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HUNGARY IN THE NIGEM MODEL

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Abstract

This paper presents a nationwide economy model for Hungary used by the National Bank of Hungary for analyzing the effects of world shocks, for quarterly forecasting exercises and other policy simulations. The study has two main goals: Firstly, it presents a model for the Hungarian economy developed in collaboration between the National Bank of Hungary and the National Institute of Economic and Social Research. The model is a one-sector aggregate economy model with a theoretically consistent supply side. Foreign direct investment is given a particular role in explaining the sources of growth both in the production process and in foreign trade. Secondly, there is a brief discussion of the National Institute's Global Econometric Model (NIGEM), to which the Hungarian model is linked. In this setup, we are also able to analyze the effect of world shocks on the domestic economy. For testing model properties, policy simulations are presented for various shocks. A case study on the effect of the Russian crisis on Hungary is also discussed for the purpose of testing parameter adequacy. Simulation results show that the Hungarian block of the NIGEM model is able to capture the effects of these shocks, hence it might be an appropriate model framework for analyzing different shocks.

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1. Introduction

Since the start of the 1990s, economic modelers in transition economies have been faced with two main challenges. The first one, which has been a rather specific problem for these countries, is the task of building macro-econometric models of the transition using very few and unreliable data. The second one, which is a general consequence of the globalising world, where interactions among national economies are becoming more and more important, is a modeling of the domestic economies interactively with the rest of the world. This paper tries to give answers to both challenges. We present a national economy model for Hungary estimated on quarterly data with different econometric techniques, and link this block to the National Institute Global Econometric Model (NIGEM).
This paper is mainly a result of cooperation between the National Institute of Economic and Social Research (NIESR)[1] and five Central-European Central Banks, including the National bank of Hungary.[2,3] The aim of the project was twofold. (1) Building nationwide macro-econometric models for policy simulations and forecasting for five accession countries: the Czech Republic, Estonia, Hungary, Poland and Slovenia. (2) Inserting these five national economy models into the NIESR's NIGEM model, to be able to perform multicountry analyses and forecasting for the accession period.[4] In this paper we discuss the properties of the Hungarian block, used at the National Bank of Hungary, for economic analyses. Although the basic structure is similar to what is described by Barrell et al. (2001), this is not exactly the same block used by the NIESR for Hungary in the NIGEM, as we made a few modifications to make it more suitable for analyses at the NBH.

Section two gives a brief description of the basic properties of the Hungarian model. Section three presents the core equations of the block. In section four some basic simulation results are presented. Section five discusses a case study on the Russian crisis, while section six draws some conclusions.

[1] We would like to thank Ray Barrell, Dawn Holland, Ian Hurst for coordinating the project. We are grateful to Dawn Holland Judit Neményi and the economists of the NBH Economics Department for helpful comments. Naturally, all the remaining errors are of our own.
[2] The other four central banks are the Czech National Bank, the National Bank of Poland, the Bank of Slovenia and the Bank of Estonia.
[3] The research was undertaken by support from the European Community's Phare ACE Programmes 1997.
[4] The main results of the research can be found in Barrel et al (2001) "An Econometric Macromodel of Transition: Policy Choices in the Pre-accession Period"

2. Main properties of the Hungarian model

The starting structure of the model is the NIESR's model-structure for developed OECD countries, which is described in NIESR (2001). This is basically a standard New-Keynesian model, where agents are assumed to be forward looking at least in some markets, but nominal rigidities slow the process of adjustment to various shocks. The economy is a one-sector model, with a detailed demand and supply side, and a consistent stock-flow relationship.

The structure of the Hungarian block is very similar to that of the developed economies, but we made some modifications, especially in explaining the sources of growth and trade integration with foreign direct investments (FDI). The parameters were estimated on a panel of 5 EU Accession countries.[5]

2.1. The stylized structure of the Hungarian block

The following is a brief summary of the stylized structure of the Hungarian block. The paper, however, only presents the estimated econometric equations specific for the Hungarian model. The other parts of the model that are similar to the general NIGEM structure are not discussed.[6]

Table 1
The stylized model equations

Balance of payments and external trade

$CBV=XGV-MGV+XSER-MSER+IPDC-IPDD+BPT$
$XGV=PXA*XGI$
$MGV=PMA*MGI$
$IPDC=f(ROR,GA_{-1})$
$ROR=f(WDIPDD_{-1}/WDGL_{-1}, ROR_{-1})$
$IPDD=f(GL_{-1}, RX, RX_{-1}, DEBT_{-1}, EQPR, GIP)$
$EQPR =f(WDIPDD_{-1}/WDGL_{-1}, ROR_{-1})$
$BPT=f(RX, CED, BPT_{-j})$

[5] See the details later.
[6] The whole equation list can be found in NIESR(2001).

Supply side

$CU = Y/YP$
$E=f(EE,LF)$
$EE=f(Y, COMP, CED, FDIS)$
$FDIS= FDI\times RX/PY+FDIS(_{-1})$
$KP=f(Y, USER)$
$KG =(1-KGDEP)\times KG_{-1}+GI$

$$YP=\gamma\left[\delta(KP+KG)^{\frac{\sigma-1}{\sigma}}+(1-\delta)\left(E\times e^{\lambda\log(FDIS)}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

$U=(LF-E)/LF$

Prices, costs

CED=f(PMA, ULT, CU)
COMP=f(Y, EE, FDIS,WHUINF)
EFEX=f(RX, nominal exchange rate of trading partners)
PXA=f(PXG, WDPO, WDPFDV, WDPFLD, WDANF, WDPMM)
PMA=f(PMG, WDPO, WDPFDV, WDPFLD, WDANF, WDPMM,RX)
PXG=f(CED, CPX, RX)
PMG=f(PXG, CPXM, RX)
REFEX=f(CED, RX, prices of trading partners)
ULT=f(COMP,EE,FDIS)
USER=f(R3M, LR, Y, PY, CTAX, COMP)

Demand

Y = C + PSI+GC+GI+DS+XVOL-MVOL
$C=f(NW/CED,PDI/CED)$
$PSI=KP-(1-\delta)*KP-1$
XVOL=XGI +XSER*RX/CED
MVOL=MGI+MSER*RX/CED*REFEX
$XGI= f(S, REFEX, FDIS)$
$MGI=f(TFE, XVOL, REFEX)$
$XSER=f(S, REFEX)$
$MSER=f(TFE, XSER, REFEX)$
PDI=COMP+OPI+TRAN-TAX

Wealth

NW=DEBTP+RX*NA+MISC-LIABS
$NA=NA_{-1}+CBV$
$EQP=f(EQP_{+1},HUKP_{+1,}Y, PY, COMP, KP, R3M)$

Monetary sector

$$R3M = \lambda_1 R3M_{-1} + \lambda_2(\log(CED) - \log(CEDT)) + \lambda_3(\Delta\log(CED_{+j}) - \Delta\log(CEDT_{+j}))$$
$$+ \lambda_4(\log(Y) - \log(YT)) + \lambda_5(CBR - CBRT) + \lambda_6 R3M^{EL} + \lambda_7 CRAWL + \lambda_8 IPREMC$$

Government

BUD=TAX+MTAX+CTAX-TRAN-GIP
TAX=f(PY,Y,GBR-GBRT)
MTAX=f(CED,C)
CTAX=f(PY,Y)
TRAN=f(u)
GIP=f(DEBT,LR)
DEBT=$DEBT_{-1}$+BUD-CASH

There are three major actors in the economy: *households, the corporate sector and the government*. All wealth is allocated to domestic and foreign households, and the stock of government debt is assumed to form part of the wealth.[7] *Foreign trade* is divided into goods and services trade, where all supply and demand and competitiveness factors are taken into account. One innovation in our Hungarian block compared to standard macroeconomic models is that supply conditions are also taken into account in the equation describing exports of goods. Thus, export capacity is determined by the amount of FDI stock. *Supply* is determined by capital stock and employment. We assume a CES production function, with labor augmenting technical progress, where technology depends on foreign direct investment stocks. Capital and labor are derived as a first order condition from the production function. On the *demand side*, consumption depends on disposable income and real net wealth, while private sector investment comes from the capital demand equation. The change in stocks is assumed to be exogenous.
Domestic *prices* depend on import prices and unit labor costs, and the capacity utilization variable. The latter tries to capture the changing elasticity of demand across the states of the business cycle. *Real wages* are a function of productivity and the unemployment rate. Government expenditure is divided into four major categories: government consumption, government investment, household transfers and interest payments. Government consumption and investment are exogenous, while transfers depend on the unemployment rate. The government finances itself by three types of taxes: income taxes, profit taxes and miscellaneous taxes.

As mentioned earlier, the model is basically neo-Keynesian: due to nominal rigidities, demand shocks play an important role in the short run, while in the long run technology and factor endowments determine the level of real variables. Expectations play a key role in the adjustment process.

[7] So there is no Ricardian equivalence in the model.

2.2. Expectations

At the final stage, the Hungarian block will be able to work with both forward and backward looking variables, similarly to models of other countries. At the current stage, however, only a part of the forward-looking elements work. Expectations in the model work through the following mechanisms:

Inflation expectations

1. *Wages:* In the compensation equation we have a variable for inflation expectations, which directly affects wages.[8]
2. *Monetary policy reaction function:* Depending on the chosen monetary policy option, future inflation can be part of the monetary policy reaction function.

The Interest rate and the exchange rate

1. *The short-term interest rate and exchange rate:* As can be observed, the main policy variable is the short-term interest rate, the other one being the exchange rate. The uncovered interest rate parity condition holds and creates the connection between the two variables.
2. *Long term interest rate:* Long-term interest rates in the long run are determined by an autoregressive scheme and by short term rates, while in a forward looking mode the expectation hypothesis is assumed to hold, in other words, long term interest rates are derived as a weighted average of expected future short term rates.

Equity prices

In the backward mode, equity prices depend on their lagged values, long rates and shares in the world portfolio. In the forward-looking mode, current equity prices depend on their future value and the profit rate.

2.3. Policy options

There is a wide variety of monetary policy options which can be used for the comparison of different monetary policy regimes. The built-in policy rules are as follows (See also **Table 1**):

1. Exchange rate fixed to the Euro zone. (λ_6= 1, other λ-s are zero)
2. Hungary is a member of the euro-zone. (λ_6= 1[9], other λ-s are zero)
3. Inflation targeting (λ_3 is positive, other λ-s are zero)
4. Nominal GDP targeting (λ_2=λ_4 are positive, other λ-s are zero)
5. Combined inflation and nominal GDP targeting ((λ_2=λ_4 , and λ_3 are positive, other λ-s are zero)
6. Taylor-rule (λ_3 and λ_4 are positive, other λ-s are zero)
7. Fixed nominal interest rate (λ_1 =1, other λ-s are zero)
8. Special rule: Current account and inflation targeting, Endogenous risk premium ((λ_3 is positive, λ_5 is negative and λ_7 =λ_8 = 1, other λ-s are zero)

[8] This is still not effective in the current setup.
[9] This also means that Hungarian macroeconomic variables are in the ECB's reaction function.

3. Core equations

All of the key equations of the model are in error correction form, as most of the other equations of the model. This ensures that the variables converge to a theoretically defined long run structure, while the adjustment to this equilibrium is gradual. Parameters are generally estimated on a panel of five countries: the Czech Republic, Estonia, Hungary, Poland and Slovenia. This method was chosen because (1) we had more or less reliable quarterly data only from 1994-1995, which seemed to be a very short period if we wanted to use individual country estimates. By using panel techniques we were able to increase the degrees of freedom significantly. (2) As all of these countries are small open economies[10] and they are at a similar stage in the convergence process, it seemed to be a good assumption that the long-run parameter values are the same for the five countries.

Our estimation is a quasi-panel, which means that in some cases country-specific coefficients were used in the short run dynamics. In most of the cases panel error correction was used. Three main econometric techniques were used: (1) the long-run parameters were determined by OLS and SUR or the DOLS method proposed by Stock-Watson (1993). In the second step, we estimated the short-run dynamics, using the error correction term. (2) In some cases the long-run parameters were estimated together with the short-run dynamics, using NLS. (3) In some cases we restricted the long-run parameters, using theoretical considerations.[11].

3.1. Supply

The basis of the supply side is a CES production function with capital and labor.[12] The technical progress is labor augmenting, and it is determined by the stock of FDI. This functional form is supported by empirical studies.[13] The production function was specified in the following way:

$$YP = \gamma \left[\delta (KP + KG)^{\frac{\sigma-1}{\sigma}} + (1-\delta)\left(E \times e^{\lambda \log(FDIS)}\right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \quad (2\text{-}1)$$

where

σ is the elasticity of substitution,

λ is the coefficient of technological progress ,

γ is a scaling factor,

δ is the capital share parameter.

[10] The only exception is Poland.

[11] An example can be the capital demand equation, where the values were obtained from the production function.

[12] The reason for using the more general CES production function instead of a Cobb-Douglas type is that empirical results do not support the unit elasticity of substitution between capital and labor. (Duffy-Papageorgiou (2000)). This statement was reinforced by our estimation results.

[13] See Barrel and Pain (1997), Holland and Pain (1998), Barrell and Holland (2000).

The labor equation and capital demand equation can be derived from the first order conditions (FOCs) of the production function with respect to employment and capital. Using the FOC for labor, assuming that real wages are different from the marginal product of labor in a constant and taking a natural logarithm, produces the following employment equation:

$$\log(YP/E) = c + \sigma \log(COMP/(PY * E)) + (1-\sigma)(\lambda \log(FDIS)) \qquad (2\text{-}2)$$

Similarly one can derive an equation for capital:

$$\log(YP/(K)) = c + \sigma \log(USER)) \qquad (2\text{-}3)$$

where c is a constant

Assuming that actual and potential output only differ in a stationary component, (2-2) can be rewritten as follows:

$$\log(Y/E) = c + \sigma \log(COMP/PY * E) + (1-\sigma)(\lambda \log(FDIS)) + \phi(L)e_t \qquad (2\text{-}4)$$

From the equation above σ and λ can be determined. The δ parameter has been calibrated using the capital-labor ratio and the factor shares in the National Accounts. Dividing the first order conditions of the production function according to labor and capital, and assuming that the factor incomes are generated according to their marginal product after some rearrangement it results in the following formula:

$$\frac{\delta}{1-\delta} = \left[\frac{K}{L}\right]^{\frac{1-\sigma}{\sigma}} \left[\frac{r * K / PY * Y}{COMP / PY * Y}\right] * e^{\frac{\sigma-1}{\sigma}\lambda \log FDIS} \qquad (2\text{-}5)$$

The γ parameter was calibrated for producing a zero output gap for 1998. As a result the coefficient values are:

σ = 0.563
λ = 0.218
γ = 0.474
δ = 0.972

Employment was modeled without self-employment (e.g. employees in employment) with the profit maximizing condition above and assuming that self-employment moves in line with the labor force.

Table 2
Employment
(t statistics in parenthesis)

Employees in employment[14]

$$\Delta LOG(EE)=-0.007-0.099*(LOG(EE_{-1})-LOG(Y_{-1})$$
(3.6) (-4.3)

$$+0.563*LOG(COMP_{-1}/(EE_{-1}*CED_{-1}))-(0.563-1)*0.218*LOG(FDIS_{-1}))$$
(20.1) (18.3)

R^2: 0.11
Adjusted R^2: 0.08
Probability F statistic = 0.00
Probability LM test (2lag) = 0.35

Self-employment

$$\Delta E=\Delta EE+(E_{-1}-EE_{-1})/LF_{-1}*\Delta LF$$

For capital demand the long-run structure is already determined by the production function parameters. The short run elasticities come from the average NIGEM parameters:

Table 3
Capital accumulation

$$\Delta LOG(KP)=0.898*\Delta LOG(KP_{-1})+0.001+0.006*\Delta LOG(Y)+0.013*\Delta LOG(Y_{-1})-$$
$$-0.002*(LOG(KP_{-1}/Y_{-1})+0.563*LOG(USER_{-1}))$$

3.2. Demand

Consumption is modeled using the standard theoretical relationship (see for example Campbell and Deaton (1989)), where it is a function of income and financial wealth. In order to ensure long-run stability of consumption, net wealth elasticities sum up to unity.

[14] For simplicity we use CED instead of PY for calculating real wages in the employment and wage equations. As we do not have an intermediate sector in the model, the modeling of commodity price shocks with PY in the employment block would be extremely difficult. A positive commodity price shock that increases import prices, by construction would decrease PY, which would put downward pressure on wages. This would not be a desired property.

Table 4
Consumption
(t statistics in parenthesis)

$$\Delta LOG(C)= 0.002-0.120*(LOG(C_{-1})-0.985*LOG(PI_{-1}-TAX_{-1})*100/CED_{-1})-$$
(0.98) (-3.5) (64.1)

$$-(1-0.985)*LOG(NW_{-1}/CED_{-1}*100)+0.152)+0.708*\Delta LOG(C_{-1})$$
(-11.6) (9.1)

R^2 = 0.76
Adjusted R^2 = 0.75
Probability F statistics = 0.00
Probability LM test (2 lag) = .99

The growth of exports by Hungary far exceeded that of GDP, reflecting a process of integration to the world economy. The increase in market share could not be simply explained by relative price movements. This implies that standard export demand functions do not work in this context. Hence, other variables capturing the increasing export capacity should also be incorporated. The empirical evidence suggests that integration can be well explained by the amount of foreign direct investment in the economy (Jakab et al (2000)).

In the long run, the dynamics of exports is assumed to depend on demand and supply, e.g. foreign effective imports and FDI stock. The FDI stock variable was only included in the case of goods export, as for services its role was not supported by the data. The real exchange rate causes only temporary deviations, as its deviations from its equilibrium position can only be stationary.[15] Imports depend on domestic absorption and exports in the long run, while real exchange rate movements only temporarily create deviations from the steady state.

Table 5
Foreign trade
(t statistics in parenthesis)

Export of goods

$$\Delta LOG(XGI)=0.056-0.097*(LOG(XGI_{-1})-3.579-0.255*LOG(FDIS_{-1})-LOG(S_{-1}))-$$
(5.8) (2.4) (7.5) (8.0)

$$-0.09*LOG(REFEX_{-1})-0.338*\Delta LOG(XGI)$$
(-1.7) (-3.9)

R^2: 0.35
Adjusted R^2: 0.34
Probability F statistic = 0.00
Probability LM test (2lag) = 1.00

[15] See following paragraphs for a discussion on the equilibrium real exchange rate.

Import of goods

$$\Delta LOG(MGI)=0.027-0.395*(LOG(MGI_{-1})-0.714*LOG(TFE_{-1}XVOL_{-1})-$$
(3.4) (5.4) (12.1)

$$0.720*LOG(XVOL_{-1})-15.528)+0.402*(LOG(REFEX_{-1})+0.186*\Delta LOG(MGI_{-1})$$
(22.7) (-23.7) (3.6) (2.4)

R^2: 0.17
Adjusted R^2: 0.15
Probability F statistic = 0.00
Probability LM test (2lag) = 1.00

Export of services

$$\Delta LOG(XSER*RX/CED*100)=0.0434-0.458*(LOG(XSER_{-1}*RX_{-1}/CED_{-1}*100)-$$
(2.7) (5.7)

$$7.696-LOG(S_{-1}))-0.242*LOG(REFEX_{-1}))$$
(321.7) (2.0)

R^2: 0.22
Adjusted R^2: 0.20
Probability F statistic = 0.00
Probability LM test (2lag) = 0.12

Imports of services

$$\Delta LOG\ (MSER*RX/CED*REFEX)=0.036$$
(1.7)

$$-0.545*(LOG(MSER_{-1}*RX_{-1}/CED_{-1}*REFEX_{-1})*100.)$$
(5.3)

$$+2.662-0.556*LOG(TFE_{-1}-XVOL_{-1})$$
(1.8) (5.3)

$$-0.532*LOG(XSER_{-1}*RX_{-1}/CED_{-1})*100.))$$
(9.2)

R^2: 0.24
Adjusted R^2: 0.23
Probability F statistic = 0.00
Probability LM test (2lag) = 1.00

3.3. Real exchange rate, equilibrium real exchange rate

Our model is a one-sector economy, so it cannot take into account relative price movements, which might be important for Hungary. As such it cannot handle the productivity based equilibrium real appreciation: the Balassa-Samuelson effect. This can create problems in the modeling, in the estimation and the forecasting phase.[16] In

[16] For simulation it is not a problem, as we cannot create a shock in this setup that affects tradables and nontradables assymmetrically.

both cases the problem is that to the extent of the BS effect trade volumes are not affected by the amount of equilibrium real appreciation. The magnitude of this effect depends on two factors: the size of the real exchange rate elasticity and the BS effect. Unless taking this problem into account, estimated coefficients and forecasted trade volumes are biased.

We avoided this problem in the estimation phase by using a two-step estimation procedure for the trade equations. (1) An equilibrium real exchange rate variable was estimated, with regressors of productivity, net foreign assets, terms of trade.[17] (2) Then the real exchange rate's deviation from its equilibrium value was used as a regressor of the trade volume. Looking at the estimated elasticities (Table 5) and taking into account the estimated size of the BS effect during the accession which is around 1% annually[18], we concluded that the distortion in forecasting exports and imports cannot be higher than half a percentage point annually. This does not seem to be very significant and can be corrected for with residual adjustment.

3.4. Prices, wages

The basic domestic price equation is the consumer price equation. The GDP deflator equation is not an estimated one; it is simply a weighted average of the consumer and foreign trade prices. Consumer prices are a function of foreign and domestic cost factors, e.g. import prices and unit labor costs, and it also depends on demand conditions. This latter effect is captured by the output gap variable, which tries to estimate the effect of mark-up changes (e.g. the elasticity of demand) across different states of the business cycle.

Table 6
Consumer prices
(t statistics in parenthesis)

$$\mathbf{\Delta LOG(CED)=0.012-0.138*(LOG(CED_{-1})-0.310*LOG(ULT_{-1})-}$$
(3.9) (-6.2) (10.9)

$$\mathbf{-(1.0-0.310)*LOG(PMA_{-1})+0.588)+0.121*\Delta LOG(CED_{-1})+0.056*\Delta LOG(PMA_{-1})}$$
(-35.6) (1.5) (1.8)

$$\mathbf{+0.167*CU_{-1}}$$
(2.3)

R^2: 0.71
Adjusted R^2: 0.70
Probability F statistic = 0.00
Probability LM test (2lag) = 0.43

Wages depend on productivity in the long run, but in the short run the unemployment rate also plays a role. Naturally, the unemployment rate coefficient measures the flexibility of the labor market. The latter was taken from average country estimates in NIGEM.

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[17] These are the usual variables in reduced form equilibrium exchange rate estimations. (See for example MacDonald (2000)).
[18] See Kovács (2001) for discussion.

Table 7
Wages
(t statistics in parentheses)

$$\Delta LOG(COMP/EE)=\underset{(8.3)}{0.040}-\underset{(-4.6)}{0.157}*(LOG(COMP_{-1}/EE_{-1})-$$

$$-LOG(CED_{-1})-\underset{(39.8)}{0.753}*LOG(Y_{-1}/EE_{-1})-0.865)-\underset{(6.8)}{0.005}*U_{-1}$$

R^2= 0.18
Adjusted R^2 = 0.17
Probability F statistics = 0.00
Probability LQ test (4 lag) = 0.07

3.5. Stock-Flow Consistency

The model has consistent stock-flow accounting in the sense that the increase in wealth consistently comes from changes in flows and the revaluation of stocks. As all domestic wealth is allocated to households, the accumulation of household wealth apart from revaluation should come from the current account balance and the government balance. [19]

$$NW=NW_{-1}+CBV*RX-BUD \qquad (2\text{-}6)$$

From the asset side the model distinguishes the following types of assets:

$$NW = DEBTP + RX*NA + MISC\text{-}LIABS \qquad (2\text{-}7)$$

For stock and flow consistency (2-6) and (2-7) should hold at the same time. As DEBTP and NA are determined from the government budget and the current account balance, MISC-LIABS should adjust to ensure the equality.[20]

3.6. Long run steady state

As mentioned earlier, a theoretically consistent supply side is the basis of the model. The supply side consists of six equations:

$$YP = \gamma\left[\partial(KP+KG)^{\frac{\sigma-1}{\sigma}} + (1-\partial)(E*\exp(\lambda\ln(FDIS)))^{\frac{\sigma-1}{\sigma}})\right]^{\frac{\sigma}{\sigma-1}} \qquad (2\text{-}8)$$

$$\frac{E}{Y} = \gamma^{\sigma-1}(1-\partial)^{\sigma} * \exp(\lambda*(\sigma-1)*\ln(FDIS))*(\frac{COMP}{E*PY})^{-\sigma} \qquad (2\text{-}9)$$

$$\frac{KP}{Y} = \gamma^{\sigma-1}\partial^{\sigma} * (USER)^{-\sigma} \qquad (2\text{-}10)$$

$$E = LF*(1-U*) \qquad (2\text{-}11)$$

$$KG = KG_{-1}(1-\theta)+GI \qquad (2\text{-}12)$$

$$CU = 1 \qquad (2\text{-}13)$$

In the long run the output gap is 1. This means that actual output equals its potential level. As government investment is exogenous, this also holds for government capital. Assuming that there is an equilibrium unemployment rate, which is given from outside of the model and is determined by institutional factors, long-run labor supply is also exogenous. The real cost of capital is exogenous from world interest rate assumption. As such (2-9)-(2-12) is given from outside of the Hungarian block. The steady state capital output ratio and the labor supply determines long run output at a given level of FDI stock, which is treated as exogenous. Assuming that in the long run

[19] In the following equations for the simplicity of exposition we have put aside the revaluation term.

[20] In fact the change in MISC-LIABS should equal the change in debt stock held by foreigners.

government capital behaves similarly to private capital, solving the equations yields the steady-state (long-run) output:

$$Y^* = \frac{(1-\partial)^{\frac{\sigma}{\sigma-1}}(LF(1-U^*)\exp(\lambda\ln(FDIS))}{(1-\gamma^{\sigma-1}\partial^{\sigma}USER^{1-\sigma})^{\frac{\sigma}{\sigma-1}}} \tag{2-14}$$

One can verify that steady-state output is a positive function of the FDI stock, and a negative function of the unemployment rate and the real interest rate.

As steady-state output is determined from the supply side, demand should adjust to make the output gap zero. Table 8 shows the mechanisms of a one-percent supply shock.[21] It can be seen that output increases by 0.19 percent in the long run.[22] Consumption increases by a much larger amount, because it adjusts to the zero growth of government consumption and stocks. The current account balance and the real exchange rate converge back to their baseline level.

Table 8
The effect of a one-percent technology shock
(percentage deviation from base)

	GDP	*Household consumption*	*Private investment*	*Goods and services exports*	*Goods and services imports*
1 quarter	0.00	0.00	0.00	0.00	0.00
1 year	0.01	0.00	0.00	0.02	0.00
2 year	0.07	0.02	0.02	0.06	-0.01
5 year	0.16	0.09	0.11	0.14	0.04
17 year	0.19	0.37	0.18	0.15	0.18
	Employment	*Compensation*	*Household consumption deflator*	*Real exchange rate*	*Private capital*
1 quarter	0.00	0.00	0.00	0.00	0.00
1 year	-0.01	-0.05	-0.07	-0.03	0.00
2 year	-0.03	-0.06	-0.08	-0.08	0.00
5 year	0.00	0.00	-0.07	-0.06	0.03
17 year	0.01	0.14	-0.03	-0.02	0.14

[21] As a technology shock, we increased the stock of FDI by one percent. We were interested in the effect of FDI only from a technological point of view, so we ignored its role in financing. Practically what we did was increase the stocks with leaving the flows unchanged.
[22] In fact, from the analytical solution one can conclude that the long-run output effect of the FDI stock should equal the parameter lambda e.g. 0.217 in our case. As the capital adjustment is very slow, after 17 years the analytical solution does not come back exactly from the simulation.

4. Simulation properties

In the assessment of the simulation properties of the model the exchange rate and interest rates are assumed to be constant during the simulations. This is so for two main reasons. (1) We do not believe that any of the standarnd exchange rate models can provide an adequate description to really explain the empirical behavior of the Forint. (2) Most of our forecast is conditional on current policy, so we are interested in constant policy variables.

To analyze simulation properties, we looked at the following shocks: exchange rate shocks, fiscal shocks, supply (FDI) shocks, foreign demand (German fiscal) shocks and foreign supply (oil price) shocks. Before analyzing the results in detail, let us briefly summarize the most important conclusions.

(1) The total exchange rate pass-through to consumer prices is around 5 years.
(2) Exchange rate depreciation increases imports after two years, as the generated positive export and output effect overrides the negative substitution effect on imports.
(3) A fiscal shock mainly affects output and the current account, while its inflationary effect is very small.
(4) A 1 billion USD FDI investment increases output by 0.5% in the long run. According to our calculations, as the improvement in trade overcompensates the deterioration in the income balance, the current account improves.
(5) A 10% permanent German government consumption shock increases Hungarian output by 0.1-0.2%.
(6) A 10% oil price shock generates an output loss after one year.

4.1. Monetary shock

As a monetary shock, we increased the nominal exchange rate by 1%.

Table 9

Effects of a one-percent exchange rate shock

	GDP	*Household consumption*	*Private investment*	*Goods and services exports*	*Goods and services imports*	*Output gap*	*Employment*
1 quarter	0.00	0.00	0.00	0.00	0.00	-0.51	0.00
1 year	0.24	0.00	0.11	0.09	-0.22	21.56	0.02
2 year	0.35	0.04	0.28	0.16	-0.19	23.76	0.15
5 year	0.17	0.30	0.23	0.08	0.14	2.09	0.17
17 year	0.01	0.03	0.02	0.00	0.00	-0.88	-0.01
	Compensation	*Household consumption deflator*	*Inflation [a]*	*Import prices*	*Real effective exchange rate*	*Current account balance [a,b]*	*Budget balance [a,b]*
1 quarter	0.00	0.00	0.00	1.04	-0.99	-0.16	-0.01
1 year	0.07	0.21	0.16	1.02	-0.78	0.23	-0.01
2 year	0.57	0.66	0.47	1.01	-0.34	0.39	0.05
5 year	1.35	1.00	0.06	1.01	0.01	0.03	0.04
17 year	0.99	0.98	0.00	1.00	-0.01	-0.06	-0.01

[a] percentage point deviation from base
[b] as a percentage of GDP

The real exchange rate depreciates: Initially, as prices are rigid, the real depreciation is approximately 1 %. Nominal depreciation takes a total of four years to fully feed through into the CPI. As the exchange rate shock causes a boom to last longer than four years, this causes prices to increase by more than 1%.

Net exports increase: Owing to the real depreciation, exports of goods and services increase, while imports decrease temporarily. It is worth noting, however, that after two years imports will start to increase, as the substitution effect is overridden by the income effect of the higher output.

Consumer prices increase: As import prices increase quickly, and they have a major role in domestic prices, consumer prices also increase. The pass-through to consumer prices is 0.2 in one year's time and 0.7 in two years' time.

The current account initially deteriorates, then improves significantly: As trade volumes remain unchanged initially, while USD export prices decrease, the current account deteriorates initially. Later, as net exports at constant prices increase, the current account starts to improve.

Consumption increases: The increase in output exerts upward pressure on disposable income and thus consumption.

Investment increases: Higher output raises capital demand, which leads to higher investment.

Overall output increases temporarily and as the productive capacity is not affected, the output gap also increases.

Government balance improves: Higher output means higher taxes, which together with decreasing transfers, improves the budget balance.

4.2. Fiscal shock

As a fiscal shock, government consumption was permanently increased by 10%.

Table 10
Effects of a 10% government consumption shock

	GDP	Household consumption	Private investment	Goods and services exports	Goods and services imports	Output gap	Employment
1 quarter	0.67	0.00	0.12	0.00	0.47	67.05	0.00
1 year	0.66	0.03	0.34	-0.01	0.53	60.06	0.08
2 year	0.42	-0.11	0.37	-0.07	0.61	26.58	0.22
5 year	-0.03	-1.01	0.06	-0.14	0.23	-6.54	0.03
17 year	-0.01	-2.28	-0.01	0.00	-0.15	0.14	0.01
	Compensation	Household consumption deflator	Inflation [a]	Import prices	Real effective exchange rate	Current account balance [a,b]	Budget balance [a,b]
1 quarter	0.00	0.00	0.00	0.00	0.00	-0.49	-1.04
1 year	0.23	0.16	0.12	0.00	0.16	-0.53	-0.76
2 year	0.75	0.41	0.29	0.00	0.41	-0.69	-0.29
5 year	0.53	0.20	-0.09	0.00	0.20	-0.56	-0.11
17 year	-0.03	-0.02	0.01	0.00	-0.02	0.20	-0.02

[a] percentage point deviation from base
[b] as a percentage of GDP

An increase in government consumption raises domestic demand and output. The increased demand implies a *deterioration in the current account and pushes inflation up.* It is important to note, however, that more than 30% of the increased demand leak out via higher imports in the first quarter, so output increases initially by less than 70% of the original shock.[23]

Private consumption decreases permanently: As higher government consumption in the medium term is financed by higher taxes, household disposable income decreases, and consequently consumption also decreases.

Investment increases: Higher output raises capital demand, which leads to an increase in investment.

GDP increases: As a result, GDP is higher for 2-2.5 years.

The current account deficit increases: As the volume of imports increases, while that of exports remains unchanged, the current account deficit increases by around half a percentage point of GDP.

The government balance initially deteriorates. Then the gap is gradually closed by higher tax receipts.

4.3. Supply (FDI) shocks

As a supply shock the flow of FDI is increased by 1 billion USD for one year. As the stock of FDI is cumulated from the flows, this is a permanent shock to technology.

Table 11
A 1 billion USD shock to FDI

	GDP	Household consumption	Private investment	Goods and services export	Goods and services imports	Output gap	Employment
1 quarter	0.00	0.00	0.00	0.00	0.00	-0.68	0.00
1 year	0.05	-0.01	0.01	0.08	0.00	-0.58	-0.06
2 year	0.29	0.00	0.11	0.30	-0.06	-0.24	-0.16
5 year	0.63	0.12	0.43	0.64	0.14	0.08	-0.05
17 year	0.54	1.02	0.54	0.46	0.54	0.01	0.03
	Compensation	Household consumption deflator	Inflation [a]	Import prices	Real effective exchange rate	Current account balance [a,b]	Budget balance [a,b]
1 quarter	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 year	-0.09	-0.12	0.00	-0.16	-0.16	0.06	-0.05
2 year	-0.35	-0.30	0.00	-0.42	-0.42	0.34	-0.08
5 year	-0.16	0.08	0.00	-0.34	-0.33	0.59	0.06
17 year	0.47	-0.01	0.00	-0.03	-0.03	-0.06	0.00

[a] percentage point deviation from base
[b] as a percentage of GDP

GDP increases permanently by around 0.5%.

Net export increases: The increased stock of FDI raises export capacity, so net exports increase.

Investment increases permanently: The increased stock of FDI means labor augmenting technical progress, which requires an increase in the capital/labor ratio. This means that investment should increase permanently.

[23] As government consumption is around 10% of GDP, a 10% government consumption shock means an approximately 1% output shock.

As capital adjusts very slowly, the required higher capital/labor ratio can only be achieved by lower employment initially. In the longer term, however, as capital increases in absolute terms, employment also increases.

The higher productivity also allows real wages to increase.

Private consumption increases permanently: A permanently higher output and net wealth increase consumption permanently. However, as an initial response, lower employment and real wages diminish consumption.

Consumer prices fall: As supply increases and unit labor costs fall, consumer prices fall.

Real exchange rate depreciates temporarily: As a consequence of falling consumer prices, the real exchange rate depreciates.

Current account improves: As net exports increase in volume, trade in the current balance is improving. However, due to higher repatriated FDI income, the income balance deteriorates initially. As the trade effect dominates, the current account improves.

Government balance deteriorates initially: At first, taxes decline due to lower wages, household income and higher unemployment. In the medium term as output increases, taxes increase causing the balance to improve.

4.4. Foreign demand shocks

For a foreign demand shock, we increased German government consumption by 10%.

Table 12
The effects of a permanent 10% German government consumption shock

	Foreign demand	*GDP*	*Household consumption*	*Private investment*	*Goods and services export*	*Goods and services imports*	*Output gap*	*Employment*
1 quarter	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 year	1.32	0.07	0.00	0.01	0.22	0.12	0.07	0.00
2 year	0.63	0.18	0.02	0.04	0.39	0.18	0.17	0.03
5 year	0.12	0.30	0.13	0.20	0.29	0.09	0.19	0.16
17 year	-0.04	-0.09	-0.10	-0.09	-0.06	-0.05	-0.04	-0.04
	Compensation	*Household consumption deflator*	*Inflation* [a]	*Import prices*	*Nominal effective exchange rate*	*Real effective exchange rate*	*Current account balance* [a,b]	*Budget balance* [a,b]
1 quarter	0.00	0.00	0.00	-0.34	0.11	0.13	0.02	0.00
1 year	0.00	-0.04	-0.04	-0.23	0.09	0.02	0.08	-0.03
2 year	0.07	0.00	0.03	-0.08	0.06	-0.22	0.17	-0.02
5 year	0.68	0.33	0.09	0.04	0.01	-0.13	0.23	0.06
17 year	-0.13	0.00	-0.01	0.07	-0.02	0.02	-0.05	0.00

[a] *percentage point deviation from base*
[b] *as a percentage of GDP*

Foreign demand increases by 1.3% in one year due to higher German imports.

Import prices decline , so consumer prices also fall slightly .

The *real exchange rate appreciates*, as a result of the falling domestic and rising German consumer prices.

Higher foreign demand implies *higher exports.* (0.2% in one year)

The *output increases 0.1-0.2%* on a few years' horizon.

4.5. Foreign supply (oil price) shocks

For a foreign supply shock we increased oil prices by 10% for 2 years.

Table 13
The effects of a 10% temporary oil price shock

	Foreign demand	GDP	Private consumption	Private investment	Goods and services export	Goods and services imports	Goods export in USD	Goods import in USD	Output gap
1 quarter	0.71	0.00	0.00	0.00	0.00	0.00	-0.22	0.70	0.00
1 year	0.68	0.02	-0.03	-0.02	0.11	0.04	-0.09	0.81	0.02
2 year	0.48	-0.12	-0.15	-0.09	0.18	0.17	0.22	1.19	-0.14
5 year	-0.23	-0.15	-0.26	-0.08	-0.07	-0.09	0.16	0.09	-0.09
17 year	-0.08	-0.02	-0.16	-0.03	-0.05	-0.09	-0.10	-0.15	-0.01
	Employment	Compensation	Household consumption deflator	Inflation [a]	Import prices	Nominal effective exchange rate	Real effective exchange rate	Current account balance [a,b]	Budget balance [a,b]
1 quarter	0.00	0.00	0.00	0.00	0.88	-0.01	-0.07	-0.59	-0.04
1 year	0.01	0.03	0.17	0.13	0.97	-0.01	0.06	-0.49	-0.04
2 year	0.03	0.21	0.46	0.31	1.19	-0.01	0.28	-0.71	-0.02
5 year	-0.07	0.03	0.19	-0.07	0.31	-0.01	0.03	-0.03	-0.02
17 year	0.00	-0.02	0.01	0.01	0.05	-0.01	-0.02	0.05	0.01

[a] percentage point deviation from base
[b] as a percentage of GDP

Import prices increase immediately by 0.9 percent.

In the short run foreign imports increase somewhat, as the recessionary effect in developed economies is overridden by increased demand in oil-exporting countries. In the medium term, however, foreign demand decreases.

While net exports increase in volume, due to the deterioration of the terms of trade, the *current account balance deteriorates* by around 0.5 percentage points of GDP in one year.

As a result of an increase in import prices, *inflation also increases by* 0.13 percentage points in one year. This causes real wages and consumption to decrease.

On the two-year horizon, output loss is around 0.1%. For shorter periods output is not declining due to higher foreign demand.

The effect on the government balance is negligible.

5. The output effect of the Russian crisis

After estimating the whole model it might be interesting to know to what extent the simulation properties of the model are in line with the data. In order to be able to use it for policy decision making, we expect the model to approximately reproduce past events. We do not think that this kind of model structure might be appropriate to describe the mechanism of the transition process from a planned to a market economy. In the past few years, however, the Hungarian economy entered an accession period, where the basic mechanisms might be described by the kind of models we presented in the paper. For running counterfactual simulations we had to choose a reference period which enabled the assessment of the properties of the model. The Russian crisis was an obvious candidate.

As is well-known, the Russian crisis was a financial and payment crisis. For the Hungarian economy we also had major real consequences. To assess the global effect of the crisis we might take into account the following two stylized facts:

1. Russian imports decreased by 9 billion USD in the course of two quarters, and they started to increase only gradually. According to our knowledge its level is still below that prior to the crisis .
2. The default of the Russian State caused the emerging market risk premium to increase sharply.

As every shock in an interrelated world, the Russian crisis also had major indirect effects in addition to the direct ones. For example, the 1999 slowdown in the EU was partially explained by weaker German exports to Russia.

We can summarize the direct effects for Hungary in the following manner:

1. The fall in Russian imports meant a drop by one half in Russia's imports from Hungary.
2. Due to the rise in the emerging market risk premium, the calculated interest rate differential on the Forint increased by 150-200 basis points for roughly one year.
3. Due to increased uncertainty, the Forint weakened by 2% within the intervention band for about six months .

The aforementioned effects were the direct effects of the Russian crisis, and they are quite easy to spot in the data . However, the total effects of the Russian crisis on Hungary is a much more complex issue for two main reasons:

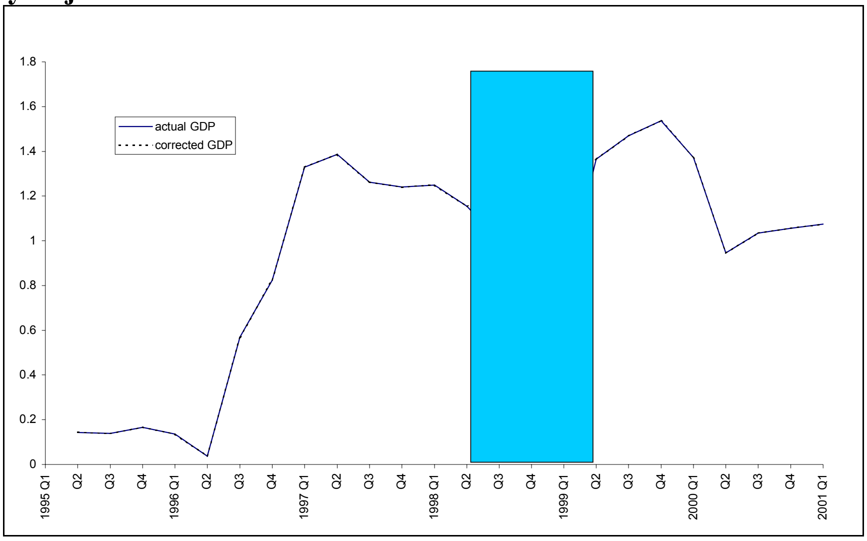
1. As orthogonal shocks are very rare in the world, individual shocks can never be analysed without external assumptions.
2. The data series available are very short, so the detection of possible outliers cannot be resolved with exact econometric methods.

Thus, we tried to restrict our analysis to as few variables as possible, so that we could avoid unnecessary data mining. Hence, our analysis was restricted to GDP and its major components. In a future phase we might include other variables, as well. We used the following methodology for producing "stylized facts" for the crisis:

1. After a seasonal adjustment of the series, quarterly growth rates were calculated.
2. Using expert judgment, we searched for possible outliers between 1998 Q2 and 1992Q2.
3. Whenever there were any outliers, we replaced them by the average for the pre- and post-crisis level.

For an illustration of the methodology, here is the GDP series:

Figure 1
Seasonally adjusted GDP and the correction for the effect of the Russian crisis



The chart clearly showes that the effect of the crisis occurred between 1998Q3 and 1999Q1. The shock values for the GDP components were calculated using the same methodology.

Table 14
Effect of the Russian crisis on the growth-rate of GDP components: actual data

	Household consumption	private investment	export of goods and services	import of goods and services	GDP	Foreign demand
1998	0.0	-0.2	-1.2	-0.2	-0.3	na
1999	0.0	-0.6	-2.7	-1.6	-1.1	-3.7

We were unable to estimate the foreign demand effect with the methodology presented above, due to the lack of quarterly data. There were no estimates available for 1998 whatsoever , and the slowdown for 1999 was assumed to be totally attributable to the crisis. From Table 14 one might conclude the following results:

1. The Russian crisis basically affected output through the trade channel, and reduced exports more than imports.
2. The effect for consumption and investment was virtually nill.
3. The main output effect occurred in 1999.

After producing the "facts", we needed input shocks for the model, so we applied the following input shocks for simulation:

1. A 4.5 and then a 9 billion drop in imports in the developing Europe block. From the third quarter a gradual increase onwards. The import series returns to the baseline in seven years' time.[24]
2. A 200-basis-point shock to the risk premium for one year.
3. Two percent nominal depreciation lasting for one year.

After implementing the shocks we ran model simulations, the results of which are presented in Table15.

Table15
Effect of the Russian crisis on Hungarian output: Simulation results

	Household consumption	Private investment	Exports of goods and services	Imports of goods and services	GDP	Foreign demand
1998	0.0	-0.1	-0.9	-0.4	-0.3	na
1999	-0.5	-0.7	-2.8	-1.6	-1.2	-3.4

A comparison of Table 14 and Table15 suggests that the model approximately reproduced the stylized facts.

6. Conclusion

In the paper, we presented the basic structure of a Hungarian Model used for policy simulation at the NBH. The model contains detailed demand and supply side mechanisms. By linking to the rest of the world in NIGEM, we were able to analyze the effects of both domestic and foreign shocks. As Hungary is a highly open economy, it is vital to be able to implement an interactive analyses of the domestic economy and the rest of the world. We presented simulation results for various domestic and foreign shocks, together with a case study on the effects of the Russian crisis on Hungary. We found that according to the simulation results, the Hungarian block of the NIGEM model was able to reproduce the stylized facts observed after the Russian crisis. This suggests that it may be an appropriate model framework for analyzing different world and domestic economy shocks.

[24] The dynamics of closing the gap is based on actual data up to the first part of 2001.

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F.1. List of variables

BPT balance of payment transfers, in USD
BUD government budget balance
C household consumption
CASH is the seignorage
CBR current account balance, as percentage of GDP
CBV current account balance, in USD
CED household consumption deflator
CEDT target price level
COMP compensation
CRAWL the rate of the crawling peg
CTAX corporate tax rate
CU output gap
DEBT government debt
DS change in stocks
E employment
EE employees in employment
EFEX nominal effective exchange rate
ELRX EUR/USD exchange rate
ELLR long-term interest rate in the Euro region
EQP equity price index
EQPR rate of return on foreign liabilities
FDI inflow of foreign direct investments,USD
FDIS stock of FDI investments at constant prices
GA gross assets, USD
GBR government budget ratio, as a percentage of GDP
GBRT target government budget ratio, as a percentage of GDP
GC government consumption
GI government investment
GIP government interest payments
GL gross liabilities, USD
IPDC credit interest- and dividend payments, USD
IPDD debit interest and dividend payments, USD
KG government capital
KP private capital
LF labor force
LIABS household liabilities
LR long-term interest rate
MGI volume of goods import
MGV value of goods import, USD
MISC miscellaneous assets of households
MSER import of services, USD
MTAX miscellaneous taxes
MVOL volume of goods and services import
NA net assets of Hungary, USD
NW household wealth
OPI other personal income
PDI personal disposable income

PI personal income
PMA import prices, HUF
PMG manufacturing import prices, HUF
PSI private sector investment
PXA export price, USD
PXG manufacturing export price, USD
PY GDP deflator
R3M short-term interest rate in Hungary
$R3M^{EL}$ short term interest rate in the Euro region
REFEX real effective exchange rate
ROR rate of return on foreign assets
RX HUF/USD exchange rate
S foreign demand (effective import)
TAX personal income tax
TFE total final demand
TRAN government transfers to households
U unemployment rate
ULT trend unit labor costs
USER user cost of capital
WDGA gross world assets
WDGL gross world liabilities
WDIPDD gross world interest- and dividend payments
WHUINF inflation expectations in wage setting
XGI volume of goods export
XGV value of goods export, USD
XSER sevrice export, USD
XVOL volume of goods and services export
Y GDP
YP potential GDP
YT GDP target

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