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A Model of Ukrainian Macroeconomic Indicators

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Summary

In this paper we present the macroeconomic model elaborated by the Modeling Group of the International Center for Policy Studies. This paper includes the theoretical background as well as a detailed explanation of the two parts of the model: forecasting of nominal GDP and inflation and forecasting of consolidated budget revenue.

Introduction

After the collapse of the USSR, Ukraine became an independent state. There were many problems that had to be solved very quickly. Various international democratic groups began to assist Ukraine in this task.

The Soros International Economic Advisory Group (SIEAG), one of these organizations, formally began working in Ukraine in accordance with the agreement between George Soros and the Minister of Economy, Roman Shpek in August 1994. Now the project exists as a part of the International Center for Policy Studies.

One of the most important projects for the Ukrainian Government undertaken by the SIEAG under the supervision of Professor Georges de Menil and with financial support of TACIS, has been the macroeconomic forecasting model. The first goal of the model was to provide a monthly forecast of the rate of inflation and nominal GDP, and help with the planning and preparation of the consolidated budget for 1997 and 1998. This project became a high priority for the Cabinet of Ministers of Ukraine, as it allowed the Ukrainians to develop an independent forecast of macroeconomic indicators, with which they can negotiate more effectively with the IMF.

The model was worked out by close cooperation between the SIEAG and the relevant departments of the Ministry of Economy, the Ministry of Finance, and the National Bank of Ukraine (Ihor Shumylo, Maryna Shapovalova, Viktor Lysytski). At that time one of the greatest problems was that government institutions rarely cooperated, while only competing against each other. Therefore, the project was based on the principles of increasing the co-operation between the SIEAG and various governmental agencies, as well as strengthening the links among these agencies.

In this paper we give a brief description of this model. The structure of our paper is as follows. In part 1 a review is given of the relevant macroeconomic theories, a brief explanation of the tax system in Ukraine and some econometric notions about the modeling. Part 2 and part 3 explain the mechanism of forecasting the nominal GDP and inflation and the method of forecasting consolidated budget revenue respectively. Abilities of the model and its future development are given in the consequences.

1. Theoretical Background

The first part of the model, which is used to forecast the price level and nominal GDP, is based on the simple proposition that the overall level of prices equilibrates the supply and demand for money[1].

We consider in keeping with the equation that Cagan (1956) developed to analyze the hyperinflations of the 1920s, that demand for money is a function of real output and inflationary expectations

$$\frac{M^d}{P} = L(Y, \pi^e) \; ,$$

If we assume that the demand function is linear in logarithm, and let lower case letters represent the logarithm of upper case letters, this becomes

$$m^d - p = \alpha_0 + \alpha_1 y - \alpha_2 \pi^e \qquad (1)$$

We take the supply of money to be equal to the money multiplier times the monetary base. The monetary base moves with its counterparts in the balance sheet of the central bank - net credit to the government, net credit to the economy and net foreign assets. In logarithm, this can be written

$$m^s = k + b \qquad (2)$$

This simple system is closed by the demand for money is equal to the supply of money

$$m^s = m^d = m \qquad (3)$$

In developed, market economies, it is generally necessary to add to this system one or more aggregate demand equations of a Keynesian type. Such an equation or set of equations would relate aggregate output, Y, to the price level, expected inflation, monetary and fiscal and other variables. In the context of transition, in which movements of production are dominated by structural factors (see Blasnchard (1997)), it is more reasonable to assume that output is supply constrained, and therefore, for our purposes, to take Y as exogenous.

Empirical evidence suggests further that inflationary expectations appear to be unbiased; i.e. though households and firms can err often in their inflationary predictions, those errors are not systematic. This allow us to write

$$\pi^e = \pi$$

Under these conditions, the model of equation (1) through (3) can be written as

$$\begin{aligned} m &= k + b \\ p^* &= m - \alpha_0 - \alpha_1 y + \alpha_2 \pi \end{aligned} \qquad (2', 1')$$

We have put a star on the value of the price level which is determined by this system in order to indicate that this is an equilibrium price level that is dictated by underling monetary fundamentals. In the short run, the actual price level deviates above and below its monetary tendency. We model these short run dynamics with an error-correction mechanism, as follows:

[1] For details see De Menil, G. et al. (1998).

$$\Delta p = \delta(p^*_{-1} - p_{-1}) + \gamma Sh \tag{4}$$

Sh is a price shock corresponding to increase in administrated prices, or the removal of price controls. In equation (4), Sh generates an immediate increase in inflation, but the error correction term, the first term in the equation, continually draws the actual price level back to its monetary equilibrium.

The theoretical framework of the second part of our model is a so-called aggregate tax revenue calculation approach and tax legislation of Ukraine.

The principal components of the Ukrainian tax system can be described in the following way. Currently, payments to the pension fund are the single most important source of revenue, accounting for about 24% of taxes raised by the Ukrainian government. Note the importance of the value added tax. It yields more revenue than either profit tax, personal income tax or payments to the Chernobyl fund. The fall of the relative importance of the profit tax is also of some interest. In 1996, it accounted for 18 % of all revenue collected, but by 1997 this figure was down to 13 %.

The system of tax collection is highly complicated. Even at the level of an enterprise it is rather difficult to forecast tax payments as too much information is necessary. If we operate at the macro level, such a task becomes impossible. Therefore, in our model we operate with aggregated across the whole economy data, which gives us the opportunity to simplify. In general, we use tax base and tax rate as basic variables in the model of budget revenues forecast. For example, in forecasting revenues from VAT we use the current tax rate and GDP as a proxy for tax base. However, for forecasting of the revenues from the Pension Fund; we use wage fund as a tax base.

Therefore, planned tax collection, namely tax rate multiplied by the tax base, is a good explanatory variable in the model of forecasting budget revenues. Such a model has a lot of advantages. Firstly, it reflects the real world, taking into account payments arrears, lags in payments etc. Econometric estimation shows us the coefficient of correlation between real and planned tax collection. Secondly, it uses trends of tax collection which prevailed during the historical period. Eventually, it is rather flexible as it gives the opportunity to introduce coefficients which reflect changes in government fiscal policy and tax legislature.

This description reveals the general approach to forecasting budget revenues. In our model, basing on the above described approach, we make forecasts for each kind of taxes independently.

To estimate the model we used the programming package Econometric Views, Version 2. Thus the EViews guide was a great necessity for us and gives a detailed explanation of the technique. We should note that, as a rule, all variables we use are in a logarithmic scale to make the time series and regressions linear.

2. Forecasting of Nominal GDP and Inflation

In this part of the description we consider the nominal GDP and Inflation forecast. We consider CPI as a major indicator that reflects the fluctuation of the general price level. Therefore, we devote much attention to the CPI forecast.

2.1. Estimation and forecasting of CPI

Since CPI is a major component of general price level it is rational to assume that short run deviation from the long run trend of general prices substantially influences CPI. Therefore, to forecast CPI we use an error correction model: first we estimate the long run equilibrium level of price-deflator and then, we use lagged difference between the long-run equilibrium level and actual price deflator level as an error correction term in the short-run regression for CPI.

2.2. Long-run equilibrium equation of CPI

This equation looks like:

$\ln(MM/P) = \alpha_0 + \alpha_1{*}D + \alpha_2{*}\ln(Y) + \alpha_3{*}\ln(Y[-1]) + \alpha_4{*}\ln(\pi_{cpi}(-1)) + \alpha_5{*}\ln(\pi_{cpi}(-2))$[2],

where: (1)

MM – M2 without foreign deposits,
P – price deflator,
D _ a dummy, $D_i=0$, i<=February,1997, $D_i=1$, i>February,1997,
Y _ real GDP,
π_{cpi} _ consumer price inflation,
α_0, α_1, α_2, α_3, α_4, α_5 _ coefficients,
numbers in brackets stand for lag.

There are many disputes among different economic schools about what factors influence the demand for real money balance and, thus, long run equilibrium price level. Nevertheless, all of them agree that it is an aggregate output that influences the demand for real money balance the most. The logic behind this is as follows. The bigger the output produced in an economy, the more money is needed to serve it. This is why we include the output as an explanatory variable in our long-run equilibrium equation.

[2] For detailed regression output of all equations see appendixes.

Furthermore, in transition economies, persistence of inflation is caused by various subjective factors that cannot be predicted by theory. These factors determine the inflation in the past and, thus, can help to predict its value in the next period. In addition, we assumed that in Ukraine people have adaptive expectation and, thus, that the agents (i.e. market participants) always expect that the most recently observed value of any variable will continue to prevail in the near future. For these two reasons we include CPI inflation lagged one and two periods as endogenous variables in the equation.

The dummy is used to reflect the change in real money balance trend. The trend has different slopes: α_0 until some threshold date and $\alpha_0+\alpha_1$ afterwards. Using the stability breakpoint test we infer that February 1997 is such a threshold. Therefore, D takes value of 0 until February 1997 and 1 otherwise.

2.3. Short-run equation of CPI

From the equation (1) we can determine the value of our long-run price deflator level (P*) which can be calculated as follows:

$$\ln(P^*) = \exp[\ln(MM) - (\alpha_0 + \alpha_1 * D + \alpha_2 * \ln(Y) + \alpha_3 * \ln(\pi_{cpi}(-1)) + \alpha_4 * \ln(\pi_{cpi}(-2))]$$

Then we can calculate the deviation of the actual price level from its equilibrium level and construct the short-run inflation adjustment of the actual price level towards its long-run value which looks like:

$\ln(\pi_{cpi}) = \beta_1 * [\ln(P^*[-1]) - \ln(P[-1])] + \beta_2 * \ln(\pi_{cpi}(-1)) + \beta_3 * SH + SFI$, where: (2)

P _ GDP-deflator,
SH _ administrative price shock,
SFI _ seasonal fluctuation index,
β_1, β_2, β_2 _ coefficients.

Besides including the difference between the long-run level of CPI and actual GDP-deflator in the regression as explanatory variables, we use:

- Price shock, a index which measure the degree of influence of an administrative price rise (i.e. the government decided to increase utility payments which should be paid by households in September, 1996) on the general price level.
- Seasonal fluctuation index. This index is constructed on the basis of expert estimates and takes positive value in winter and negative in summer, such that
$$\sum_{i=1}^{12} SFI_i = 0$$
(1 stands for January and 12 - for December). Thus, the index is designed to reflect the increase in food production prices in winter, and decline in them in summer.
- Consumer price inflation lagged one period. This variable takes into account inflation expectations.

To forecast CPI based on these two equations we should have expert estimates of money supply, real GDP, shocks and seasonal fluctuations in the future. Future money supply we estimate as a money base times money multiplier. For money multiplier we use 1.5 (the average level) adjusted on seasonal fluctuations. To forecast the level of real GDP we use official data from state budget and ARIMA model that we developed. Seasonal fluctuation index used with this purpose is the same as in the previous year and the shock variable usually takes a value of zero if the government does not announce an administrative price increase in the future. The other variables are given by statistics department (CPI and GDP-deflator data) or are calculated basing on the equation (1) results (level of P*).

2.4. Estimation and forecasting of WPI

To forecast WPI we use the following estimated equation.

$\pi_{wpi} = \gamma_1 * (\pi_p(-1)) + \gamma_2 * (E/E(-1)) + \gamma_3 * (\pi_{cpi})$, where (3)

E _ exchange rate,
WPI _ wholesale price index,
γ_1 ,γ_2 ,γ_3 _ coefficients.

Here we assume that the change in wholesale prices is correlated with the change in consumer prices and with the previous change in the general price level because the nature of these variables are very similar. Since the wholesale prices are very sensitive to terms of trade conditions, we included in the RHS of the equation the change in exchange rate, as a proxy of change in terms of trade conditions.

Having estimated equation (3) we could forecast WPI. The value of (P/P (-1)) is lagged 1 period, so we do not need to make assumptions about its level. For CPI we use the value obtained from CPI forecasting. The only variable, which value we should assume is the change in exchange rate. Our estimates about exchange rate are based on the official data about the currency corridor.

2.5. Forecast of GDP-deflator

Experts of our group agree that the nature of this variable is such that it could be calculated as a weighted average of CPI and WPI in the following way:

$$\pi_p = 0.7 * \pi_{cpi} + 0.3 * \pi_{wpi}$$

2.6. Forecast of nominal GDP

$$PY = P * Y, \text{ where:}$$

PY _ nominal GDP.

To forecast nominal GDP we should make assumptions about the real GDP level.

3. Forecasting of Consolidated Budget Revenue

In this part of the description of the model we consider the revenue side of the budget. We present the method of estimation of the major taxes, namely: value - added tax, profit tax, sales taxes, stamp tax, payments for land and payroll taxes. The methodology used in the excise tax case could be employed to forecast other taxes.

3.1. VAT Revenues

Firstly, we assume that all final goods and services produced and sold during a given period, i.e., the entire gross domestic product, are subject to a general VAT tax. This means that the tax is applicable to both consumers and capital goods and it would be paid by the last seller, whether this good is bought by a consumer, as a capital good by a firm or added to inventory by a firm. In the model this assumption is represented by the following equation:

$$VAT\_M = R*PY, \text{ where:}$$

VAT_M _ "maximum available" budget revenues from VAT,
R _ tax rate.

In order to calculate real revenues from VAT we should take into account tax exemptions, delays in tax payments, tax evasion and other factors. Therefore, the final equation which estimates VAT revenues has the following form:

$$VAT\_R = \alpha_1 + \alpha_2*VAT\_M + \alpha_3*VAT\_M(-1), \text{ where:}$$

VAT_R _ the actual revenues to the budget from the VAT;
α_2 and α_3 _ coefficients, which represent tax collection in current and previous months respectively.

3.2. Profit tax revenues

Profit tax is levied on an enterprise's gross profit. Therefore, in order to calculate profit tax revenues for the budget we need to estimate taxable income. The basic principle in determining taxable income is simple enough. Gross income of the enterprise is reduced by costs incurred in doing business, and the net is net income subject to tax. For the purposes of our forecast we need to aggregate incomes of all enterprises across the country and here problems arise. Mostly they deal with exclusions and deductions such as capital gains, tax exemptions, charitable contributions, etc. This involves determining and forecasting the value of the items that should be deductible as business costs and what the timing of such changes should be. Unfortunately, this is not feasible on a aggregate level. In order to simplify we have taken nominal GDP as an explanatory variable of profits across the national economy. Econometric estimates have shown that a correlation between these two variables exist. In order to construct a final equation we have taken into account also seasonality effects due to accountancy practice of the enterprises to correct valuation of their profits before the end of each half of the year:

$$PROF = \alpha_1 * PY + \alpha_2 * SEAS(6) + \alpha_3 * SEAS(12)$$

Finally, profit tax revenues are calculated as a function of above described variable “profit”. Again seasonality factor is present in order to take into account corrections of payments to the budget at the end of each year. Profit tax payments have also a lag of one period:

$$PROF\_R = \alpha_1 * PROF + \alpha_2 * PROF(-1) + \alpha_3 * SEAS(12)$$

3.3. Revenues estimated on the basis of the wage fund forecast

In this part of our model we consider taxes which are usually called payroll taxes. These taxes provide a source of revenue for the social security system. As a matter of administration, the payroll taxes are collected from the employer, including the contributions of both employer and employee, the latter being withheld at the source. These taxes are on gross earnings and usually no allowance is made for exemptions.

In Ukraine, the employer is required to make monthly contributions to pension, social security and Chornobyl funds. These social fund payments are made in lump sum for all Ukrainian employees of any employer and are calculated as a percentage of the employee's earnings. Therefore, for the purposes of the forecast we need to estimate the wage fund making distinction at the same time between the wage fund which is due and which is paid.

The total due wage fund is calculated by multiplying the average wage and the number of workers. Average wage is determined by the value of the average wage in the preceding period and by the change in the average over the present period:

$$AWT = AWT_{-1} * DAWT \text{ , where:}$$

AWT _ the value of the average wage
DAWT _ the change in the average over the present period.

The change in the average wage is estimated using an econometric technique where the dependent variables are change in the average wage over the previous period and change in consumer price index (CPI) in present and previous periods. We have also included two dummy variables for the last and first months of the year. They introduce seasonal effect on the average wage, which occurs due to a practice of additional payments to the employees at the end of each year. In general, the equation has the following form:

$$DAWT = f(DAWT_{-1}, DCPI_{-1}, SEAS(1), SEAS(12)).$$

Calculation of the number of workers in the national economy is based on the research on payroll taxation in Ukraine. In particular, this study makes a conclusion that with the current payroll tax rates the labor force in Ukraine decreases each month by 0.4% (labor force shifts into the unofficial economy). From the other side, the study of the foreign experience showed that 25% payroll tax rate will lead to zero labor mobility. Therefore,

$$N = N_{-1}(1 + f(t))$$
$$f(0.52) = -0.004$$
$$f(0.25) = 0,$$

where:
t - tax rate,
N - number of workers.

Next we assume exponential functional form of the dependence of changes in the labor force due to changes in payroll tax rate:

$$f(t) = \alpha_0 e^{-\alpha_1 t^2} + \alpha_2, \text{ where:}$$

f(t) - labor force mobility,
α_0 and α_1 - minimal and maximal number of workers in the national economy,
α_2 - the maximal speed of labor force movement out of the official economy.

Combining two equations together we obtain the final one for the calculation of the number of workers in the official economy:

$$N = N_{-1}(1 + \alpha_0 e^{-\alpha_1 t^2} + \alpha_2).$$

Now it is easy to get a due wage fund:

$$RWF = AWT * N.$$

The paid wage fund (the turnover account for wages in the National Bank of Ukraine in the historical period) is estimated as the part of the due wage fund. Although this method of estimation is rather simple, it gives us the opportunity to see how large the difference is between the paid wage fund and the due wage fund. Also a coefficient is introduced to take into account wage arrears:

$$WFC = (0.7 + k) * RWF, \text{ where}$$

WFC - paid wage fund,
k - coefficient of payments of wage arrears estimated using the data for the period 1996-1997.

Using the above mentioned technique of calculation of the paid wage fund, we form the basis for estimation of revenues from the payments to the Pension fund (variable R_PF), the Chornobyl fund (variable R_CHF) and also revenues for the personal income tax (variable R_PIT):

$$R\_PF = \alpha_1 WFC$$
$$R\_CHF = \alpha_2 WFC$$
$$R\_PIT = \alpha_3 WFC.$$

The observed correlation between these variables is robust enough to use them in our model and to make regular forecasts.

3.4. Sales taxes

The sales tax can be a general type when the same tax rate is imposed on purchases of all commodities, and a selective type, also referred to as an excise tax, which is levied at different rates on the purchase of different commodities. Sale taxes generally take one of the two forms: a unit tax is a given amount for each unit purchased, and an ad valorem tax is computed as a percentage of the value of the purchase. When considering the case with Ukraine, we shall deal with excise taxes and custom duties of ad valorem form as these are the kinds of taxes which are used here.

3.5. Excise taxes

Excise taxes are very popular in developing countries due to their ease of administration. They are collected from sellers at the retail level. Relative to an income tax, there are fewer individuals whose behavior has to be monitored by the tax authorities.

In Ukraine excise tax is imposed on such traditional excisable goods as alcoholic beverages, tobacco products, cars and tires for them, jewelry etc., with the tax rate in the range of 10 to 300% of the release price or purchase price in case of imported goods. Such a diversity of tax rates and product groups on which the tax is levied creates problems of forecasting because too much information is available.

Therefore, calculate excise revenues on the aggregate level. The main assumption here is that the nominal excise revenues for a month ‘j' are equal to the real revenues for the same month in the previous year multiplied by the current CPI:

$$R\_EXC = (R\_EXC(-12)/CPI(-12))*CPI*EXC\_COEF.$$

Here we have also introduced excise coefficient. It measures tax collection in the current year. This coefficient is calculated in the following way. Firstly, we calculate the level of tax collection for the first 6 months of the current year compared to the previous year:

$$\gamma = \frac{\sum_{i=1}^{6} \mathrm{EXC\_R}_i^{97} / CPI_i^{97}}{\sum_{i=1}^{6} EXC\_R_i^{96} / CPI_i^{96}}.$$

Now, if we multiply γ by the sum of excise revenues collected in the previous year we will have an approximation of the sum of tax collection in the current year. Using this proxy and the sum of tax collection in the first 6 months of this year we can calculate the level of tax collection until the end of this year compared to the previous year:

$$\beta = \frac{\gamma * \sum_{i=1}^{12} \frac{EXC\_R_i^{96}}{CPI_i^{96}} - \sum_{i=1}^{6} \frac{EXC\_R_i^{97}}{CPI_i^{97}}}{\sum_{i=7}^{12} \frac{EXC\_R_i^{96}}{CPI_i^{96}}}.$$

Coefficient β enters into the model as a variable “EXC_COEF”.

3.6. Customs duties

Customs duties are another kind of sales tax. In Ukraine, they are charged at a level from 0% to 200% of the contract value of import shipments. The value of import is the primary variable used for forecasting of customs duties revenue. As this value is in dollars in official statistics, we use the following equation to convert import value into the local currency:

IMH = IM*E where:

IMH –the value of import in Hryvna,
IM – value of import in dollars.

In order to calculate custom duties revenues we use value of import shipments multiplied by the weight of customs duties collected in the previous month in the last month’s value of import. This gives us an approximation of what should be collected in the current period. However, such an approximation can be erroneous. In order to avoid accumulation of errors we introduce the following error correction mechanism: we calculate a proxy of custom duties revenue for the previous month in a way discussed above. Then we compare this proxy with the actual value. The final equation has the following form:

$$R\_CUSTOMS = \frac{R\_CUSTOMS(-1)}{IMH(-1)} * IMH + \alpha\,(\mathrm{R\_CUSTOMS(-1)} - \frac{\mathrm{R\_CUSTOMS(-2)}}{\mathrm{IMH(-2)}} * IMH(-1)),$$

where α is a coefficient which shows the significance of the error correction.

3.7. Stamp tax

In Ukraine stamp taxes are paid for transactions with securities, carrying out of auctions, stock exchange transactions, foreign travel passport issue etc. In general, the stamp tax is a fee on civil and some business transactions. This means that the size of business activity should cause a consequent increase in stamp tax receipts. The increase in the price level should also increase stamp tax receipts as in such a case the value of the civil transactions goes up. In our model we consider GDP and CPI as the primary variables explaining stamp tax receipts. The lagged variable of stamp tax receipts takes into account actual tax receipts during the historical period:

$$R\_STAMPTAX = \alpha * NGDP * CPI + \beta * R\_STAMPTAX(-1).$$

3.8. Payments for land

We now turn to taxation of stocks, i.e., of wealth. Such taxes are imposed on pieces of property. The benefit rationale for wealth taxation is that public services increase the value of real properties and should therefore be paid for by the owners. In other words, the property owners should pay for particular services which go to raise property values.

In Ukraine payment for land depends on space and location of the plot of land. Theoretically, such payments in real terms should be constant since the supply of land is given. Therefore, the first variable in our model is the revenues for payments for land received in the corresponding period of the previous year corrected with CPI. However, in real life, payment for land is not a constant. The return to land is in the nature of economic rent, being a return to a factor of production in inelastic supply. Therefore, land taxation may change with business activity in order to encourage or discourage land utilization without creating excess burden on businesses. We introduced a change in the nominal GDP variable in order to account for this in our model:

$$R\quad LAND = \alpha \frac{R\quad LAND(-12)}{CPI(-12)} * CPI + \beta \frac{NGDP}{NGDP(-1)} + \quad R\quad LAND(-1).$$

3.9. Other taxes

The forecast uses the same methodology as in the excise tax case.

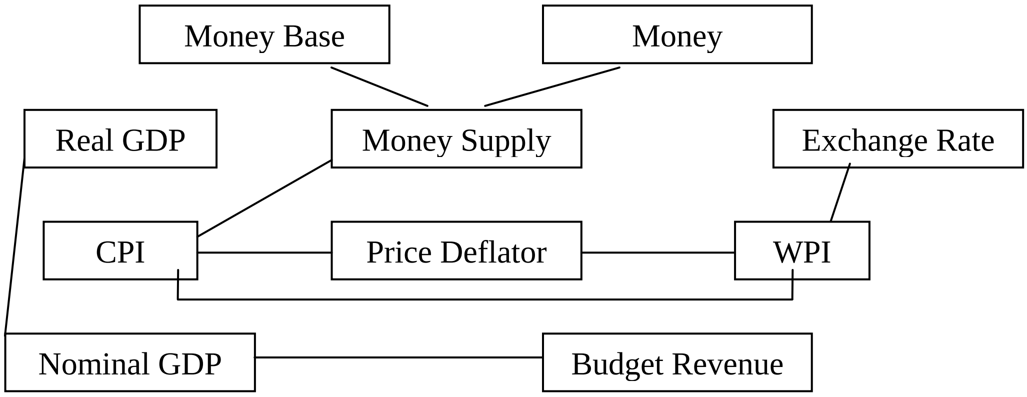
Consequences

Besides the direct use of the model for forecasting nominal GDP, inflation and budget revenue, the model has some application. One can use it to evaluate alternative scenarios of economic development. For example, it could tell us what would happen with GDP, inflation and budget deficit if the government decided to change exchange or tax rates, increase money supply, etc. Also, this model allows us to install so-called reverse ties: we could first assign a size of the budget deficit as an exogenous variable, and then the model will determine the appropriate level of GDP and inflation as well as the money base and the money supply.

Finally, we plan to expand the model by working out the forecast of real GDP, foreign trade balance and T-bills conditions.

Appendices

A. The principal scheme of the model



B. Notes on the general model specification

The monetary part of the model is represented by three equations. Tests are performed on each of the model components.

An integrated approach of the model verification assumes the following key stages:

- ***Multicollinearity check.*** The absence of multicollinearity was verified directly via the correlation matrix. The value of correlation coefficient greater than 0.9 immediately causes linear correlation of the regressors.
- ***Stationarity of Series.*** The stationarity check procedure underlying the Augmented Dicker-Fuller tests is used at this stage. Stabilized series of regressors is assumed in the derivation of the standard inference procedure for regression models. Nonstationarity of regressors invalidates many standard results.
- ***Normality of residuals distribution.*** As a rule, the distribution of residuals is standard Gaussian. This indicates that efficiency of estimation is not under the influence of residuals. The Jarque-Bera criteria test was applied to all squared residuals.
- ***Homoskedasticity of disturbances.*** The results of White's heteroskedasticity tests shows that disturbances in all equations are both homoskedastic and independent of regressors. The F-statistic and a statistic with an asymptotic χ-squared distribution proof the null hypothesis. This is a general test for model misspecification and results of the test assume that the specification of the model is correct.

Analysis of the long-term money demand equation

Let us consider the equation for equilibrium price level estimation

$$mm\text{-}p = f(y,\ y_{-1},\ \pi_{CPI\,-1},\ \pi_{CPI\,-2},D,\ \mu),$$

where all lowercase variables are in a logarithmic scale,
μ stands for stochastic disturbances.

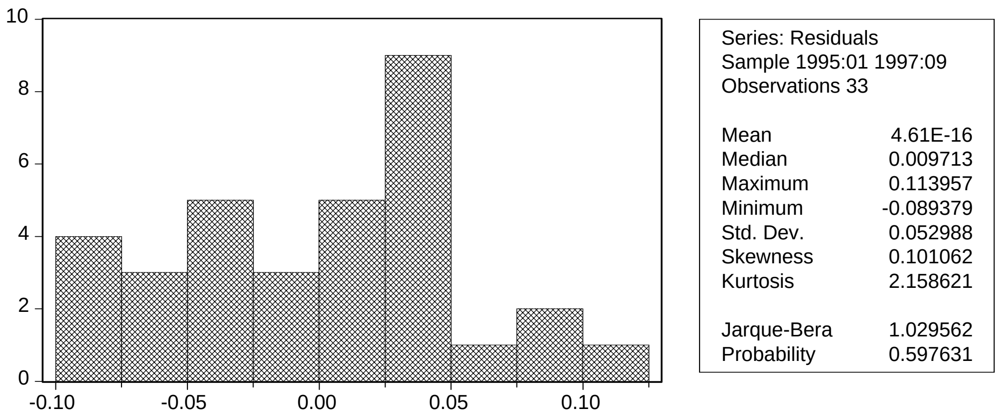
Correlation matrix is shown below.

Correlation Matrix

	LOG(MM/P)	LOG(Y)	LOG(CPI(-1)/CPI(-2))	LOG(CPI(-2)/CPI(-3))
LOG(MM/P)	1.000000	0.344216	-0.596974	-0.634516
LOG(Y)	0.344216	1.000000	-0.196302	-0.192024
LOG(CPI(-1)/CPI(-2))	-0.596974	-0.196302	1.000000	0.642780
LOG(CPI(-2)/CPI(-3))	-0.634516	-0.192024	0.642780	1.000000

The regressors are sufficiently linear independent to be included to the model.
The histogram of residuals is shown in the figure. According to the Jarque-Bera criteria, the distribution is normal with the probability of 0.597.

Figure 1
Distribution of residuals (P=0.59)



The results of White tests for the for the first equation can be found in the table.

White Heteroskedasticity Test

F-statistic	1.121745	Probability	0.372532
Obs*R-squared	5.676026	Probability	0.339030

Test Equation:
LS // Dependent Variable is RESID^2
Date: 12/10/97 Time: 13:39
Sample: 1995:01 1997:09
Included observations: 33

Variable	CoefficienStd.	Error	t-Statistic	Prob.
C	-0.055629	0.122088	-0.455645	0.6523
C1	0.001623	0.001635	0.993028	0.3295
PDL01	0.044284	0.106947	0.414070	0.6821
PDL01^2	-0.008070	0.023399	-0.344867	0.7329
PDL02	-0.012191	0.015378	-0.792755	0.4348
PDL02^2	0.013382	0.031553	0.424118	0.6748

R-squared	0.172001	Mean dependent var	0.002723
Adjusted R-squared	0.018668	S.D. dependent var	0.003061
S.E. of regression	0.003033	Akaike info criter	-11.43362
Sum squared resid	0.000248	Schwarz criterion	-11.16152
Log likelihood	147.8297	F-statistic	1.121745
Durbin-Watson stat	2.047615	Prob(F-statistic)	0.372532

The hypothesis of heteroskedacticity is not accepted.

The following table represents ADF tests results on stationarity of levels and in the first differences (where it's necessary). Since the ADF statistic is smaller than the critical value for correspondent significant level, we accept the stationarity hypothesis.

Augmented Dickey-Fuller Unit Root Test on LOG(MM/P)		
ADF Test Statistic -1.022055	1% Critical Value*	-3.6353
	5% Critical Value	-2.9499
	10% Critical Value	-2.6133
Augmented Dickey-Fuller Unit Root Test on LOG(CPI/CPI(-1))		
ADF Test Statistic -2.126822	1% Critical Value*	-3.6422
	5% Critical Value	-2.9527
	10% Critical Value	-2.6148
Augmented Dickey-Fuller Unit Root Test on LOG(Y)		
ADF Test Statistic -2.758905	1% Critical Value*	-3.6496
	5% Critical Value	-2.9558
	10% Critical Value	-2.6164
Augmented Dickey-Fuller Unit Root Test on RESID		
ADF Test Statistic -3.499816	1% Critical Value*	-3.6353
	5% Critical Value	-2.9499
	10% Critical Value	-2.6133

*MacKinnon critical values for rejection of hypothesis of a unit root.

All series are non-stationary. We check co- integration (in term of our equation). Test showed that residual of equation is stationary. We can use error correction mechanism discussed at the third part of this description.

Analysis of the short-term money demand equation

Let consider short-run inflation dynamic equation

$$\pi_{CPI} = f(\, (p^*-p)_{-1}, \pi_{CPI\,-1}, SH, SFI, \mu)$$

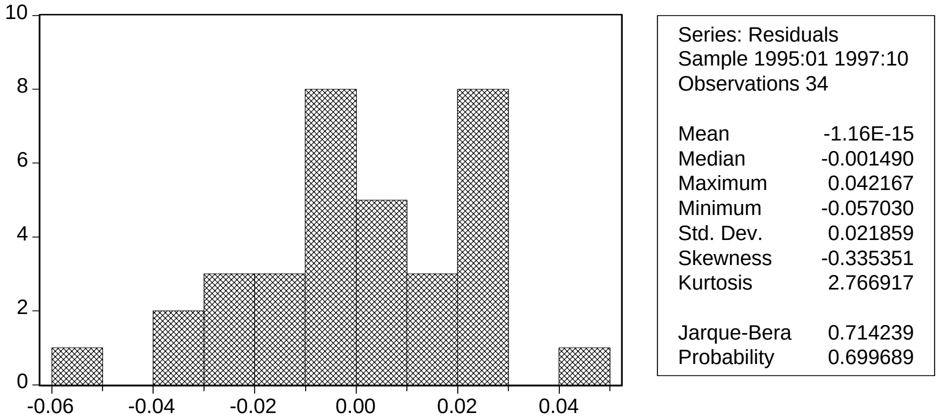
The results of the tests, similar to those mentioned above are given here for Equation 2.

Correlation Matrix

	LDCPI(-1)	ZZ	LOG(PS1(-1))-LOG(P(-1))
LDCPI(-1)	1.000000	0.219103	-0.188758
ZZ	0.219103	1.000000	-0.040081
LOG(PS1(-1))-LOG(P(-1))	0.188758	-0.040081	1.000000

Figure 2

Distribution of residuals (P=0. 69)



ADF Test Statistic –4.343649	1% Critical Value*	-3.5745
	5% Critical Value	-2.9241
	10% Critical Value	-2.5997

White's test shows the source of partial heteroskedacticity in the Equation 2 - non-homogeneous disturbance of SH regressor.

White Heteroskedasticity Test

F-statistic	1.505990	Probability	0.213931
Obs*R-squared	8.525433	Probability	0.202078

Test Equation:
LS // Dependent Variable is RESID^2
Date: 12/10/97 Time: 13:25
Sample: 1995:01 1997:10
Included observations: 34

Variable	CoefficienStd.	Error	t-Statistic	Prob.
C	4.35E-05	0.000148	0.294474	0.7706
LOG(PS1(-1))-LOG(P(-1))	0.000347	0.001672	0.207639	0.8371
(LOG(PS1(-1))-LOG(P(-1)))^2	0.013664	0.012377	1.104016	0.2793
LDCPI(-1)	0.000590	0.005684	-0.103776	0.9181
LDCPI(-1)^2	-0.007455	0.032600	-0.228679	0.8208
ZZ	0.033508	0.015106	2.218208	0.0351
ZZ^2	-0.312287	0.187741	-1.663397	0.1078

R-squared	0.250748	Mean dependent var	0.000239
Adjusted R-squared	0.084248	S.D. dependent var	0.000486

Analysis of the wholesale price index equation

The results for the WPI index estimation equation are shown below

$$WPI/WPI(-1)=f(CPI/CPI_{-1}, E/E_{-1})$$

Augmented Dickey-Fuller Unit Root Test on LCPI			
ADF Test Statistic -2.515609			
Augmented Dickey-Fuller Unit Root Test on WPI			
ADF Test Statistic -2.731770	1%	Critical Value*	-3.6353
	5%	Critical Value	-2.9499
	10%	Critical Value	-2.6133

*MacKinnon critical values for rejection of hypothesis of a unit root.

Significance level for stationarity check is given below:

Series	LEXRATE	WPI	LCPI
ADF Statistic	-4.966251	-2.731770	-3.281453
Signif. Level	1%	10%	5%

Correlation Matrix

	DWPI	DCPI	EXRATE(-1)/EXRATE(-2)
DWPI	1.000000	0.748344	0.507076
DCPI	0.748344	1.000000	0.183999
EXRATE(-1)/EXRATE(-2)	0.507076	0.183999	1.000000

Augmented Dickey-Fuller Test Equation
LS // Dependent Variable is D(LCPI)
Date: 12/10/97 Time: 18:35
Sample(adjusted): 1995:01 1997:10

Augmented Dickey-Fuller Unit Root Test on ZZ		
ADF Test Statistic -3.885990	1% Critical Value*	-3.5092
	5% Critical Value	-2.8959
	10% Critical Value	-2.5849

*MacKinnon critical values for rejection of hypothesis of a unit root.

White Heteroskedasticity Test:

F-statistic	2.052015	Probability	0.129854
Obs*R-squared	7.203333	Probability	0.125525

Most of the series are autocorrelated with the first lag that leads to inference uncertainty. However, the first lags were mostly included into equations, so parameter estimation was legitimated. Additional testing by the Augmented Dicker-Fuller tests had shown the stationarity of regressors.

General model specification tests showed substantial adequacy level and stability of the model. Standard inference procedure is adequate underlying estimated parameters values. The results of the tests confirm that the specification of the model is correct.

C. **Regression Output of the Nominal GDP and Inflation Part of the Model**

Long-run equilibrium equation for CPI

$ln(MM/P) = 0.29 + 0.29*D + 0.51*ln(Y) + 0.26*ln(Y(-1)) - 0.35*\pi_{cpi} (-1) - 0.18*\pi_{cpi} (-2)$

LS // Dependent Variable is LOG(MM/P)
Date: 11/24/97 Time: 16:34
Sample(adjusted): 1995:01 1997:10
Included observations: 34 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.292406	0.180761	1.617640	0.1162
D	0.288186	0.024797	11.62171	0.0000
PDL01	0.513660	0.078579	6.536831	0.0000
PDL02	-0.350690	0.097158	-3.609487	0.0011

R-squared	0.877113	Mean dependent var	1.503341
Adjusted R-squared	0.864825	S.D. dependent var	0.150386
S.E. of regression	0.055291	Akaike info criterion	-5.680155
Sum squared resid	0.091713	Schwarz criterion	-5.500583
Log likelihood	52.31872	F-statistic	71.37574
Durbin-Watson stat	1.462166	Prob(F-statistic)	0.000000

Lag Distribution of ln(Y)	i	Coefficient	Std. Error	T-Statistic
. *|	0	0.51366	0.07858	6.53683
. * |	1	0.25683	0.03929	6.53683
	Sum of Lags	0.77049	0.11787	6.53683

Lag Distribution of ln(CPI(-1)/CPI(-2))	i	Coefficient	Std. Error	T-Statistic
* .|	0	-0.35069	0.09716	-3.60949
* .|	1	-0.17535	0.04858	-3.60949
	Sum of Lags	-0.52604	0.14574	-3.60949

Short-run equation for CPI

π_{cpi} = 0.05*[ln(P*[-1]) - ln(P[-1])] + 0.24*π_{cpi} (-1) + 0.92*SH				
LS // Dependent Variable is π_{cpi} Date: 06/12/97 Time: 16:03 Sample(adjusted): 1994:01 1997:04 Included observations: 40 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ln(P*(-1))-ln(P(-1))	0.053000	0.017797	2.977933	0.0051
SH	0.921591	0.057683	15.97691	0.0000
π_{cpi}(-1)	0.244157	0.035413	6.894526	0.0000

R-squared	0.927298	Mean dependent var	0.075630
Adjusted R-squared	0.923368	S.D. dependent var	0.097574
S.E. of regression	0.027011	Akaike info criterion	-7.150984
Sum squared resid	0.026995	Schwarz criterion	-7.024318
Log likelihood	89.26214	F-statistic	235.9634
Durbin-Watson stat	0.962344	Prob(F-statistic)	0.000000

WPI Equation

WPI/WPI(-1) =0.26*(P[-1]/P[-2]) + 0.38*(E/E(-1)) + 0.35*(CPI/CPI[-1])				
LS // Dependent Variable is WPI/WPI(-1) Date: 09/30/97 Time: 17:47 Sample(adjusted): 1995:03 1997:08 Included observations: 30 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
P(-1)/P(-2)	0.268190	0.110056	2.436857	0.0217
E/E(-1)	0.378643	0.083289	4.546109	0.0001
CPI/CPI(-1)	0.353835	0.110870	3.191437	0.0036

R-squared	0.822547	Mean dependent var	1.029633
Adjusted R-squared	0.809402	S.D. dependent var	0.033242
S.E. of regression	0.014512	Akaike info criterion	-8.370862
Sum squared resid	0.005686	Schwarz criterion	-8.230742
Log likelihood	85.99478	F-statistic	62.57645
Durbin-Watson stat	1.115558	Prob(F-statistic)	0.000000

Regression Output of the Consolidated Budget Revenue Part of the Model

VAT Equation

VAT_ R= 46.22 + 0.06* VAT_M + 0.32* VAT_M(-1)

Dependent Variable is VAT _R
Date: 12/18/97 Time: 15:48
Sample(adjusted): 1994:02 1995:12
Included observations: 23 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	46.21612	22.56489	1.804181	0.0863
VAT_M	0.061944	0.021012	3.336701	0.0033
VAT_M(-1)	0.322076	0.098562	3.539709	0.0021

R-squared	0.989161	Mean dependent var	252.5648
Adjusted R-squared	0.988077	S.D. dependent var	157.7624
S.E. of regression	17.22615	Akaike info criterion	5.813964
Sum squared resid	5934.802	Schwarz criterion	5.962072
Log likelihood	-96.49618	F-statistic	912.6211
Durbin-Watson stat	1.958462	Prob(F-statistic)	0.000000

Equation for profits

PROF = 0.09* PY + 0.31* PROF(-3) + 0.23*@SEAS(12)*CPI + 0.48*@SEAS(6)*CPI

LS//Dependent Variable is PROF
Date: 07/30/97 Time: 19:25
Sample: 1996:01 1996:05 1996:07 1997:06
Included observations: 17

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PY	0.085400	0.027720	3.080848	0.0088
PROF(-3)	0.313353	0.109612	2.858737	0.0134
@SEAS(12)*CPI	0.233049	0.317059	0.735035	0.4754
@SEAS(6)*CPI	0.484369	0.279688	1.731822	0.1069

R-squared	0.441259	Mean dependent var	1064.250
Adjusted R-squared	0.312319	S.D. dependent var	543.1670
S.E. of regression	450.4295	Akaike info criterion	12.42273
Sum squared resid	2637528	Schwarz criterion	12.61878
Log likelihood	-125.7151	F-statistic	3.422202
Durbin-Watson stat	1.232284	Prob(F-statistic)	0.049549

Equation for profit revenues

ln(PROF_R) = 5.37 + 0.25* ln(PROF) + 0.2*@SEAS(12) - 0.16* ln(PROF(-1))				
LS // Dependent Variable is ln(PROF_R) Date: 07/30/97 Time: 19:06 Sample(adjusted): 1995:07 1997:06 Included observations: 24 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.368587	0.821407	6.535841	0.0000
ln(PROF)	0.251541	0.095088	2.645348	0.0155
ln(PROF(-1))	-0.159014	0.086583	-1.836551	0.0812
@SEAS(12)	0.203982	0.226322	0.901290	0.3782

R-squared	0.464194	Mean dependent var	6.030922
Adjusted R-squared	0.383823	S.D. dependent var	0.333229
S.E. of regression	0.261575	Akaike info criterion	-2.531060
Sum squared resid	1.368426	Schwarz criterion	-2.334717
Log likelihood	0.318192	F-statistic	5.775638
Durbin-Watson stat	1.531498	Prob(F-statistic)	0.005163

Equation for average wage

DAWT = 0.21* DAWT(-1) - 0.18* D1*DAWT(-12) + 0.1* D12*DAWT(-12) + 0.35* CPI/CPI(-1) + 0.44* CPI(-1)/CPI(-2)				
LS // Dependent Variable is DAWT Date: 05/30/97 Time: 17:46 Sample(adjusted): 1995:03 1997:04 Included observations: 26 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DAWT(-1)	0.210509	0.096971	2.170853	0.0416
D1*DAWT(-12)	-0.183947	0.028682	-6.413240	0.0000
D12*DAWT(-12)	0.099003	0.019208	5.154292	0.0000
CPI/CPI(-1)	0.358753	0.198769	1.804872	0.0855
CPI(-1)/CPI(-2)	0.436547	0.215289	2.027722	0.0555

R-squared	0.844008	Mean dependent var	1.051208
Adjusted R-squared	0.814295	S.D. dependent var	0.074403
S.E. of regression	0.032063	Akaike info criterion	-6.709080
Sum squared resid	0.021588	Schwarz criterion	-6.467138
Log likelihood	55.32563	F-statistic	28.40556
Durbin-Watson stat	1.988775	Prob(F-statistic)	0.000000

Equation for pension fund

R_PF = 0.42* WFC				
LS // Dependent Variable is R_PF Date: 11/03/97 Time: 18:43 Sample(adjusted): 1996:04 1996:10 1997:01 1997:04 Included observations: 11 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
WFC	0.424384	0.007897	53.74098	0.0000

R-squared	0.638818	Mean dependent var	610.7675
Adjusted R-squared	0.638818	S.D. dependent var	62.91262
S.E. of regression	37.80947	Akaike info criterion	7.351627
Sum squared resid	14295.56	Schwarz criterion	7.387799
Log likelihood	-55.04227	Durbin-Watson stat	0.399633

Equation for Chornobyl fund

R_CHF = 0.08* WFC				
LS // Dependent Variable is R_CHF Date: 09/27/96 Time: 11:35 Sample: 1995:11 1996:06 Included observations: 8				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
WFC	0.087862	0.001407	62.43801	0.0000

R-squared	0.861557	Mean dependent var	11859.87
Adjusted R-squared	0.861557	S.D. dependent var	1452.048
S.E. of regression	540.2765	Akaike info criterion	12.70063
Sum squared resid	2043291.	Schwarz criterion	12.71056
Log likelihood	-61.15403	Durbin-Watson stat	1.658771

Equation for profit income tax

R_PIT = 0.14* WFC				
LS // Dependent Variable is R_PIT Date: 09/27/96 Time: 10:46 Sample: 1995:12 1996:08 Included observations: 9				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
WFC	0.143876	0.004604	31.25304	0.0000

R-squared	0.349469	Mean dependent var	20263.96
Adjusted R-squared	0.349469	S.D. dependent var	2417.000
S.E. of regression	1949.444	Akaike info criterion	15.25504
Sum squared resid	30402655	Schwarz criterion	15.27695
Log likelihood	-80.41812	Durbin-Watson stat	1.115636

Equation for stamp tax

ln(R_STAMPTAX) = -8.06 + 1.13* ln(Y*CPI) + 0.32* ln(R_STAMPTAX(-1))				
LS // Dependent Variable is ln(R_STAMPTAX) Date: 09/02/97 Time: 18:08 Sample(adjusted): 1995:01 1997:07 Included observations: 31 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8.061173	2.094078	-3.849509	0.0006
ln(Y*CPI)	1.132107	0.282320	4.010008	0.0004
ln(R_STAMPTAX(-1))	0.328720	0.149449	2.199544	0.0363

R-squared	0.920103	Mean dependent var	2.410398
Adjusted R-squared	0.914396	S.D. dependent var	0.623992
S.E. of regression	0.182568	Akaike info criterion	-3.309499
Sum squared resid	0.933270	Schwarz criterion	-3.170727
Log likelihood	10.31015	F-statistic	161.2265
Durbin-Watson stat	1.641523	Prob (F-statistic)	0.000000

Payments for Land Equation

ln(R_LAND) = 1.72 + 0.06* ln(R_LAND(-12)*CPI/CPI(-12)) + 1.51* ln(PY/PY(-1)) + 0.52* ln(R_LAND(-1))				
LS // Dependent Variable is ln(R_LAND) Date: 09/02/97 Time: 19:08 Sample(adjusted): 1995:06 1997:07 Included observations: 26 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.720788	0.528534	3.255776	0.0036
ln(R_LAND(-12)*CPI/CPI(-12))	0.064320	0.034401	1.869696	0.0749
ln(PY/PY(-1))	1.513870	0.213981	7.074788	0.0000
ln(R_LAND(-1))	0.517105	0.122256	4.229681	0.0003

R-squared	0.729368	Mean dependent var	4.158162
Adjusted R-squared	0.692464	S.D. dependent var	0.295723
S.E. of regression	0.163996	Akaike info criterion	-3.475189
Sum squared resid	0.591683	Schwarz criterion	-3.281636
Log likelihood	12.28506	F-statistic	19.76377
Durbin-Watson stat	2.020506	Prob (F-statistic)	0.000002

Equation for custom duties

CD-CD(-1)/IMH(-1)*IMH = -0.33* CD(-1)-CD(-2)/IMH(-2)*IMH(-1) - 0.89* MA(12)				
LS // Dependent Variable is CD-CD(-1)/IMH(-1)*IMH Date: 09/11/97 Time: 19:05 Sample(adjusted): 1995:01 1997:06 Included observations: 30 after adjusting endpoints Convergence achieved after 17 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CD(-1)-CD(-2)/IMH(-2)*IMH(-1)	-0.331350	0.049945	-6.634355	0.0000
MA(12)	-0.885834	0.000108	-8229.441	0.0000

R-squared	0.809801	Mean dependent var	-1.686332
Adjusted R-squared	0.803008	S.D. dependent var	30.57815
S.E. of regression	13.57173	Akaike info criterion	5.280318
Sum squared resid	5157.372	Schwarz criterion	5.373732
Log likelihood	-119.7729	F-statistic	119.2143
Durbin-Watson stat	2.548793	Prob (F-statistic)	0.000000

D. The Model

B=B(-1)+emiss1

MM=mu*B*(1-remtrend)

p*=exp(ln(mm)-(0.29240614 + 0.28818557*C1 + 0.51365979*ln(Y) + 0.2568299*ln(Y(-1)) - 0.35069017*ln(CPI(-1)/CPI(-2)) - 0.17534508*ln(CPI(-2)/CPI(-3))))

p=p(-1)*(k_wpi*wpi/wpi(-1)+(1-k_wpi)*cpi/cpi(-1))

π_{cpi} = 0.052289654*(ln(P*(-1))-ln(P(-1))) + 0.26936003*π_{cpi}(-1) + 0.92010804*SH + FPI

WPI/WPI(-1) =0.26*(P[-1]/P[-2]) + 0.38*(E/E(-1)) + 0.35*(CPI/CPI[-1])

PY=p*Y

R_VAT = 46.22 + 0.06* VAT_M + 0.32* VAT_M(-1)

R_PF = 0.42* WFC

ln(R_LAND) = 1.72 + 0.06* ln(R_LAND(-12)*CPI/CPI(-12)) + 1.51* ln(PY/PY(-1)) + 0.52* ln(R_LAND(-1))

R_CHF = 0.08* WFC

CD-CD(-1)/IMH(-1)*IMH = -0.33* CD(-1)-CD(-2)/IMH(-2)*IMH(-1) - 0.89* MA(12)

ln(PROF_R) = 5.37 + 0.25* ln(PROF) + 0.2*@SEAS(12) - 0.16* ln(PROF(-1))

ln(R_STAMPTAX) = -8.06 + 1.13* ln(Y*CPI) + 0.32* ln(R_STAMPTAX(-1))

PROF = 0.09* PY + 0.31* PROF(-3) + 0.23*@SEAS(12)*CPI + 0.48*@SEAS(6)*CPI

R_PIT = 0.14* WFC

DAWT = 0.21* DAWT(-1) - 0.18* D1*DAWT(-12) + 0.1* D12*DAWT(-12) + 0.35* CPI/CPI(-1) + 0.44* CPI(-1)/CPI(-2)

$$R\_EXC = (R\_EXC(-12)/CPI(-12)) * CPI * EXC\_COEF.$$

$$R\_CUSTOMS = \frac{R\_CUSTOMS(-1)}{IMH(-1)} * IMH + \alpha\,(\mathrm{R\_CUSTOMS(-1)} - \frac{\mathrm{R\_CUSTOMS(-2)}}{\mathrm{IMH(-2)}} * IMH(-1)),$$

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