MODELING OF MACROECONOMIC DEVELOPMENT IN THE SR

PROFESSIONAL SEMINAR ORGANISED BY THE NBS

The papers presented at the seminar are published in a shortened version.

The European Commission in its „Report on Progress of each Candidate Country towards membership of the European Union" of 9 October 2002 characterised Slovakia as a functioning market economy. The pioneer years of transformation, during which Slovakia's economic development was stigmatized by numerous institutional changes and shocks in the process of building of new economic structures, belong to the past. The standardisation of economic environment is accompanied by an increasing need to describe the functioning economic mechanisms and economic policy role in this system and to quantify the impacts of individual economic policy decisions. A useful tool for the identification of economic relations and links as well as for testing the ability of the economic policy to influence the economy is a macroeconomic model. From the National Bank of Slovakia point of view and with regard to the implementation of an inflation targeting strategy, the macroeconomic model represents a significant supporting factor in the monetary policy decision-making process. At the same time, the model creates a disciplinary framework for medium-term inflation forecasts and, last but not least, it increases credibility of monetary policy and transparency of its communication. The merits of macroeconomic models are not only in their application by the institutions responsible for strategies and implementation of economic policies. Moreover, creation of macroeconomic models enriches the development of economic science in a significant manner, and thus is a challenge for the academic community.

The seminar „Modelling of macroeconomic development in the Slovak Republic" organized by the National Bank of Slovakia aimed at creating conditions for professional discussions among the institutions directly involved in economic policy formulation and representatives of economics research. I also believe that the seminar will give a boost to further development of macroeconomic modelling not only in institutions such as the Ministry of Finance of the Slovak Republic, the Slovak Academy of Sciences, the National Bank of Slovakia, but also among analysts representing the business sector. A continuation in the work begun, further contributions in research in the macroeconomic modelling area and raising its sophistication level will definitely be helpful in defining economic policy strategies and in their implementation.

Peter Ševčovic, member of the NBS Bank Board,
Chief Executive Director of the NBS Monetary Division

AN ECONOMETRIC MODEL OF THE SLOVAK REPUBLIC

Juraj Valachy, Judita Kucserová
Financial Policy Institute of the Ministry of Finance of the Slovak Republic

1. Basic description of the model

Under the Public Finance Management Reform project financed by the World Bank, an econometric model of the Slovak economy inter alia has been developed by Mr. Scott Livermore, a consultant. This model enables better forecasting of the economy outlook and at the same time it facilitates the examination of the impact of various policies and measures on the economy, including the links of fiscal policy instruments to the real economy.[1]

The model is expected: (1) to produce forecasts for the Slovak Republic in a consistent framework both in the short-term and long-term horizon, (2) to analyse the risks to the economic outlook and their influence on the budget, and (3) to simulate the effect of various measures and policies on the economy.

The model is a quarterly one (most variables are modelled as a quarter-on-quarter growth) and it has an error–correction form.[2] This approach makes it possible to distinguish between long-run and short-run dynamics. In determining the short-term dynamics, the main role is played by statistical significance of the variables, while in the case of a long-term relationship the theoretical foundations are more important. The data are seasonally adjusted in accordance with the methodology used by the Statistics Office of the SR.

The model structure is based on the income-expenditure accounting system with the explicitly treated supply side. In the long run the Slovak Republic is modelled as a one-sector economy with a Cobb-Douglas production function. Hence, the equilibrium growth rate of potential output of the Slovak economy is primarily influenced by the growth in population and productivity. Potential output growth is a result of growing investments, mainly of foreign direct investments. This production function, where output is determined by productivity growth, capital supply and equilibrium employment, lends the fundamental anchor to the model. For example, in the long run, the variables, such as the wages, GDP deflator, employment and investments are derived from the equations of the first-order profit maximisation condition. The equilibrium employment rate (structural employment) is exogenous, and is used together with the labour supply to get the equilibrium unemployment. Prices are modelled as a flexible mark-up on costs, where the margin size depends on the economy's cyclical position. In the short-run, output is a function of aggregate demand, and that is why the model contains standard demand equations for household consumption, foreign trade and investments. The consumption of the government and stock-building are exogenous.

2. The model description in more detail

The core model describes the real economy both from the supply and demand side. The labour market (employment and wages), external sector, fiscal and monetary sectors are used as additional satellites..

Supply side

Potential output: $YHAT = e^{TFPt}K_t^{\alpha}ET_t^{(1-\alpha)}$, (Cobb-Douglas production function)
Total factor productivity : TFP = f(FDI stock, government investments)
Employment: ET = f(GDP, real average wage)

In the long-term horizon, the employment is at the level, where marginal labour productivity is equal to real wages, but short-term dynamics is influenced also by the output growth and lagged dependent variables. Employees and employers negotiate the wages, nevertheless the firms then choose an employment level based on the negotiated wages.

Demand sidey

GDP: GDP = C+GC+IF+X–M

The private consumption equation relates the real consumption to the real income and borrowing costs (and/or alternative non-saving costs). As an income variable, the gross disposable income is used. In the long-run, the coefficient in the case of the real disposable income is equal to 1.

The profit maximisation condition provides a long-run

[1] More detailed information on the model is given on www.finance.gov.sk/ifp
[2] The entire model is implemented in the Eviews software system.

investment equation. Short-run dynamics is determined by additional variables, such as government investments, corporate profits or FDI inflow. The government consumption and stock building are exogenous parameters.

Exports: X = f(0.85 . MEUR + 0.15 . MCZ,WCRR)
Imports: M = f(TFE, WCR, TREND), where TFE = C + GC + IF + IS + X

Exports and imports are determined by the foreign demand and Slovakia's competitiveness. Since Slovakia is a "small" country, her capability to affect her trade conditions is quite limited. The foreign demand is approximated by the import weighted average in the Euro area (MEUR) and in the Czech Republic (MCZ), where the weights are 0.85 and 0.15, respectively. The competitiveness is approximated by unit labour costs relative to the Euro area and the Czech Republic. The import is a function of the total final expenditure (TFE) and competitiveness.

Economy-wide average earnings

Wages: ER ER = f(GDP/employment, GDP deflator, CPI, equilibrium – real unemployment)

Long-term revenues are determined by the profit maximalisation condition, where real wages are equal to marginal productivity. However, the wages equation is usually a result of negotiation process. Employees and employers negotiate the real wages, and the relative power of these two groups determines the final result (relative power is usually captured by unemployment gap, in this case it is the difference between unemployment and the level consistent with equilibrium employment). However, the employees are also interested in real disposable wages, and the employers are interested in product wages. Therefore, we have included also the CPI in the wage equation, although the main weight in the wage equation is based on the GDP deflator.

Monetary sector – prices, interest rate and exchange rate

Several variables and equations related to prices are built in the model. It is essential though that they are mutually linked assuming the static and dynamic homogeneity. The long-run inflation is merely a monetary phenomenon and the SR model has a vertical Phillips curve.

The monetary policy (the basic interest rate) is set in line with a Taylor rule, linking the interest rate with the inflation and output gap. The exchange rate (SKK/EUR) is modelled through real interest rate differential and risk premium. In simulations, financial sector reactions can be switched off completely as needed (e.g. assuming Slovakia_s membership in the Euro area, neither the interest rates, nor the exchange rate will be able to react to shocks).

The external sector

Export of goods and services is included in the model as one variable. Hence, in the trade balance calculations it is necessary to separate the overall exports and imports into goods and services. This split is calculated using the share of goods in the total exports (and then also in imports). The other items in the current account, such as current transfers, revenues, dividends, etc. are aggregated in one variable and are assumed to be exogenous. A separate variable represents the net FDI inflow, but the other balance of payments variables, such as the capital account or financial account are not modelled.

The fiscal sector – general government consolidated sector

This is a simplified representation of the general government sector modelled using cash principle with no further adjustments, e.g. privatisation or state guarantees provision. More detailed analyses of the public sector, revenue projections and government finances budgeting over several years ahead are conducted using additional approaches jointly with relevant departments of the Ministry of Finance of the Slovak Republic. This sector is included in the SR model for a basic simulation of macroeconomic development impact levels on the budget.

The fiscal and real sectors link is still incomplete. The link from the economy to the fiscal sector is achieved via the interest rates and mandatory expenditures (e.g. unemployment payments). The link from the fiscal sector to macroeconomy is secured through effective tax rates, government investment expenditure and government consumption as such.

Future development

- establishing better links between macroeconomic and fiscal development
- links between international economy and the Slovak Republic through trade (demand), monetary sector (interest rate), FDI impact and commodity prices.

The position of international economy (especially Euro area) will become ever more important and there-

EFFECT OF THE EURO AREA IMPORTS CHANGE ON THE PROJECTION OF DEVELOPMENTS IN THE ECONOMY'S RELEVANT INDICATORS
a relative change in variable value as compared with the original scenario (in per cent, if not stated otherwise)

year	private consumption	gross investments	GDP	employment	unemployment rate (% points)	average income	CPI	short-term interest rate (% points)	koruna for euro	government sector balance (% GDP)	current account (% GDP)
1	0.0	0.9	0.5	0.1	-0.1	0.3	0.0	0.3	-0.1	0.0	0.2
2	0.2	1.6	0.8	0.5	-0.4	0.9	0.2	0.8	-0.3	0.0	0.3
3	0.4	1.5	0.8	0.6	-0.5	1.5	0.6	0.8	-0.5	0.1	0.3
4	0.6	1.3	0.7	0.5	-0.4	2.1	1.0	0.7	-0.6	0.2	0.2
5	0.7	0.9	0.5	0.4	-0.4	2.6	1.4	0.7	-0.6	0.2	0.1
6	0.8	0.6	0.3	0.3	-0.3	3.1	1.7	0.5	-0.6	0.2	0.0
7	0.9	0.2	0.2	0.2	-0.2	3.5	2.1	0.4	-0.5	0.2	0.0
8	1.0	0.0	0.0	0.1	-0.1	3.9	2.5	0.3	-0.5	0.2	-0.1
9	1.0	-0.2	-0.1	0.0	0.0	4.1	2.6	0.2	-0.4	0.2	-0.1
10	1.1	-0.4	-0.1	0.0	0.0	4.3	2.7	0.1	-0.3	0.3	0.0
15	1.1	-0.4	-0.1	0.0	0.0	4.4	3.0	0.0	0.1	0.3	0.0
20	1.0	-0.3	-0.1	0.0	0.0	4.4	3.1	0.0	0.3	0.3	0.0
30	1.0	-0.6	-0.2	0.0	0.0	4.7	3.4	0.1	0.3	0.3	0.1

fore the Ministry of Finance of the Slovak Republic has established cooperation with the company OEF (Oxford Economic Forecast), in order to achieve a full linking of our model with the world developments. The OEF has developed its own models for individual countries worldwide, including their grouping (multi-country model) and commodity prices. All countries are mutually linked either through foreign trade or indirectly via the interest rates, exchange rates or commodity prices. Our model integration into the OEF worldwide model enables us to quantify the impact of economic developments in the world on the Slovak Republic.

To this end, in cooperation with the OEF we intend to extend the model further on the side of the external and monetary sectors:

- separation of motor vehicles exports from the rest of goods exports + link to FDI
- inclusion of absolute competitiveness in the export equation
- modification of interest rates modelling from the use of a Taylor rule to the modelling using the National Bank of Slovakia's inflation targeting and the ECB rates.
- improvement of the EUR/SKK exchange rate modelling using our analyses to determine equilibrium exchange rate based on the BEER method.

Simulation of Slovakia's exports acceleration

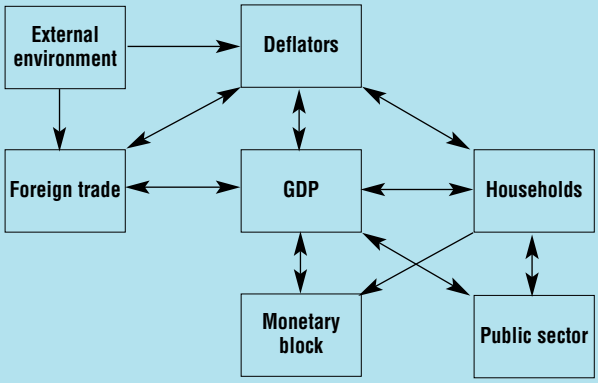
The exports to the Euro area countries makes nearly 60 per cent of the total Slovakia_s exports, and an annual growth of the Euro area import from Slovakia by 2 per cent would have a beneficial effect on the entire economy. This scenario assumes that a shock is of a permanent nature and the central bank is able to identify the presence of this shock immediately. This is considered to be a typical positive demand shock partly offset by growing imports. This shock will increase the GDP and will improve external balance, which in turn will lead to employment and investments growth. As potential output is changing only slowly, the economy may experience slight overheating causing a moderate growth in prices. The price increase will make the central bank to raise interest rates, which in turn weakens investments.

ECONOMETRIC MODEL ECM–ISWE05Q1

Ján Ďuraš, Institute of Slovak and World Economy, SAS

The ECM–ISWE05Q1 model is based on error-correction models. It can be basically described as a small demand-side model of the Slovak economy. An upgrade of an earlier macroeconomic model ECM-ISWE04Q1 (Ďuraš et. al. (2004)), it now includes a monetary block and a state budget block. Furthermore, in several equations existing functions were refined or modified to render a more accurate picture of the reality and current trends in the Slovak economy. The model draws on quarterly data spanning the period from the first quarter of 1993 till the last quarter of 2004. It comprises 28 regression equations, 54 major endogenous and 14 exogenous variables. Findings published in respect of earlier ECM models of Slovakia (Gavura, Tkáč (1999), Haluška, Olexa, Országová (2001), Haluška and others (2004)) were taken into account during its development. This paper features a short description of the main function relations and links between individual model equations.

Figure 1 ECM-ISWE05Q1 model structure



Model structure

The model breaks down into six main blocks. The GDP block is an aggregating one, computing individual domestic demand components and the total product of the economy. The foreign trade block contains equations determining the volume of imports and exports of goods and services, as well as equations producing import and export deflators. The prices and deflators block calculates deflators for individual GDP components, and price indices. Equations in the block of households describe labour market developments and the generation and use of household income. The monetary block models interest rates and loans, the public sector block computes state budget revenues and expenditures. Interactions between blocks are shown in Figure 1. The impacts of external environment enter the model both through import prices of EU15 countries and the price of Brent oil, affecting our import prices, and through demand for our exports shown as EU15 imports. Another exogenous variable is the euro exchange rate. The deflators block is linked to the foreign trade block – import prices influence the producer price index, which is an explanatory variable for the deflator of Slovak exports. The mutual link between the deflators block, the block of households and the GDP block stems from the impact of unit labour costs on domestic prices, while nominal wages in turn depend on the productivity of labour, and the CPI and final consumption of households are influenced by gross disposable income. Apart from that, final consumption of households also depends on developments in interest rates on deposits and the amount of loans, which are described in the monetary block. Similarly, loans to enterprises and households are one of the explanatory variables for investments. In the state public sector block, indirect taxes are modelled using domestic demand components, whereas direct taxes depend on several variables identified in the household and GDP blocks.

Assuming non-stationary economic time series, ADF and KPSS unit root tests were carried out. Except for prices with test results of I(2), the variables were stationary after first differentiation. In estimating long-run relations in individual equations, despite rather short time series, which might affect the quality of results, a cointegration analysis based on the Johansen methodology was applied. Where no cointegrating vector could be found, or its estimate was not robust given the specifications of the relevant VAR model, the equation concerned was estimated in a transformed ADL form.

GDP and foreign trade blocks

In the model, household final consumption at constant prices (*HC*) depends, both in the long and the short run, on real gross disposable household income (*HDD/PC*) and loans to households (*ACH3B*) adjusted for the household final consumption deflator (*PC*). In the long run, it is also influenced by interest rates on deposits (*IRDT*). Their effect, in line with economic theory, is opposite to that of growth in gross disposable income and loans. In other words, if interest rates on deposits are higher households save more and spend less. In the equation for final consumption of general government (*G1*), current state budget expenditures (*SBFE*), translated into constant prices using the public consumption deflator (*PG*), are the explanatory variable. In the long run, the gross fixed capital formation at current prices (*DFKP*) is determined by foreign direct investments (*FDI*) net of privatisation (*QFDIPA*), by state budget capital expenditures (*SBCE*) and loans to firms and households (*ACEH3B*). In the long run, a 1%

growth in loans leads to a 0.40% increase in investments, a 1% rise in state budget capital expenditures will result in investments moving up 0.61%, and a 1% increase in foreign direct investments will give rise to a 0.16% increase in investments. In the short run, state budget capital expenditures are the only significant variable.

In the import deflator (*PMGSR*) equation, both in the short and the long run, the import deflator for EU15 countries (*PIM_EU15*), the average EUR/SKK exchange rate and the Brent oil price index (*IPOIL95*) appear as explanatory variables. The deflator of exports of goods and services (*PEGSR*) depends on developments in both the industrial producer price index (PPI95M) and the import deflator (*PMGSR*).

The equation for import of goods and services shows that, in the long run, import at constant prices (*MGSR*) is a function of domestic demand (*DD*), export (*EGSR*) and the ratio of import price and producer price indices. According to the equation, a 1% increase in domestic demand will trigger a 0.57% rise in import; similarly, a 1% increase in export will cause import to rise 0.66%. If the real exchange rate, measured as the ratio of import price and producer price indices, picks up by 1%, import will decrease by 0.20%. Meanwhile, in the short run, a 1% rise in domestic demand will send import up by an entire 0.98% and a 1% increase in exports by 0.94%. The effect of the exchange rate is inconclusive. Development in real export (*EGSR*) is influenced by EU15 import (*IM_EU15*), the real exchange rate and real accumulated foreign direct investments net of privatisation (R*ECFDIPA*). The structure of Slovakia's export is going through major changes and net export has fared well in the recent years despite a continuing appreciation of the real exchange rate and a neutral external environment. This development can be explained by foreign direct investments (*FDI*), which have an impact on Slovakia's export capacity growth[1]. In the long run, a 1% exchange rate appreciation will lead to a 0.41% reduction in export, whereas a 1% rise in EU15 import or in real accumulated FDI will increase export by 0.60% or 0.52%, respectively. FDI bring about a rise in export capacity after a 2.5-year time lag.

Prices and deflators block

Manufacturing producer prices (*PPI95M*) are modelled on the basis of production costs; both in the long and the short run, the import deflator (*PMGSR*), the oil price index (*IPOIL95*) and the unit labour cost are the explanatory variables. In the equation determining the core inflation index (*CORE95*), the impact of producer prices (*PPI95*) and exchange rate development (*IEURSKP95*), which affects prices of imported goods, were considered. Overall consumer prices are based on development in core inflation (*CORE95*) and administered prices (*REG95*). The deflators of individual domestic demand components depend on the consumer price and producer price indices. The gross domestic product deflator (*PY*) is calculated by means of an identity as the ratio of sums of individual GDP components at current and constant prices.

Household block

The equations in the household block describe labour market developments and the generation and use of household income. The equation for the average number of registered employees (*L*) captures a positive long-run relation to the real gross domestic product (*Y*) and a negative relation to the real labour cost (*W/PPI95M*). A change in real GDP has a short-run effect on employment. The negative wage relation is in line with economic theory, as wage increases lead to lower labour demand by employers. Growth in aggregate demand will induce a higher demand for labour as a production factor. In the long run, a 1% rise in GDP increases employment by 0.47%, a 1% increase in the real cost of labour (*W/PPI95M*) reduces employment by 0.38%. The equation for the average monthly nominal wage (*W*) reflects the typical labour market behaviour. Growth in the productivity of labour (*Y/L*) makes for nominal wage growth, the consumer price index (*CPI95*) represents the pressure exerted by trade unions and employees on wage growth at a rate offsetting inflation. A rise in the unemployment rate (*URD*) causes a drop in wages, as the labour supply outweighs demand. Furthermore, the household block calculates, based on labour market developments, individual components of household income generation and use, as well as the gross disposable income as the difference between the households' current income and current expenditures.

Monetary block and public sector block

The monetary block models interest rates and loans to households and enterprises. In the equations for average interest rates on deposits (*IRDT*) and loans (*IRLT*), the NBS basic interest rate (*IRDISC*) is the key variable. Loans to households (*ACH3B*) are explained by the backdrop of development in interest rates on loans (*IRLT*) and household consumption (*HCP*), whose growth generates demand for credit financing. Similarly, loans to households and enterprises (*ACEH3B*) depend on interest rates on loans (*IRLT*), household consumption (*HCP*) and the firms' own resources (*ORE*). If own resources are low, demand for loans is higher, which is why they appear with a negative sign in the equation.

In the public sector block, state budget revenues and expenditures are calculated. Revenues from the value-added tax (*TVAT*) are modelled by means of final consumption of households (*HCP*) and investments (*DFKP*). The effective tax rate (*TVATER*) comes in as an additional variable. Excise taxes (*TC*) depend on final consumption of households (*HCP*). The equation for income tax (*TW*) uses gross wages and salaries (*YW*), gross mixed income (*HZD*), and the effective income tax rate (*TWER*)

[1] A more detailed analysis of the impact of FDIs on Slovakia's export performance is presented by Tóth and Chudík (2004).

as explanatory variables. The corporate income tax (*TYZ*) depends on the firms' gross operating surpluses (P*ROF*). State budget expenditures (S*BE*) are determined by total state budget revenues (*SBR*) and its deficit (*SBDEF*).

Conclusion

The accuracy of the model can be assessed on the basis of indicators shown in Table 1. For ex-post simulation of the ECM-ISWE05Q1 model as a whole covering the period from 2000:Q1 till 2004:Q4, the following are shown in respect of major model variables: the root mean square error (*RMSE*); the mean error (*ME*) and the mean absolute error (*MAE*); the mean percentage error (*MPE*) and the mean absolute percentage error (*MAPE*). Properties of the model were tested on a dynamic model simulation. The overall model fit is acceptable. Among GDP components, household consumption was overestimated by an average SKK 1 billion in the period simulated, the mean absolute percentage error was at its highest in final consumption of general government and in gross fixed capital formation, reaching about 3% or 4%, respectively. The time horizon for the dynamic simulation was chosen to reflect a turning point in the economic development occurring in 1999 – 2000, as shown in the time series of model variables. In case of model simulation covering the maximum time span for which data on all variables is available, i.e. since 1996, the total simulation error increases expectedly. The square error for GDP reaches 3.37, the mean absolute percentage error 1.6% and the mean absolute error 2.85 billion.

A quarterly model, the ECM–ISWE05Q1 is a small demand-side model of the Slovak economy. It is an upgrade from the former ECM-ISWE04Q1 extended to include a monetary block and a state budget block. Furthermore, in several equations existing functional dependences were refined to provide a more accurate picture of the reality and current trends in the Slovak economy, yielding better results in ex-post simulation and enhanced forecasting capabilities. The ECM-ISWE model is under permanent development, the objective remains to fine-tune the newly-introduced equations in the monetary block and the public sector block, which posed the greatest problems in the simulation, and to expand the model to include a production side.

Table 1 Results of simulation of equations and the ECM-ISWE05Q1 model as a whole, 2000:Q1 2004:Q4

	RMSE	ME	MAE	MPE	MAPE
GDP, at constant prices of 1995 (c. p. 1995)	2.20	0.05	1.80	0.05	0.96
Final consumption of households, c. p. 1995	1.48	1.07	1.22	1.10	1.25
Final consumption of public sector, c. p. 1995	1.37	-0.21	1.13	-0.36	2.96
Gross fixed capital formation, c. p. 1995	2.19	0.17	1.83	0.42	3.95
Export of goods and services, c. p. 1995	2.57	-0.32	1.92	-0.14	1.14
Import of goods and services, c. p. 1995	3.53	0.66	2.70	0.52	1.77
Producer price index – PPI95	0.006	0.003	0.005	0.243	0.324
Producer price index – PPI95M	0.009	0.005	0.007	0.411	0.547
Consumer price index	0.006	0.004	0.005	0.226	0.314
Core inflation index	0.007	0.004	0.006	0.296	0.417
Employment, registered	6.69	2.88	5.32	0.15	0.27
Average nominal monthly wage	141.19	68.34	117.35	0.54	0.89

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QUARTERLY PROJECTION MODEL OF THE TRANSMISSION MECHANIS

Miroslav Gavura, Branislav Reľovský
Monetary Policy Department, National Bank of Slovakia

This article briefly describes the basic features and structure of the Quarterly Projection Model (QPM)[1], used by the National Bank of Slovakia in preparing medium-term projections of economic development in the SR and policy analyses. The QPM as a component of the monetary policy decision-making process represents an analytical tool by which it is possible to simulate alternative scenarios of future development that are dependent either on the differing development of exogenous factors or a different intensity of the effect of economic mechanisms. Using these scenarios it is then possible to assess the basic risk factors of the projection and create confidence intervals around the basic projection.

The structure of the model is based on the description of the transmission mechanism for small open economies with an inflation-targeting regime. The model's simplicity and comprehensibility is guaranteed by the creation of a model with few equations, built at an aggregate level. This is the gap model, which is based on the premise of the monetary cycle theory and the neutrality of money. The basis of this approach is the assumption that monetary policy in practice cannot influence long-term trends in an economy's development. It is a long-term process of increasing the quality and performance of a transitional economy, i.e. real convergence. Monetary policy can react only to the cyclical part of the economy, which is represented by the deviation of the development of individual economic indicators from the long-run (equilibrium) trend.

The composition of forward-looking components and active monetary policy in the form of endogenous set monetary variables (interest rates and the exchange rate) belongs to the key features of the model. This allows forming of expectation to be used as another indirect channel of the transmission mechanism. The forward-looking component of economic subjects is captured in the model by means of expectations as to the development of the exchange rate and inflation. In the case of the central bank a forward-looking component is a reaction function which changes the setting of the interest rates in the case of a deviation in expected inflation from the set target.

A combined approach, bringing together an econometric estimate of the parameters and calibration, was used in identifying the parameters of the model of the SR economy.

In accordance with the assumption of the monetary cycle theory the model is composed of two relatively independent blocks. **The first is the Quarterly Projection Model** which by means of simulation forecasts the cyclical behaviour of economic variables. The QPM is the main instrument serving for creating predictions of economic indicators in the medium-term horizon. The Quarterly Projection Model describes the basic transmission mechanism channels, and thereby intermediates the formal form of a unified theoretical framework in which monetary policy considerations are made.

The second block represents a model which should separate the cyclical and trend component of economic variables, using historical data. An instrument used is the **Multivariate Filter with Unobserved Components** (MVF-UC), which iteratively estimates unobserved trend and cyclical variables from observed economic indicators[2].

Structure of the QPM modelM

The model identifies three channels through which the real economy is affected by monetary policy: **1. the effect of real monetary conditions (*rmci*)**, i.e. real interest rates and the real exchange rate, on the development of aggregate demand and aggregate supply, **2. the inflation expectations** channel influencing real demand through changes in consumer behaviour, **3. the impact of monetary policy on the development of the nominal exchange rate** and its direct impact on the prices of imported goods. This channel causes immediate changes in prices of tradable goods.

The form of the cyclical part of the QPM model is

[1] The model presented was created at the Monetary Policy Department of the NBS with technical support from the International Monetary Fund. The assistance was focused on two fields. The first was technical cooperation in building the QPM model itself and the information environment. The second field of cooperation was oriented on efficient managing the implementation of the whole monitoring and forecasting process at the NBS. The detailed information about the model is published on www.nbs.sk.

[2] The MVF-UC is used only for estimating long-run trends and cyclical components in a history, and does not influence the attributes of the core model.

composed of 8 basic behavioural equations forming the core of the model system. Besides this, the model works with a number of equations having the nature of various transformations, identities and simple autoregressive relations. The whole model comprises more than 100 equations. In a more detailed description of the QPM we shall however concentrate only on the behavioural part of the model, which describes the transmission mechanism.

The behaviour of aggregate demand is, with regard to the nature of the model in the IS curve, represented by the output gap. The aggregate demand curve defined in this way assumes that the cyclical component of the economy is influenced, besides its own persistence, also by monetary policy and foreign demand. The influence of monetary policy is effected via changes in real interest rates and in the real exchange rate (rmci). Foreign demand enters into the model in the form of the output gap (with a lag) consistently with the cyclical component of the domestic economy.

The dynamic equation of aggregate supply is based on the modified Phillips curve, which describes the basic relations between the price level, expectations and the real economy. With regard to the different determinants influencing the development of individual components of the CPI, the Phillips curve is disaggregated into four sub-aggregates and parameters for fuel prices, foodstuffs, net inflation excluding fuel prices and administered prices are estimated separately. Given that monetary policy can influence the development of net inflation excluding fuels at most, this price index plays a key role in conduction of monetary policy. Other equations, while having retained a similar structure, are however influenced to a significant extent by factors outside the influence of monetary policy.

Net inflation excluding fuels is expressed by means of the contribution of domestic and import prices excluding fuels and the position of the business cycle (the output gap). Through the integration of inflation expectations, which are based also on headline inflation, feedback from the regulated prices sector enters to the model, and which influence in no small way the further development of inflation, in particular by means of secondary effects. The inclusion of the equilibrium appreciation of the real exchange rate into the Phillips curve serves for modelling the additional contribution to core inflation ensuing from faster price growth of non-tradable goods and services than that of tradable goods (the Balassa-Samuelson effect). An important feature of this equation is the linear homogeneity of parameters of price variables, which expresses that in an equilibrium state any particular rate of inflation will conform to the Phillips curve (with the corresponding rate of nominal exchange rate appreciation). The only element determining the actual rate of inflation in an equilibrium state is then the behaviour of the central bank, in this case quantified by the inflation target.

The interconnectedness of the domestic and foreign environment, in particular their mutual capital flows, is captured in the forward-looking uncovered interest rate parity condition (UIP). It links expectations of the development of the nominal exchange rate with the movement of interest rates and the risk premium, which investors require in deciding to allocate capital.

The process of the systematic control of inflation is ensured by a modified version of the Taylor rule. It is expressed as the weighted sum of the autoregressive component and the own active rule of the central bank. The interest rate reacts to deviations in the inflation projection from the set inflation target so that in the case of inflationary pressures it will exceed a policy-neutral interest rate level. The policy-neutral level of the nominal interest rate can be understood as such level that does not change inflation. A nominal interest rate set in this way will not induce, in an equilibrium state, any changes in real or nominal variables and thus will be neutral to the domestic economy. The presence of the GDP gap is primarily motivated by the fact that an economy's position in the business cycle is a certain forward-looking indicator of future inflationary pressures and needs not therefore necessarily express the monetary policy's interest in stabilisation of GDP development.

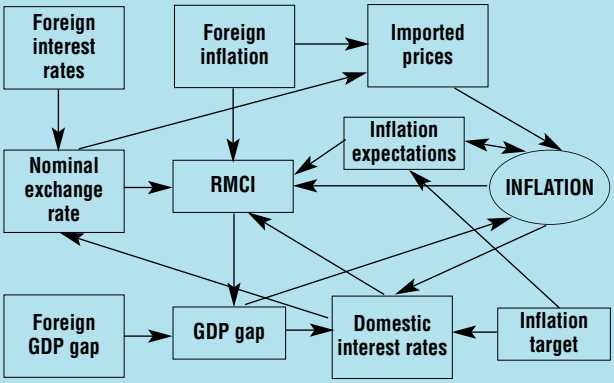
Forward-looking components in inflation and exchange rate expectations are in general reflected in the model in the form of the model's own projections.

Inflation expectations are defined in the model as a weighted average of rational and adaptive behaved economic subjects. Each of these subjects is moreover included into groups according to whether the subject adjusts its expectations to net inflation excluding fuel prices or headline CPI. In forming inflation expectations rational subjects take into consideration all available information on factors influencing inflation in the future, among which we can include the central bank's inflation target.

Expectations of the development of the nominal exchange rate are expressed as a weighted average of a forward-looking component representing rational agents and a component representing the nominal exchange rate from the preceding period, increased by the inflation differential and the equilibrium appreciation of the real exchange rate.

Imported inflation represents a separate block. Imported energy prices and imported prices excluding energy prices are separately modelled consistently with the structure of the domestic price level, where their short-run and long- run relationship is modelled separately in the form of the Error Correction Mechanism. In the tra-

Structure of the QPM



dable sector the validity of relative purchasing power parity in the long- run is assumed. In the short- run a certain auto-regressive nature is assumed in imported prices, as is assumed a projection of the development of foreign inflation in the domestic currency.

Import energy prices (as an exogenous indicator of foreign inflation in the fuel prices equation) are determined by the development of crude oil prices on world markets and the development of the SKK/USD exchange rate. Import prices excluding the development of energy prices (these enter into the other Phillips curves) are a function of the development of foreign prices and the SKK/EUR exchange rate.

The current version of the QPM is very simple, nevertheless even in this phase the model is able to formally capture and process the most important parts of the monetary policy transmission mechanism. Despite its simplicity, the model is sufficiently flexible to incorporate information of an expert nature, or results from other partial models.

Testing the model's properties on a series of standard shocks confirmed their consistency with the assumed economic interpretation. At the same time these simulations confirmed the ability of the central bank to influence, via the identified monetary transmission channels, price development towards the declared target. This justifies the model's use both for the purposes of projection, as well as in monetary policy analyses, i.e. the preparation of consistent alternative scenarios of the economy's development depending on identified possible imbalances.

The current setup of the model together with partial analyses have confirmed that the strongest and fastest channel in the transmission mechanism is the direct channel of imported inflation.

The influence of monetary policy on the economy via the rmci appears to be relatively low. To a certain extent this narrows the room for the central bank for controlling inflation by means of the real economy. In the framework of individual components the empirical results of small open economies on the dominant effect of the real exchange rate in comparison with real interest rates have been confirmed.

In identifying the model it was confirmed that the SR economy is relatively forward-looking with approximately a third of economic subjects behaving rationally. This is implied also by historical development, where the economy has managed relatively easily to compensate for negative shocks, which it had to face in past years. The representation of forward-looking economic subjects confirms the justification of the inflation expectations channel.

In expectations of the development of the nominal exchange rate there is a dominant influence of the equilibrium appreciation of the real exchange rate. This means that in the case of any deviation of the real exchange rate from the equilibrium level, the expectations of the nominal exchange rate do not exhibit tendencies to eliminate any imbalance arisen. Conversely, the expectations of the nominal exchange rate are to a great extent determined by long-term real convergence. In the case of expectations formed in this way the process of return to equilibrium may be lengthened.

Development of the QPM in the future

The core QPM model representing the framework understanding of the transmission mechanism should be gradually expanded with satellite models of disaggregated variables. In this way a model block should be built encompassing the GDP structure, external sector, public finance sector, etc.

Besides the work itself on building satellite models it will be necessary to work systematically on the way how to interconnect these models with the core QPM model. It is important to continue in developing the technical background. Managing the algorithmisation and automation of individual steps in preparing forecast will create greater room for economic discussion and the more dynamic building of satellite models.

MULTI-EQUATION MODEL FOR POLICY ANALYSIS FOR SLOVAKIA IN THE PROCESS OF ACCESSION TO MONETARY UNION

Michal Benčík
Institute of Monetary and Financial Studies, National Bank of Slovakia

Following its entry to the European Union Slovakia is now preparing for euro adoption. With this is connected a change in economic policy with an objective to stabilise the exchange rate during ERM II membership and to meet the Maastricht Criteria in the period of actually adopting the common currency. While fiscal and monetary policy instruments are available in fulfilling these aims, they are nevertheless closely tied to the Maastricht Criteria and cannot be used as freely as in the past. The aim of this paper is to adapt models from economic literature to the SR and to clarify the options of coordinated economic policy in the case of relatively optimistic assumptions regarding the external environment by outlining an illustrative scenario of future development and via a presentation of the model's comparative dynamics.

The model is based on foreign models describing cyclical development and the impact of economic policy on this development under the conditions of inflation targeting regime and a floating exchange rate by means of deviations in economic variables from their equilibrium (long-run, trend) trajectories. Monetary policy affects inflation via two channels here: via the credit channel – increased interest rates push demand down, shift the output gap towards negative values, which causes in the framework of New-Keynesian Philips curve a decrease in inflation – and via the exchange-rate channel – increased interest rates will cause, according to the uncovered interest rate parity, an appreciation in the exchange rate which leads to a decrease in inflation. Equilibrium trajectories are obtained by other (independent) models. Models for deviations are constructed so that individual variables converge on a long-run basis to equilibrium trajectories.

This scheme was improved by taking fiscal policy into account, the explicit determination of the real exchange rate, considering the trend appreciation, and by the explicit determination of net exports which under the conditions of a very open slovak economy influence demand as well as the real exchange rate. The model thus contains the following main behavioural relations:

- The Taylor rule – the interest rate for a two-week repo tender is a function of the output gap, annual core inflation and an exogenous component
- The Philips curve – core inflation is a function of its past values, the expected value of headline inflation, the exogenous component of prices, the contribution of foreign inflation and of the increase in the output gap; the function is linearly homogenous in nominal variables
- Generalised IS curve – the output gap is a function of the increase in net exports, the share of the state budget deficit in GDP, and the real interest rate for credits
- Determination of the real exchange rate – the exchange rate is a function of the ratio of potential outputs of the SR and euro area, the real interest-rate differential, net export, share of FDI in GDP, and the share of the net export in GDP. This equation is similar to those which are used for estimating the equilibrium exchange rate according to BEER methodology
- Determination of the share of net export in GDP – this is a function of the rate of growth of foreign demand, rate of growth of the real exchange rate and the output gap
- Reaction function of the average interest rate for credits – describes time lags between the BRIBOR rate and the average interest rate for credits
- Determination of the total share of the state budget deficit in GDP – takes into account the cyclical nature of parts of the state budget deficit; the share of the state budget deficit in GDP depends on the output gap

Besides this, the model contains identities (the most important of them determines the nominal exchange rate from the real exchange rate, domestic and foreign prices) and transformations deriving one variable from another by means of additive or multiplicative residuals. The structure of the model is depicted in Figure 1. The model's parameters were estimated by ordinary least squares method, for some equations with restrictions on parameters. In assessing individual estimates we took into consideration more the economic interpretability of the parameters and the suitable long-run solution of

equations rather than statistical tests. Therefore the parameters (in particular those in the Philips curve) should be seen as more or less calibrated.

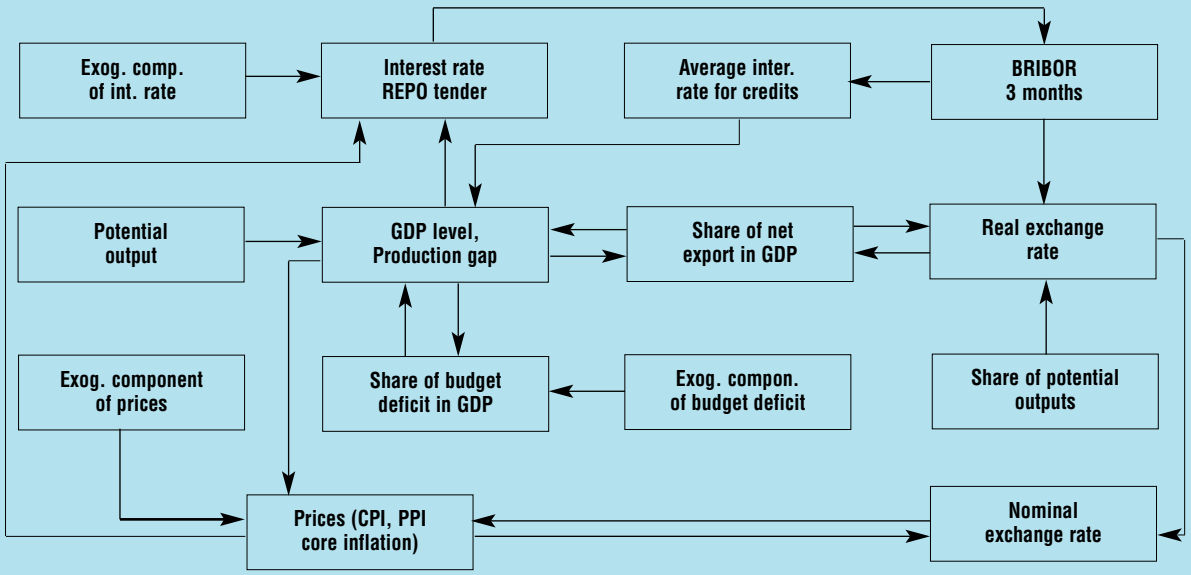
Under the assumption of a constant difference in the rates of growth of potential outputs in the SR and euro area and the assumption of a constant level of other variables this model converges towards the equilibrium defined as a constant level of inflation, output gap, state budget deficit share in GDP and the share of net export in GDP. With this is connected the specific determination of the net export, enabling the permanent appreciation of the real exchange rate and faster growth of the GDP compared to the trading partners. In order to take this phenomenon into account we abandoned the traditional specification of fixed market shares.

Equilibrium inflation falls with an increasing rate of growth of the potential output of the SR (ceteris paribus). The equilibrium output gap needs not in general be zero – it is a function of the exogenous components of fiscal and monetary policy as well as equilibrium inflation. This feature of the model, in our view, highlights the need to permanently coordinate fiscal and monetary policy.

By means of the model we calculated an illustrative within-sample and out-of-sample scenario and four alternative scenarios. In the baseline scenario the economic indicators converge to the values set by Maastricht Criteria. At the same time, we take into account a gradual reduction in short-term interest rates, though these are not assessed directly. With regard to the problems in estimating the Philips curve we have expertly adjusted inflation also on an ex ante basis. An important assumption is that the potential output in the SR grows throughout the scenario's horizon at a significantly faster rate than the potential output in the euro area. On the basis of the results obtained, we assume a persistent foreign trade deficit and weak tendency of the output gap towards positive values, since the expansionary influence of reducing interest rates outweighs the restrictive influence of fiscal policy. Another important result is the tendency towards moderate nominal appreciation of the currency, since the rate of the real appreciation is higher in the illustrative scenario than the inflation differential.

Alternative scenarios showed the following features of the simulation model:

Structure of the simulation model



• Temporary shocks have only temporary effect and they do not change the price level over the long term.

• A permanent exogenous increase in the interest rate, despite the fact that it will be partially compensated, will cause a permanent shift in the output gap towards negative values, increase slightly the state budget deficit and cause additional appreciation of the currency. The effect on inflation will be only temporary, it will however lead to a permanent shift in the price level.

• An exogenous permanent reduction in the state budget deficit will be compensated only to a small extent. It will cause a permanent drop in the output gap and interest rates, slight real and nominal appreciation and a shift in the price level.

• A permanent real appreciation (exogenous) will multiply in the model via positive feedbacks. This will bring about relatively strong nominal appreciation and a shift in the price level.

• A permanent shift in the level of potential output (without any change in the rate of growth) will cause real and nominal appreciation of the currency and a slight permanent shift in the price level.