDING/DEVELOPMENT

A small-scale macroeconomic model should be built from several core/fundamental equations. Such a stylised representation of the whole economy has also been incorporated in our model[2]:

- an IS function, i.e. aggregate demand equation, which shows the ratio/relationship/interaction of/between activity, real interest rates and exchange rates (in the case we are dealing with an open economy),
- an LM function, i.e. a money demand equation, which shows the interaction between money, activity and an opportunity costs of holding money,
- an aggregate supply function (Phillips curve), i.e. price-setting equation, which shows response of prices to output gap (the difference between actual and potential income), and
- a monetary policy reaction function.

If the economy is open, then the model should also include an uncovered interest parity function (UIP) or an exchange rate function to show the ratio/interaction between/of exchange rate and the spread between domestic and international interest rates.

The advantages of using small-scale macroeconomic models mainly derive from their rational structure constructed by putting together sound theoretical elements. Consequently, one of key features of these models is flexibility in addition to other properties listed below:

- Since they are usually used to analyse economic policy, their straightforward structure enables direct insight into the functioning of the economy and response to measures of economic policy and other exogenous shocks;

[2] Only the most basic descriptions of equations have been given. Variables, which are used in their final form are specific for each economy and depend also on statistical data taken into account. For more, see e.g. Battini and Haldane (1998).

- Assessment and calibration of coefficients is simpler than in the case of large-scale models. If we want, for instance, to take into account an economic theory or check its effects, it is simpler and more straightforward to determine appropriate coefficients. Large-scale models where the relationships between macroeconomic aggregates are not direct but are indirectly incorporated in several equations, to determine coefficients and to analyse their effects is far more complex;
- By using small-scale models, correctness (logic) of the results derived from larger-scale models can be tested. Despite a high degree of aggregation of small-scale models, they are still structured.

Although generally used small-scale models have definite strengths, criticism related to excessive level of aggregation is often voiced. Small-scale models that do not contain individual components of aggregate demand tend to make the task of analysing the relationship between the measures of economic policy and, for instance, responses produced by balance of payments, a rather demanding task.

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When building the model to be used by Slovenian policy-makers, the above-mentioned theoretical assumptions, which make the cornerstone of small open economies, have been given due consideration. The model is composed of six behaviour equations, four definition equations, and a number of ancillary equations. Individual equations for the model have been estimated for the period from the first quarter of 1994 to the third quarter of 1999, while coefficients have been defined (i.e. calibrated) in the monetary policy reaction function and in the inflation expectation equation. Since the model is to be made as transparent as possible, only variables built on data accessible to public, or such values that can be computed on the basis of such public data, have been incorporated. Variables, which are used in the model are represented in a logarithm form. Despite a high degree of aggregation, it is still possible to define individual blocks in the model, such as gross domestic product (GDP) block, supply-side block, and monetary block.

The model may be represented by means of estimated coefficient values, i.e. their values from the basic scenario[3]:

$$y_t = \ln(\exp dd_t + \exp x_t - \exp m_t) \tag{1}$$

$$dd_t = c_{10} + c_{11}(i_t - \exp\inf_{t+1}) + cc_{12} dd_{t-1} + c_{13} m3_{t-4} + \varepsilon_{1t} \tag{2}$$

c_{10} = 8.78, c_{11} = -0.18, c_{12} = -0.30, c_{13} = 0.35

$$m_t = c_{20} + c_{21}(pf_{t-1} + e_{t-1} - p_{t-1}) + c_{22} x_{t-2} + c_{23} m_{t-1} + \varepsilon_{2t} \tag{3}$$

c_{20} = 19.00, c_{21} = -2.38, c_{22} = 0.67, c_{23} = -0.43

$$x_t = c_{30} + c_{31} yf_t + c_{32}(pf_t + e_t - p_t) + c_{33} x_{t-1} + \varepsilon_{3t} \tag{4}$$

c_{30} = -4.53, c_{31} = 2.70, c_{32} = 0.04, c_{33} = -0.13

$$w_t = y_t - emp_t + p_t + c_{40} + c_{41}(e_t - e_{t-4}) + c_{42} \exp\inf_t + c_{43}(w_{t-1} - y_{t-1} + emp_{t-1} - p_{t-1}) + \varepsilon_{4t}$$

c_{40} = 4.73, c_{41} = 0.16, c_{42} = 0.18, c_{43} = 0.23 (5)

[3] For definitions of individual variables see *Appendix 1.*

$$p_t = c_{50} + c_{51}\left(pf_{t-1} + e_{t-1} - w_{t-1} + y_{t-1} + emp_{t-1}\right) + c_{52}\left(\Delta e_t + \Delta pf_t\right) +$$
$$+ c_{53}\left(p_{t-1} - w_{t-1} - y_{t-1} + emp_{t-1}\right) + c_{54}\left(y_{t-1} - y^{*}_{t-1}\right) + \varepsilon_{5t} \qquad (6)$$

c_{50} = -0.47, c_{51} = 0.19, c_{52} = 0.39, c_{53} = -0.15, c_{54} = 0.28

$$i_t = c_{60} + c_{61} m3_t + c_{62}(m3_{t-1} - b_{t-1}) + c_{63}(b_t - b_{t-1}) + c_{64} y_t + \varepsilon_{6t} \qquad (7)$$

c_{60} = -849.91, c_{61} = -88.59, c_{62} = 73.18, c_{63} = -84.96, c_{64} = 155.70

Alternatively:

$$m3_t = c_{60} + c_{61} i_t + c_{62}(m3_{t-1} - b_{t-1}) + c_{63}(b_t - b_{t-1}) + c_{64} y_t + \varepsilon_{6t} \qquad (7a)$$

c_{60} =-9,59, c_{61} = -0,01, c_{62} = 0.83, c_{63} = -0.95, c_{64} = 1.75

$$e_t = e_{t-1} - (1 - adj)\left((p_t - p_{t-1}) - tget\right) + adj\_e\left(e_{t-1} - e_{t-2}\right) \qquad (8)$$

$$\exp\inf_t = c_{70} E_t \Delta_4 p^{e}_{t+1} + (1 - c_{70})\Delta_4 p_{t-1} \qquad (9)$$

c_{70} =0.9

$$y^{*}_t = y_t - 13.11 - 0.0105t \qquad (10)$$

Equations (1)-(4) make up the definition of the domestic economic activity measured by gross domestic product. It is the sum of domestic demand, exports and imports (with minus sign). The decomposition to individual aggregates of the GDP consumption-side structure is necessary due to the structure of the model in the first place, but also with the aim to enable empirical properties of the »contribution« that each aggregate adds to the activity.

For the purpose of estimating equations, the variable for domestic demand has been defined outside the model by means of GDP, exports and imports[4], then it is computed in the model as an endogenous variable, where it is defined by explanatory variables. Thus domestic demand encompasses consumption, investments, and government spending; in other words, it is composed of aggregates that by definition behave differently. Benchmarking against monthly indicators on movements in individual components of the demand-side published by the Economic Institute at the School of Law (EIPF) has shown that their dynamics is very similar. The real value of exports and imports has been defined by means of statistics relating to National Accounts and by taking into account annual data from the statistics for exports in imports, where annual data from the statistics on the expenditure side of GDP[5] and actual dynamics within individual years from the statistics for exports and imports have been considered. Hence the data on international exchange can be compared both with real data at annual level (calculated GDP) and with the actual quarterly data (required for the model) on exports of goods and services.

Normally, the equation (2) is called an IS function, where costs of borrowing determine domestic demand. The regression equation used in our model to represent domestic demand is determined by

4 We have assumed that GDP=C+I+G+X-M, where the first three components on the right-hand side of the equation represent domestic demand (DD). This can be written as DD=GDP-X+M.

5 For 1999, forecasts made by the Institute for Macroeconomic Analysis and Development have been used (1999).

expected real interest rate and monetary aggregate M3. Monetary aggregate appears in the demand equation where in addition to the price component (the interest rate treated as an endogenous variable); not a single variable that defines demand (e.g. wages and salaries or loans) has been directly used. Introducing loans and advances to the model would enable an insight into the functioning of the credit channel of the transmission mechanism of the monetary policy, a prerequisite for such a model upgrade would be thorough understanding of the connection that exists between monetary aggregates and lending. Thus monetary aggregate indirectly affects through demand both movements in prices and economic activity. By improving the statistics relating to National Accounts, it will be possible to evaluate separately individual components of domestic demand (household consumption, investments and government spending).

Imports (3) and exports (4) equations define international exchange in a rather classical way[6]. It is the real exchange rate that influences imports to a much higher degree than it affects exports, where the principal determinant is the international economic activity. Imports of a small open economy without raw material capacities are also commensurate to the volume of exports, which is generally the main factor of economic growth and statistically influences imports with a two-quarter lag. Instead of exports playing the role of the explanatory variable for imports, it would be possible to include in the model also expectations regarding exports or orders from abroad, provided that time-series are of sufficient length. Such expectations are incorporated in the survey of business trends in processing industries made by the Statistical Office of the Republic of Slovenia (SORS) (data for these two time-series are available since January 1997, i.e. since May 1995 only).

For the purpose of defining supply side of Slovenia's economy a desegregated approach has been selected and the wage function is treated separately from price mechanism function. The function form of equations (5) and (6) is based on the Cobb-Douglas output function, while by introducing total productivity it has not been necessary to include capital (lack of data) as one of the variables that determines the behaviour of the output function.

Prices defined by the equation (6) are determined by movements in exchange rate, by the ratio between exchange rate movements and labour costs per unit of product, by the ratio between movements in prices and labour costs per unit of product (exchange rate and prices affect changes in labour costs per unit of product with a one-quarter lag) and by the difference between the actual and potential gross domestic product, although by disregarding the influence produced by economic policy in the segment of controlled prices. These explanatory variables cover factors, which affect prices in the tradable sector (exchange rate), as well as those that generally determine dynamics of prices in non-tradable sector (labour costs and output gap)[7].

We are aware that to use the output gap as a price determinant in a small open economy may be questionable[8]. Furthermore, the link between both variables has proven to be statistically non-significant. The feeble connection may be the consequence of the incorrect presentation of the output gap or the fact that in transition countries the supply side is the one that determines movements in prices. A plausible explanation suggests that over the period under review, inflation expectations changed and further restricted the influence of demand on inflation. In addition, in a small and open economy there is a valid assumption that generally demand leads to a trade deficit without fuelling

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6 A more thorough analysis of movements in exports and imports has been shown by Strojan (1999). This exercise focuses on changes in macroeconomic aggregates – more precisely to selected factors. The conclusion made by e.g. Drenovec (1999: page 19) reads that due to the exogenous – that is the one that is not prone to exchange rate fluctutations – government spending in a small and open economy such as Slovenia's as well, there is a large part of imports (and consequently deficit), that fluctuates independently of the exchange rate. Difficulties arise when such statements are to be empirically verified.

7 Compare to e.g. conclusions drawn by Drenovec (1999: page 12).

8 An exercise has been made to use "capacity utilisation" from the survey made by the SORS as the explanatory variable instead of output gap but it failed to cast more light on inflation movements in the price function.

inflation. The decision to include these variables is based upon the desire to include in the model as many theoretical assumptions as possible. Consequently, it is absolutely normal to expect that in the role of output gap in the determination of inflation will change over time; hence it may happen that in the future the application of data from the initial period that is operated with in this analysis may produce incorrect results in establishing the link between inflation and output gap[9]. The output gap has been calculated on the basis of time trend and movements in GDP, which is subsequently computed within the model. In the model the output gap is represented by a definition equation (10).

Wages, written as the equation (5), are determined in the supply-side block by movements in exchange rate and by the ratio between real wages and aggregate productivity from the preceding period.

Equation (7) is an inverse function of demand for monetary aggregate M3, i.e. an LM function, where the interest rate is the endogenous variable, while M3 is one of exogenous variables. Such representation of the equation for the demand for M3 is justified provided that the monetary aggregate target variable monetary policy that coupled with economic activity and base money supply (by using multiplicators) determines movements in interest rates. These in turn, appear together with monetary aggregate in the function of aggregate demand. One of the objectives for using the model is also to obtain additional information on movements in monetary aggregate that the Bank of Slovenia uses as intermediate target on the basis of the interaction of variables used in the model. Such information may be obtained in two ways: the first one is to apply optimising control in the model[10], which calls for broad money M3 to be treated as an exogenous variable; the second way is the alternative replacement of the written function (7) and its inverse equivalent (7a), where monetary aggregate M3 is the endogenous variable, while the interest rate is a variable determined outside the model.

The key equation of the model is the reaction function (8), which represents the functioning and responses of monetary policy. The basic logic of monetary policy functioning has been represented by the target function. It shows us which aggregate the central bank is targeting and which variables it is taking into account for that purpose[11]. Coefficients used in the equation have been calibrated so as to ensure converged and logical functioning of the model. When setting out the target function for the purpose of alternative simulations of the model it is useful to lay down a function that would enable changing target values and target variables of monetary policy. Target values of variables of monetary policy are written as in the reaction function by changing the coefficient *adj*, which tells us how active monetary policy is in determining the movements in the dependent variables in that equation – in our case it is the exchange rate. Changing target variables in the reaction function[12] would require redesigning the model to accommodate new behaviour functions.

With the aim of getting a better insight into the structure of the model and connections between individual variables, *Chart 1* has been added. Exogenous variables have been written in boxes, while endogenous variables of the model have been filled in circles.

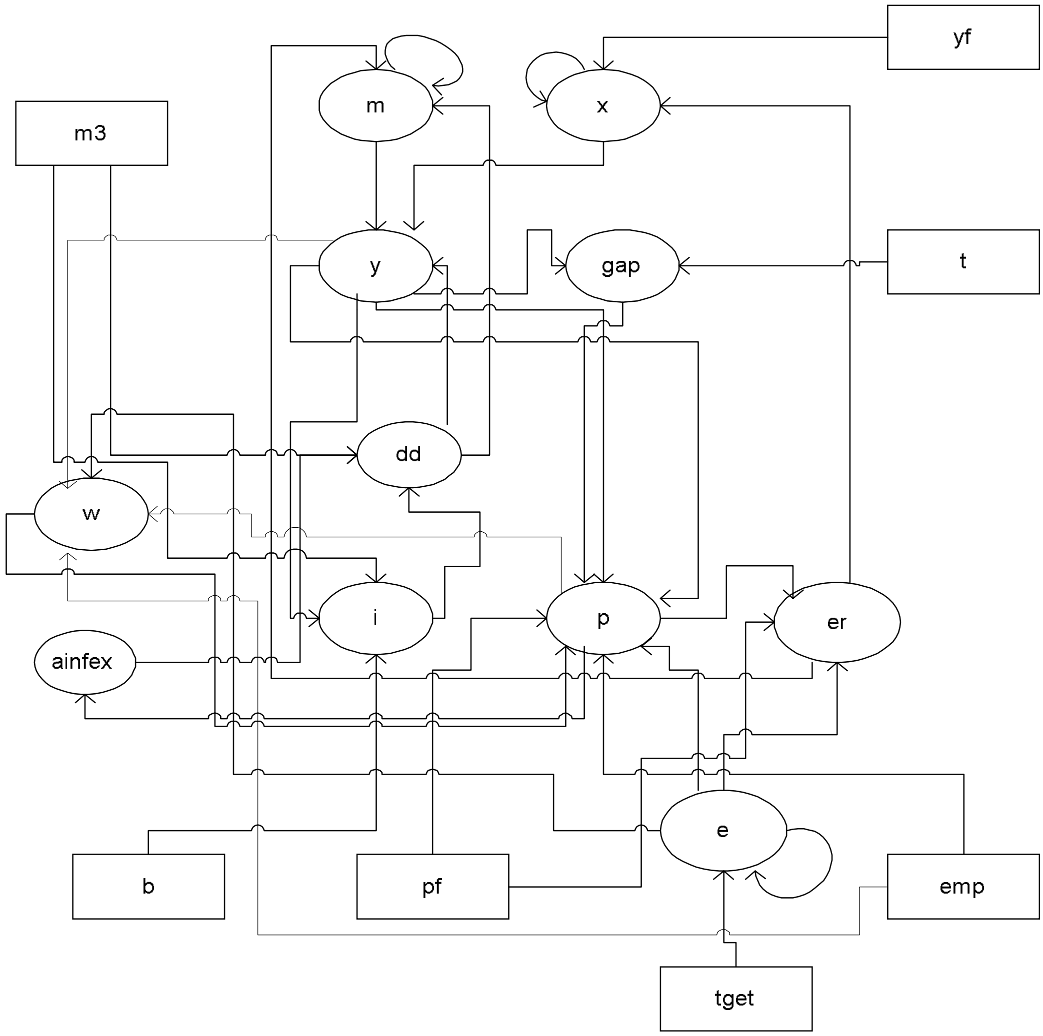
[9] By deploying Phillips curve of '70s, it would have been difficult to make a valid forecast of developments in the developed countries in the '90s.

[10] By means of the so-called "Type 2 fixing" it is possible to set the value of target variable and select instruments required to achieve the desired behaviour of the target variable.

[11] As already mentioned, for the purpose of the model simulation performed within the scope of this analysis, monetary aggregate M3 has been set as an exogenous variable. In spite of the fact that monetary aggregate has not been written in the reaction function of the central bank, it still remains the intermediate target of the Bank of Slovenia. It is conventional wisdom that when implementing monetary policy, the central bank takes into account a spate of indicators (different interest rates, developments in the money market, movements in exchange rates, money supply, etc.), that cannot be represented in the reaction function for the monetary policy in a small-scale model.

[12] Such a change shall occur in the case that there has been a shift in monetary policy relating to its intermediate target.

Chart 1: Structure and interactions of the model



2. MODEL SIMULATIONS

How versatile a model is, becomes clear when one wants to establish what are consequences and effects of exogenous variables on the functioning of economy changes, which may be independent (e.g. international economic activity, import prices) or they are set within the framework of economic policy (e.g. base money, the level of monetary policy intervention). The section contains some results obtained by simulations carried out by using the model described in the first section. At the same time, macroeconomic consequences (model simulation results) of such movements of exogenous variables on monetary policy measures will be illustrated. All simulations have been run under the software package WinSolve, which provides a framework for solving as well as simulating non-linear macroeconomic models[13]. The second part of the section shows the application of the model for a thoroughly practical case of monetary analysis that is used in the Bank of Slovenia for setting monetary target.

[13] For more information on the software package used see: http://www.econ.surrey.ac.uk/rpierse/winsolve/.

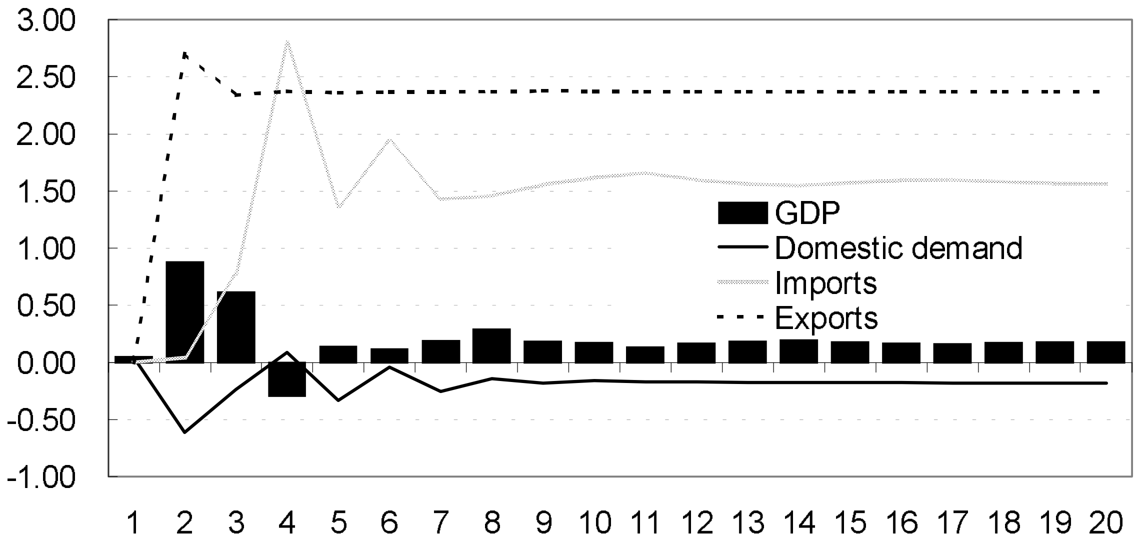
2.1. Simulation of consequences produced by changes in exogenous variables

Exogenous variables, which appear in the macroeconomic model of a small open economy, are primarily those that are related to its external environment. In the case of our model, these are variables, which present movements in foreign prices (import prices), foreign interest rates, and foreign economic activity[14]. Exogenous variables of the monetary policy, which appear in the model, represent monetary aggregates of base money and broad money supply (M3)[15]. The exogenous variable, which determines the target variable set by the Government of the Republic of Slovenia, is the target inflation in a particular year. When running the model under different assumptions, different values are assigned to each of the designated exogenous variables (shocks) that are incorporated in the model (individually and in the combination with adjusted values of other exogenous variables), and enable an extrapolation of the way in which the economy reacts to changed variables (the so-called impulse response functions).

a) Changes in international economic activity

A classical example of deploying the model in small open economies is to simulate changes in foreign economic activity on the domestic economic pattern. The starting point is to assume for the foreign economic activity that it has increased value by one per cent over a one-year-period. Responses of GDP components that appear in the model are represented in the figure shown below. It shows cumulative responses of individual components of aggregate demand where changes are posted in percentage points commensurate to the results obtained by simulation of the basic model.

Figure 1: Response of GDP components to changes in international activity by 1% (shock duration: 1st-4th quarter; in percentage points-cumulative changes)



Exports are most vulnerable when it comes to changes in foreign demand, but imports follow suit. Increase in imports is considerably more sluggish than increase in exports, then its response over a certain period may even exceed the response of exports (in other words, higher international economic

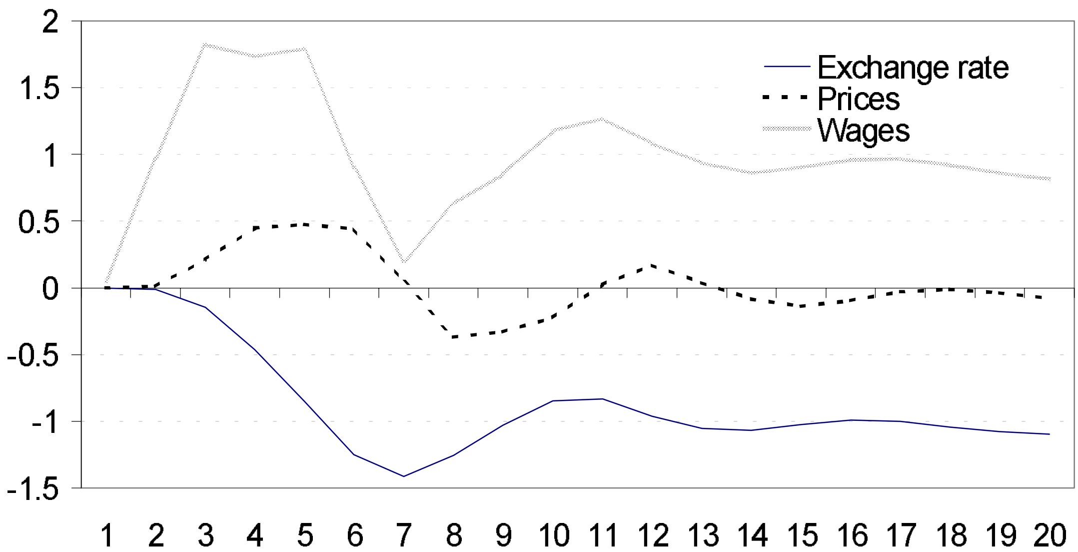
[14] Commitment to build a model as stylised and transparent as possible has resulted in mainstreaming the variables relative to foreign countries to representations of movements in relevant variables only for Germany and the USA. The shares of the two countries in all aggregated variables (foreign prices, foreign interest rates, and international economic activity) have been weighted by applying the proportion 85 (Germany) : 15 (USA).

[15] A more detailed model to include also the structured monetary block would have to consider also the interaction between the presented monetary aggregates, i.e. the transmission from the base money to broad money supply (M3).

activity may even lead to the deterioration of the current account balance!). Nonetheless, both exports and imports are back on track soon and stabilise slightly below the level prior to the jittery period. Imports sway more than exports, while the latter stabilises more quickly but above the starting level. Domestic demand responds more indolently to revving up of foreign economic activity, while cumulative decrease stabilises at the level of 0.18 percentage points. Economic activity measured by GDP increases in the same way.

What is the interaction of these aggregates and other key variables used in the model? Exchange rate appreciates spurred by the surge in exports, while cumulative appreciation stabilises at approximately one per cent. On the other hand, following the initial period of appreciation, real exchange rate depreciates for approximately three quarters and then again hits the level that is practically the same as at the kick-off. Prices behave very much like the exchange rate but tend to diverge and are even more volatile. Prices go up mainly in response to the widening output gap (surplus of actual over potential GDP), and are pushed further up by rising wages. Wages respond in volatile fashion, in cumulative terms they increase after 20 quarters by approximately 0.9 percentage points. Movements in real wages follow a similar pattern. Movements in nominal exchange rates, prices and wages under passive behaviour of monetary policy are illustrated in *Figure 2*.

Figure 2: Response of other variables to changes in international activity by 1% (duration of the shock: 1st-4th quarter; in percentage points-cumulative change)



b) Changes in international economic activity and response of monetary policy target function

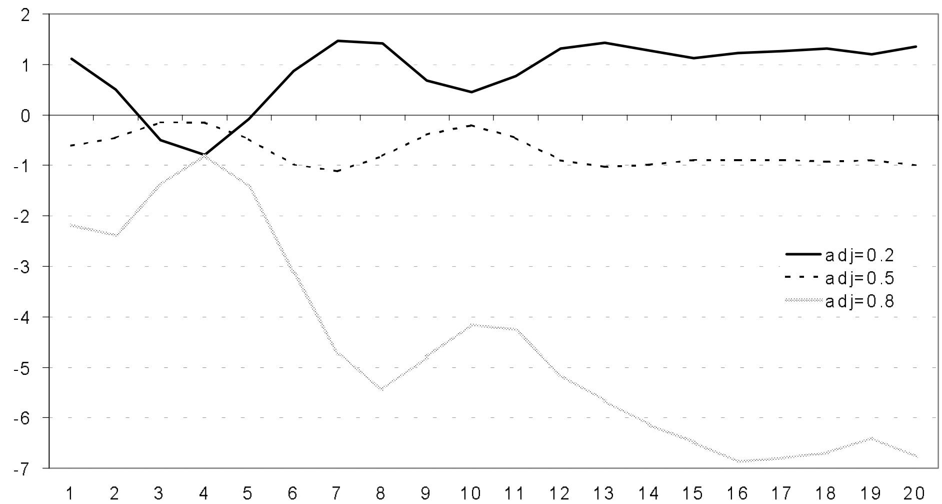
In connection with the simulations of changes in exogenous variables, it is also possible to change the target function of the monetary policy[16] that responds to change conditions in the external environment. When international economic activity revs up and is coupled with stronger pressure to appreciate exchange rate, the central bank could opt for a solution within the framework of a target function as envisaged in the model. This can take the form of depreciation of exchange rate – easily accomplished by easing off the goal set by the Government in pursuing target inflation. The issue under consideration is the response of movements in exchange rate and some other variables used in the model under the assumption that international economic activity is revving up, and in

[16] The model has been built to allow variables to be changed in order to run the model under different assuptions, while in practice simulations are made mainly by changing the reaction function coefficient; hence values, which monetary policy may set directly by e.g. adjusting the scope of intervention in the foreign currency market.

circumstances of changed values of the parameter, which determines convergence of exchange rate policy and adjustment of the actual price increase rate to the target inflation treated as exogenous factor[17]. *Figure 3* illustrates how movements in exchange rates are affected by changes in parameter *adj* in the target function. The parameter designated as *adj* shows the readiness of central banks to deploy the exchange rate as an instrument for curbing (reducing) inflation. The higher parameters signify passive adjustment of the exchange rate to the ratio between the current and the target inflation; whereas lower values indicate a more active role of monetary policy in the area of exchange rate and the active adjustment of exchange rate relative to the deviation of the actual from the target inflation.

However, one line of criticism argues that such kind of exercise does not produce an insight into the tools available to monetary policy to change values of parameters in its reaction function and does not talk about consequences produced by different instruments deployed by central banks with the aim of intervening (in our particular case) in foreign currency markets. Nevertheless, Figure 3 indicates that in the case where external circumstances change, a pro-active stance of monetary policy and convergence of developments in exchange rate and movements in inflation would be better suited to the monetary policy objective. In the case where the central bank adopts a passive role in the implementation of monetary policy, exchange rates may simply swell/may grossly appreciate (see the case of movements in exchange rate when the value of parameter *adj* in *Figure 3* equals 0.8). Change in exchange rate that in our case is the result of changing parameters of the monetary policy reaction function, affects also other aggregates. Responses of GDP and inflation under different values assigned to the parameter *adj* used in the present model as a monetary policy tool for monitoring (adjusting) movements in exchange rates with regard to the behaviour of inflation are illustrated below.

Figure 3: Change in exchange rate under different responses of monetary policy to the increased international economic activity (change in coefficient *adj* in the reaction function; changes in exchange rate with respect to the exchange rate in the case of simulation of higher international economic activity are shown below; duration of the shock: 1st-4th quarter; in percentage points-cumulative change)



[17] To illustrate more clearly the effects of monetary policy, only extreme (upstream and downstream) values of parameter *adj* have been applied – in real life, these deviations are not so ample.

Figure 4: Changes in economic activities under various responses of monetary policy in comparison with the results of the simulation of higher international economic activity (changed values of the parameter *adj*; length of shock: 1st-4th quarter; in percentage points-cumulative change)

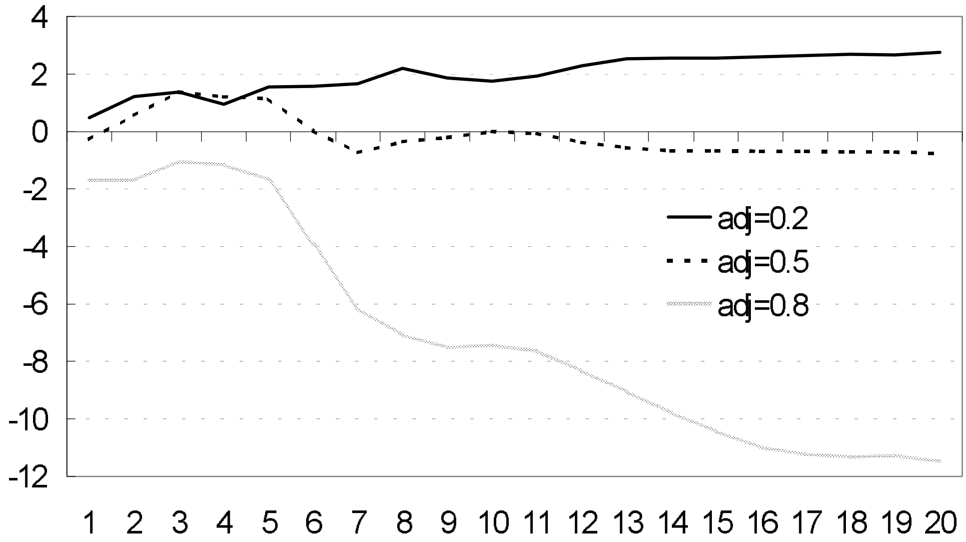
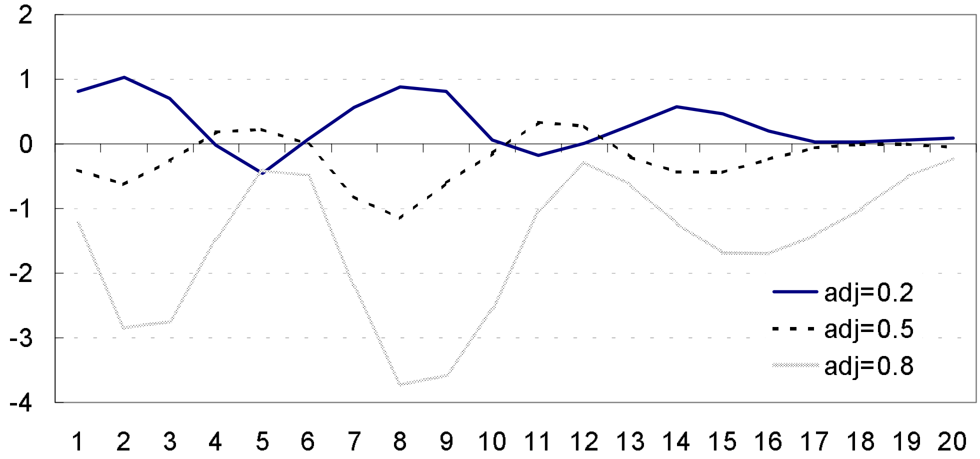


Figure 5: Changes in the rise of prices under different response of the monetary policy in comparison with the results of the simulation of higher international economic activity (changed values of the parameter *adj*; length of shock: I-IV quarters; measured in percentage points)



The response of the economic activity is rather more stable and straightforward than the inflation response. When monetary policy interferes with movements in exchange rate, it obviously leads to ample fluctuations in prices as well and could be accounted for by the influence of monetary policy on changed expectations of economic agents. True as it may be that an active exchange rate policy triggers more buoyant economic activity, it also increases prices, which in turn become volatile. The results of a simulation carried out by using a simple model reveal the underlying dilemma associated with monetary policy, which has to balance two objectives: stronger economic growth and higher, i.e. more volatile inflation.

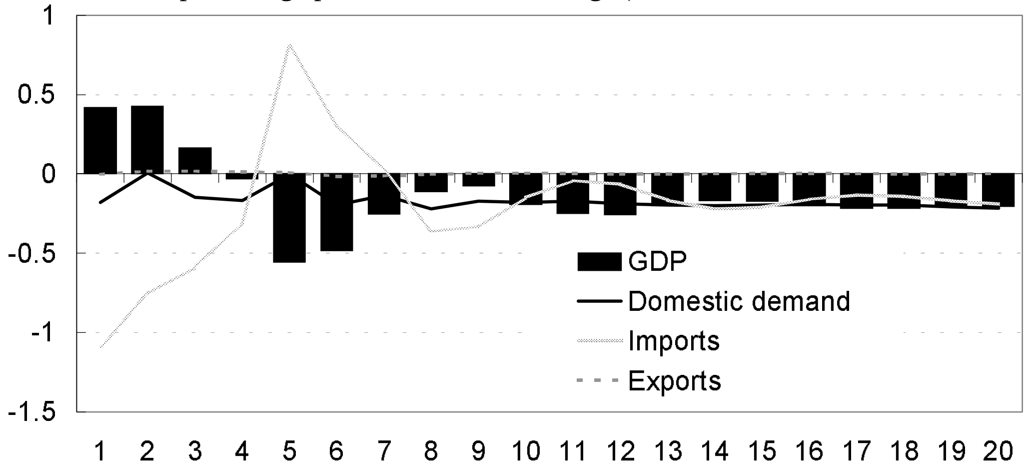
c) Change in import prices

Before turning to an overview of the simulation of effects produced by exogenous impact of monetary policy, it is worth examining a string of consequences triggered by changes in import prices (expressed as weighted average of foreign export prices)[18] on individual components of aggregate demand. Import prices make in the model one of exogenous variables and directly affect movements in the balance of payments. A typical example of raising import prices happened in 1999, when oil prices and prices of primary commodities went up in international markets. Thus in the preceding simulation we have simulated the increase in import prices of 1% for the period of one year.

As expected, imports show a jittery reaction to changes in import prices until the eighth quarter after the shock (its duration is four quarters), in cumulative terms, the change in imports stabilises at the level lower by 0.2 percentage points. Change in exports is negligible; it occurs exclusively through changes in prices (real exchange rate), which is affected *inter alia* by changes in GDP and wages. Change in GDP primarily caused by sluggish domestic demand (cumulative decrease by just over 0.2 percentage points), notches –0.2 percentage points.

Just as in the case of changes in the international activity, changes in import prices also give us a chance to examine the response of macroeconomic aggregates to the active stance of monetary policy, which would change its reaction function in response to an intervention in the area of exchange rate. Thus monetary policy in our model would again affect movements in exchange rates and would, in turn, boost exports and economic activity and hence trigger another wave of price increase.

Figure 6: Response of GDP components to change in import prices by 1% (duration of the shock I-IV quarters; measured in percentage points-cumulative changes)



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As already mentioned in the introductory part, in addition to exogenous variables, which are beyond the reach of economic policy, models may also be used for the simulation of effects produced by economic policy, which determines variables directly affected by it. The present model treats base money and broad money M3 as exogenous variables of monetary policy. In the case of developments in monetary aggregates, one can talk about the implementation of monetary policy. Additionally, monetary policy in the present model may modify/change the parameter *adj* in the reaction function. In that case, one is talking about the implementation of exchange rate policy.

[18] The model runs under the assumption that changes in commodity prices (e.g. oil or food) directly affect export prices of Slovenia's trade partners.

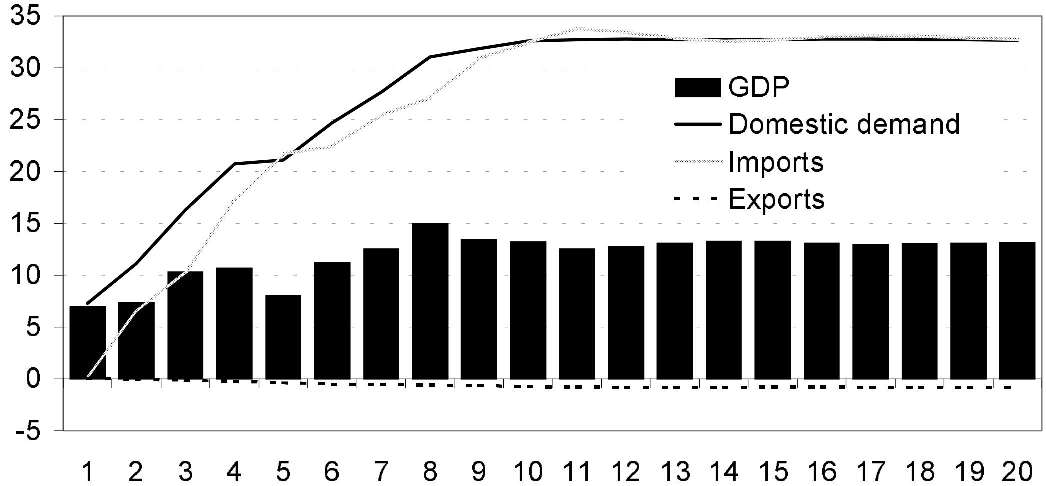
d) Change in monetary aggregates

Both monetary aggregates are deployed in the function of demand for money written in its inverse form. In equation (7) there are monetary aggregates shown together, when they are used to define the multiplicator, and separately. If exogenous change in monetary aggregate is to be simulated – and subject to the basic assumption that the multiplicator shall remain unchanged. At the same time, base money supply shall be adjusted by the same quantity as broad money M3 (this change is referred to hereunder as "change in money aggregates"). Firstly, consequences of changes in money aggregates by 1% reflected on the behaviour of basic macroeconomic aggregates, namely GDP components and some nominal variables will be examined.

Changes in the quantity of monetary aggregates lead to positive and negative consequences. Economic activity response to more money is positive. After twenty quarters, GDP surges in cumulative terms by approximately 13 percentage points. In other words, be on average 0.65 percentage points over the actual growth. GDP growth is fuelled by stronger domestic demand, which feeds on falling interest rates – demand would grow in cumulative terms by approximately 33 percentage points, i.e. on average by 1.65 percentage points over actual growth. Domestic demand growth is coupled with rise in imports that rises in cumulative terms by approximately equal cumulative amount. The response of exports to a change in money aggregates is practically neutral – in cumulative terms it even drops by 0.8 percentage points. Changes in individual components of GDP may be accounted for by the behaviour of some key nominal variables. *Figure 8* illustrates that under unchanged monetary policy behaviour, exchange rate appreciates (despite increasing current account deficit) predominately due to rising inflation (under unchanged target inflation set by the Government and pursued by the central bank).

From the macroeconomic angle, negative effects appear mostly as the result of fuelled inflation and higher wages. Cumulative increase in prices after twenty months amounts to approximately five percentage points, whereas the shock caused by more money in circulation, influences movements in prices for the period of five quarters after the shock. Wages react considerably stronger since in cumulative terms the rise notches approximately seventeen percentage points after twenty quarters and the bulk of the rise is achieved within four months after the shock. The channel through which broad money (M3) affects wages runs through changes in domestic demand and increased GDP, which is treated as exogenous variable in the equation representing wages.

Figure 7: Response of GDP components to change in money aggregates by 1% (duration of the shock 1st-4th quarter; in percentage points-cumulative changes)



e) Changed quantity of money aggregates and response of monetary policy target function

All described changes (e.g. higher economic activity and higher and hence more volatile prices) are valid in the case where the central bank does not adapt its policy of pursuing exchange rate. As has already been demonstrated, it is possible to change coefficient *adj* in the reaction function. In the case under review, this is demonstrated by more or less active monitoring of target inflation by means of adjusting exchange rate. Since *Figure 8* reveals a rather strong appreciation of exchange rate, which follows the change in the quantity of money aggregates, it is intriguing to find out about the impact the adjusted coefficient *adj* has on developments in economic activity and movements in prices. The answer can be found in *Figures 9* and *10*, where cumulative changes for both aggregates are shown related to the basic simulation (i.e. the changed quantity of money aggregates) in the case where value assigned to coefficient *adj* in the reaction function are changed/altered. To facilitate comparison, both figures show the response of economic activity and price changes under the basic scenario where the value of the coefficient *adj* equals 0.4.

By alternating coefficients embodied in the reaction function, monetary policy is well poised to affect indirectly movements in GDP and prices; hence it also affects other components of the model. However, deciding for one or the other approach is a trade-off.. In the case that priority is given to encouraging economic activity, prices follow suit. The reaction function presented below suggests that even slight changes in the coefficient *adj* result in considerable changes in both variables. Consequently, the central bank shall implement monetary policy with utmost precision. A more thorough analysis of the variability of the two investigated or any other variables would indicate the way to optimising the monetary policy function in the field of both monetary policy and narrow exchange rate policy.

Figure 8: Response of selected variables to changes in money aggregates by 1% (duration of the shock: 1st-4th quarter; in percentage points-cumulative changes)

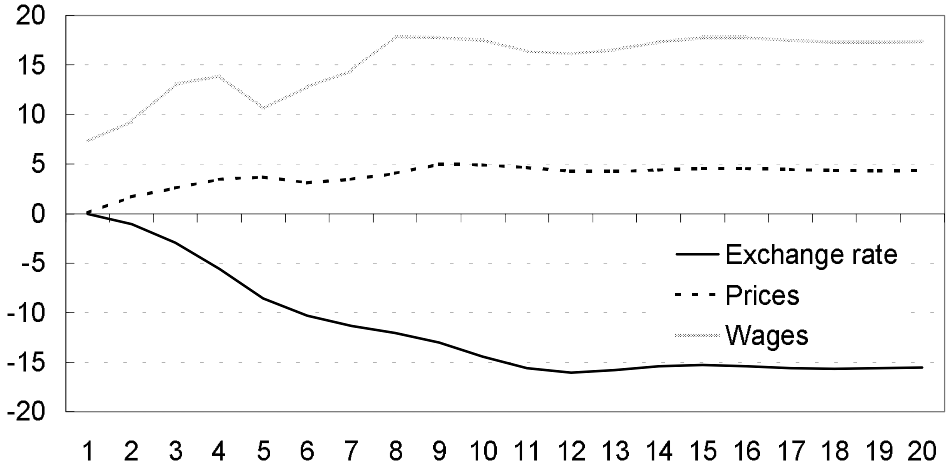


Figure 9: Changes in GDP under different responses of monetary policy in comparison with the results of simulation of larger quantity of money (altered values of the parameter *adj*; duration of the shock: 1st-4th quarter; in percentage points-cumulative changes)

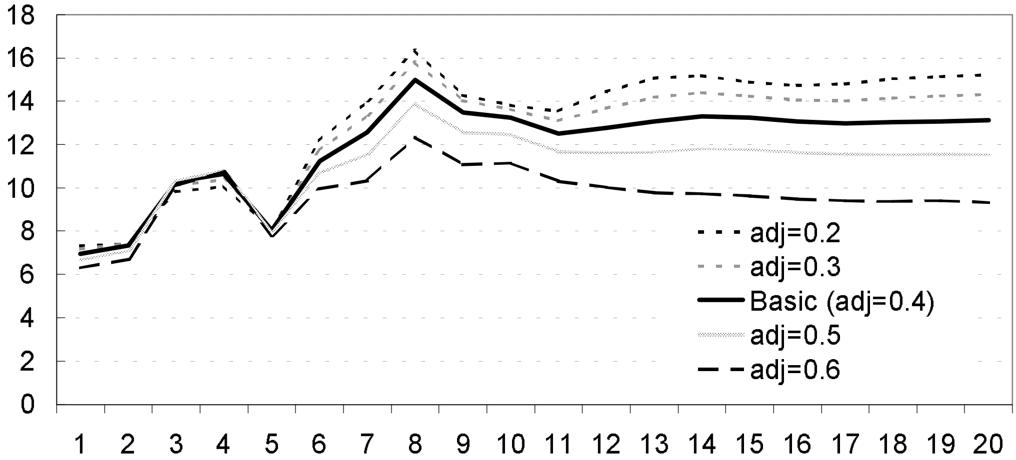
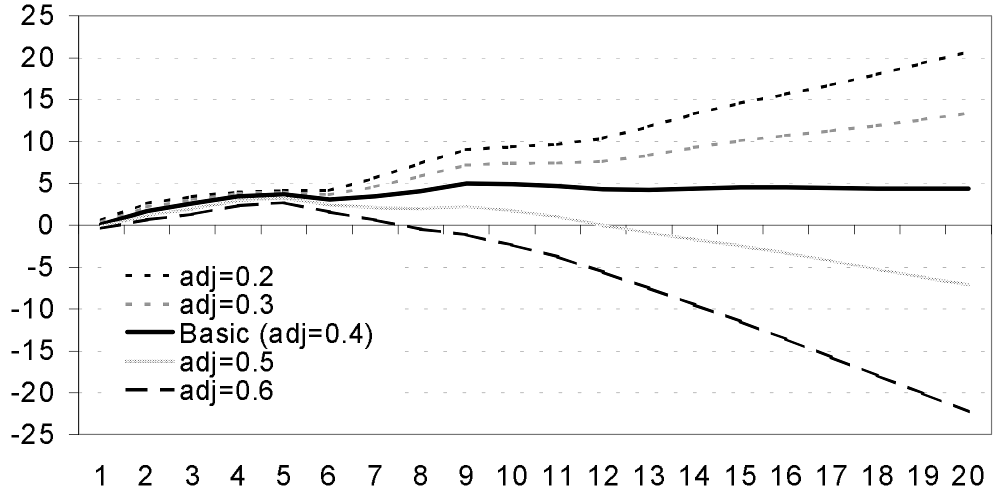


Figure 10: Changes of prices under different responses of monetary policy in comparison with the results of simulation of larger quantity of money (altered values of the parameter *adj*; duration of the shock: 1st-4th quarter; in percentage points)



2.2. Setting growth rate of intermediate target of monetary policy

That the model may be applied beyond the area of analysing transmission mechanisms of monetary policy may be illustrated by a practical example that is encountered in the Bank of Slovenia each year when setting target rate for monetary aggregate for the following year. The question policy-makers ask is the following: what should be growth of M3 if certain developments in key macroeconomic aggregates are assumed (see e.g. explanations of intermediate objective of the Bank of Slovenia for individual years). The answer or the approximation of the answer could be worked out in several ways[19], whereas an aid in setting growth rate for monetary aggregate could also be the usage of the macroeconomic model presented in this analysis. For the purpose of setting monetary aggregate growth rate, the present model may be used in two directions. Movements in M3 may be determined

[19] E.g. by means of estimate of demand for M3 or forecast of movements in consolidated balance sheet of the monetary system.

by estimating (forecasting or interpreting forecast) movements in exogenous variables incorporated in the model, the equation to approximate demand for M3 is written so as to represent monetary aggregate as endogenous variable, and then the model offers a solution for M3. There is another approach to set the framework for monetary aggregate growth by means of optimising control. Since it has not been used herein, only a brief decryption is given at the end of the section.

If M3 is written as an endogenous variable (hence the equation to approximate the demand for money supply 7a is used), then exogenous variables (excluding time trend) are also base money, money market interest rate, employment, import prices, international economic activity, and target inflation set by the Government of the Republic of Slovenia. The basic forecast envisages that interest rates on money market in 2000 on average are set to remain at the same level as at the end of 1999, that employment is due to increase by 0.8%, that import prices will remain unchanged, that international economic activity will increase by 3%, and that the target inflation is set by the Government of the Republic of Slovenia to 6%. Variables have been assigned values from public sources of data such as Autumn Report published by the Institute of Macroeconomic Analysis and Development (IMAD) as well as forecasts made by the IMF and the OECD.

Since forecasts related to exogenous variables may deviate, such variances shall be taken into account when making forecasts. Table 1 shown below illustrates average annual changes in monetary aggregate M3, provided the same values of above-mentioned aggregates are preserved and only values of certain key exogenous variables, which are not set by the central bank may be subject to changes.

Table 1: Projections of movements in monetary aggregate M3 in 2000

	Average annual growth of M3 (in %)
Basic assumptions	15%
Basic assumptions, target inflation 5%	11%
Basic assumptions, target inflation 7%	18%
Basic assumptions, import prices +1 p.p.	16%
Basic assumptions, import prices –1 p.p.	13%

The results, i.e. the forecast obtained by means of models that use alternative values of exogenous variables[20] are entirely in line with forecasted growth rate of monetary aggregate M3 of the Bank of Slovenia for 2000, which have been made by means of different techniques[21]. Even though numerous shortcuts have been used in the model, results show that subject to improvements, the model may be used as a tool/aid in setting the monetary target.

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Another path made available by the WinSolve application/software package for the purpose of setting the target value is the so-called simple optimising control. In this case, values of target variables are chosen, which should be obtained by instrumental variable M3. With this in mind, we do not impose causality or any other direct relation between monetary aggregates and target variables. Each year, the

[20] Arguments in favour of setting a band instead of precisely determining M3 growth rate are supported by the fact that by using alternative values for different exogenous variables – as well as by taking into consideration a wide range of risks inherent in forecasting developments associated with movements in M3 – different growth rates of M3 are most certainly to be obtained.

[21] Intermediate monetary policy target set by the Bank of Slovenia for the year 2000 is the annual growth in monetary aggregate M3 in the range between 12% and 18%. Annual growth is determined for the period from the average for the last quarter of 1999 to the average for the last quarter of 2000.

Government of the Republic of Slovenia sets the target rate for price rise and target growth rate for economic activity. Moreover, the Government also projects movements in some other key macroeconomic aggregates in the Budgetary Memorandum. When deciding a rate of growth of M3 by means of optimising control, it is essential to establish how much monetary aggregate should grow, i.e. to set the band in which it should be, if the planned rate of inflation and of economic activity is to be achieved. To achieve values of the set target variables by means of optimising control is not run-of-the-mill and it depends on the interaction between target and instrumental variables, while the structure of the model affects the solution. Furthermore, the selected variable may also serve as the instrument for setting only one target variable. To use the optimising control for the model in its current state is not feasible since variables incorporated in it that define inflation expectations cause difficulties connected with convergence. Thus this option to find a solution to the model remains to be addressed in future exercises.

3. CONCLUSIONS

This exercise has produced a simple macroeconomic model built on a quarterly basis and designed to serve the purpose of pursuing at least three objectives. The first objective is to deploy the model to interpret the response of the economy to changes in exogenous variables featured in the model. There are two kinds of such variables: those, which are determined beyond the reach of economic policy makers and in a small open economy usually refer to variables such as international economic activity, prices abroad, foreign interest rates, etc., as well as those that are set independently by monetary policy. When variables beyond the influence of monetary policy are changed, then the response of monetary policy to such a challenge is the issue. The second objective has been to establish what is the response of the economy to the modified values of exogenous variables connected with the simultaneous reaction of monetary policy and an appropriate change in parameters in its target function. The third objective of the analysis has been set in line with practical requirements and is related to the annual setting of intermediate monetary policy objective in the Bank of Slovenia. The idea has been to make an exercise that would demonstrate whether to trust a small-scale macroeconomic model when it comes to movements in broad money (M3) that is normally computed by means of demand for money and by consolidated balance sheet of monetary system.

By simulating changes that affect exogenous variables within the model, it has been demonstrated that the response of exports to revving up of economic activity abroad comes almost immediately, while imports follow suit. Gross domestic product increases cumulatively by approximately one fifth of the size of the shock. As exchange rate appreciates and wages go up, prices respond in a rather volatile fashion, and in cumulative terms they practically remain unchanged. Results obtained by simulation of changes in import prices are completely logical. Firstly, imports drop and the same happens to gross domestic product in cumulative terms. A larger quantity of money aggregates spurs economic activity driven by domestic demand, while rising demand is reflected in higher are more volatile prices – a recipe for creating an insecure environment where economic agents may feel threatened. The model limits further experiments with monetary policy to changes in parameters incorporated in the reaction function. By means of simulating different responses of monetary policy, it has been demonstrated that policy-makers are trapped between opting for a buoyant economic activity and a higher rate of price increase. The exercise has shown that even modest changes in parameters affected in the reaction function by monetary policy are due to trigger considerable changes in macroeconomic aggregates. Therefore, the central bank has to act prudently in the course of decision-making on the scope of these parameters - in other words, it means power to intervene in the field of exchange rate. Relatively high degree of consistency in the implementation of the model has been demonstrated also in pursuing the third objective where forecasting of movements in intermediate objective of monetary policy for the time horizon of one year from the latest known data. By changing probable values of exogenous variables, target growth of monetary aggregate has been set within the same band as determined by applying other methods.

To summarise, developing economic models as tools for dealing with economic problems and monetary policy-making in an economic environment as specific as Slovenia's is (economic transition, a small open economy, the number and scope of institutional changes) is far from being a simple task. Therefore, a forward-looking approach will unconditionally ask for a flexible and open-minded stance eventually leading to upgrades that will make the model both comprehensive and versatile. It is the monetary block that needs some fine tuning in the first place, accompanied by efforts to design a converging solution to the model by means of optimum control and coupled with the analysis of optimum functioning of monetary policy within the framework of the model adequately improved.

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Definitions for variables used in the model

y	-	real GDP
dd	-	domestic demand (C+I+G; derived from the data for y,x,m)
x	-	exports of goods and services (data base of the Bank of Slovenia+Statistical Office of the Republic of Slovenia (SORS); actual dynamics of exports of goods and services has been taken into account, annual cumulative derives from the data from the national accounts statistics)
m	-	imports of goods and services (data base of the Bank of Slovenia+SORS; actual dynamics of imports of goods and services has been taken into account, annual cumulative derives from the data from the national accounts statistics)
i	-	interest rate on the money market (data base of the Bank of Slovenia)
exp inf	-	expected inflation (defined in the model – equations 9)
m3	-	monetary aggregate M3 (data base of the Bank of Slovenia; quarterly average)
yf	-	GDP of foreign countries (data base of the Bank of Slovenia; computed as weighted average of economic activity of Germany and the USA)
pf	-	import prices in foreign currency – weighted average of export prices of Germany and the USA (IMF International Financial Statistics; quarterly average)
e	-	exchange rate (data base of the Bank of Slovenia; computed as weighted average exchange rates for German Mark (0.85) and US Dollar (0.15))
p	-	domestic prices (CPI; index per uniform base; the latest information for the quarter has been used)
emp	-	employment (number of employees in companies; quarterly average)
w	-	wages (average net wage; quarterly average)
y^*	-	potential GDP
b	-	base money (data base of the Bank of Slovenia; quarterly average)
tget	-	target inflation (Institute of Macroeconomic Analysis and Development - Spring/Autumn Report, Budget Memorandum)