Paper prepared for the EcoMod2002 conference on Policy Modelling
Brussels, July 4-6 2002

LAM modelling of East European economies: Methodology, EU accession and privatisation

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May 2002

Abstract

The paper presents a new approach to modelling economies in transition, where the adjustment processes are often nonlinear and data series are short. The model presented in the paper, the *LAM*-3 model, is the latest development in a series of long-run adjustment models, used for simulation and forecasting of several East European economies. In particular the model contains short-run equations with bilinear error corrections derived from a structural vector autoregressive model. The paper also gives the derivations of two long-run relationships of the model, those for full-capacity output (reformable and non-reformable labour) and the relationship linking prices, money, incomes and exchange rates. The short-run part evolves around the specification of price and wage dynamics according to the *NAIRU* principle. Due to the fact that series of data for East European countries are short, the parameters are evaluated with a use of a global optimisation technique (*repetitive stochastic guesstimation*) rather than by a traditional econometric method. The model was estimated and applied for Czech Republic, Estonia, Latvia, Lithuania, Poland, Slovak Republic, Romania and Ukraine. For each country it consists of 3 long-run and 21 short-run relationships. Examples of simulations presented here evaluate the European Union accessibility through inflation correlation measures and Aghion-Blanchard optimal speed of privatisation.

Keywords: Macroeconomic modelling, Central and Eastern Europe, Privatisation,
JEL classification: C53; P52

Ackolwledgments

Financial support of the INTAS 99-00472 Project *Nonlinear Structural VAR Modelling of East European Economies* is gratefully acknowledged. We are indebted to Derek Deadman for his comments on an earlier draft of the paper and to Maria Blangiewicz for her help in programming, computing and data collection. We are solely responsible for any remaining deficiencies.

1. Introduction

Empirical modelling of the Central and East European economies (CEEE's) has, for a long time, contain a number of challenging problems, of both economic and methodological nature. During the era of centrally planned economy the main problem of modelling was in the unobservability of demand due to persistent excess demand. With the resurgence of market economy in these countries the focus of modelling has moved towards the treatment of nonlinear short-run adjustment and dealing with short and unreliable data series.

It is generally accepted that, during the privatisation and restructuring periods, structural changes take form of a rather complicated adjustment towards the long-run development path. Dynamics of these processes is a different nature than in the earlier period of centrally planned economies. The long-run processes, although influencing the dynamics of main macroeconomic indicators, might be difficult to identify from short data series, typically available for CEEE's.

These problems question the rationale for using traditional econometric models and estimation methods for modelling CEEE's. An appropriate methodology should allow for constructing relatively large and disaggregated models which would enable to track and evaluate the main economic processes of CEEE's: privatisation, liberalisation and restructuring. At the same time, modelling should aim at resolving the problem of data scarcity and unavailability by using *a-priori* information in addition to those given by the data.

With these on mind, a series of so-called *long-run adjustment* (the *LAM*) models have been developed. The *LAM* models were originally developed at the Macroeconomic and Financial Data Centre at the Universities of Gdansk (Poland) and Leicester (U.K.) for modelling and forecasting of East European economies in transition. Early versions of the model (*LAM-CS*-1 and *LAM-PL*-1) were built for Czechoslovakia and Poland and used, among other things, for simulation of privatisation processes (Charemza, 1993). The series of *LAM-2* models dates back from 1993 and has been used for systematic-quarter-to quarter forecasting and simulation of the economies of the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovak Republic (Charemza and Strzala, 1997). During 1994-1999 results of the analyses have been published systematically in the *Bulletins* of the *Macroeconomic and Financial Data Centre*.

The main disadvantage of the *LAM*-2 models was the absence of consumption and investment sectors, which does not allow for closing the model with the expenditure identity. This has lead to a rather heuristic way of modelling gross national product (*GDP*), primarily on the basis of industrial growth. The new series of *LAM* models, *LAM*-3, attempts to close the system by introducing the income identity. Moreover, a number of other changes to the model structure have been introduced. Most notably, the linear error (or equilibrium)-correction mechanisms (*ECM*'s) have been replaced by the bilinear ones. However, the main features of the model remain unchanged. They are as follows.

1) The primary use of the model is to evaluate principal macroeconomic characteristics of the investigated economies such as investment, consumption, consumers' prices, wages, employment in private and state sectors and unemployment, money demand, industrial production, foreign trade (imports and exports), and gross domestic product.
2) Some of the principal requirements of the model are simplicity, ease of manipulation and feasibility of adjustment and updating. This, and especially data requirements, results in some compromise on the purity of the underlying economic assumptions.
3) The general specification of the model built for each country is identical. Each of these models is small, consisting of 25 equations, which differ among themselves mainly by parameter values. The reason for keeping the size of the models small is not only data limitations but above all, the need for ensuring manageability. There are, however, some minor differences in specification due to data availability and definitions of particular variables. So far, the *LAM*-3 have been constructed for the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovakia and Ukraine, with a model for Russia being close to completion. All models are based on quarterly data. For some countries annual models are also constructed. All structural parameters of the models are time-varying. This helps in dealing with the problems of structural breaks, typical to models of East European transformation (Qin, 1998).
4) Generally, two types of relationships are developed from a bilinear vector autoregressive (*VAR*) model by imposing appropriate restrictions: long-run and short-run relationships, the latter being essentially model deviations from the long-run path. Unlike traditional econometric models, cointegration of the variables which appear in the long-run relationships, has been assumed rather than tested.
5) Parameters of the relationships modelled have been derived through intertemporal stochastic optimisation, using heavily restrictive *a priori* knowledge regarding the initial values of parameters. The criterion function aims at minimisation of *ex-post* forecast errors. The method, called *Repetitive Stochastic Guesstimation* (*RSG*), is described in detail in Charemza (2002).

This paper does not attempt to give a full description of *LAM*–3. Instead, it concentrates on its main features, which make it distinct from other models of CEEE's and, indeed, of other models of economies in transition. We concentrate on describing the extension of a traditional structural *VAR* model by including a stochastic bilinear process resulting in a non-linear error correction. We also show the derivation of the long-run relationships incorporated into the model. Full listing of equations of the *LAM*-3 model is given in the Appendix.

2. Vector autoregressive representation of the model

As in previous *LAM* models, *LAM*-3 is derived from a general unrestricted vector autoregressive model (*VAR*) system. Suppose that such a *VAR* system of order k is given as:

$$Z_t = \sum_{i=1}^{k} A_i Z_{t-i} + \in_t \quad , \tag{1}$$

where the total number of variables in $\boldsymbol{Z_t}$ is $G + K$ and $\in_t \sim IID\ N(0_{G+K}\ , \Sigma)$, where Σ is a non-diagonal covariance matrix (assumptions for $\in_t$ can easily be relaxed; it can be any martingale difference sequence with a well-behaved spectral density matrix). Suppose that, in line with structural *VAR* methodology (see Giannini, 1992, Blangiewicz and Charemza, 2001), it is possible to formulate an orthogonal matrix Φ such that $D = \Phi\Sigma\Phi'$, where D is a diagonal matrix. In the terminology of Giannini this is the so-called K-model. Hence, we can orthogonalise (1) as:

$$\Phi Z_t = \Phi \sum_{i=1}^{k} A_i Z_{t-i} + v_t = \sum_{i=1}^{k} A_t^* Z_{t-i} + v_t \quad ,$$

where $A_i^* = \Phi A_i$ and $v_t = \Phi \in_t$. Obviously, $v_t \sim IID\ N(0_{G+K}\ , D)$.

Let us now partition Z_t as $Z_t = [y_t, x_t]'$, with the dimensions of y_t and x_t being $G \times 1$ and $K \times 1$ respectively, where x_t are strongly exogeneous for y_t. Accordingly, matrices Φ and A_i^* are block upper-triangular:

$$\Phi = \begin{bmatrix} \Gamma_0 & -B_0 \\ 0 & \Phi^{xx} \end{bmatrix}, \quad \text{and} \quad A_i^* = \begin{bmatrix} \Gamma_i & B_i \\ 0 & \theta_i \end{bmatrix}.$$

Consider now:

$$\Gamma_0 y_t = \sum_{i=1}^{k} \Gamma_i y_{t-i} + \sum_{i=0}^{k} B_i x_{t-i} + v_t^{(y)} \quad , \tag{2}$$

where $v_t^{(y)}$ comes from corresponding partition of v_t.

Clearly, (2) is a structural dynamic simultaneous equations model expressed in levels of variables y_t and x_t, if only appropriate restrictions on the coefficients allow for their identification. Such model are referred here as *SE-L*'s (simultaneous equations in levels). Alternatively, as shown above, it can be regarded as a relevant part of a structural *VAR*, if such restrictions are not imposed. One of the problems encountered while analysing (2) is that the variables in it are often nonstationary. Therefore, an inference in (2), and in particular its estimation, is well known to be inappropriate (in this paper, however, estimation is not an issue). The argument for not formulating the model in form (2) is that its structural coefficients may not have a sensible economic interpretation. One of the possible stationary alternatives to (2), assuming that the variables y_t and x_t are integrated of order one, is:

$$\Gamma_0 \Delta y_t = \Pi_y y_{t-1} + \Pi_x x_{t-1} + \sum_{i=1}^{k-1} \widetilde{\Gamma}_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \widetilde{B}_i \Delta x_{t-i} + v_t^{(y)} \ , \qquad (3)$$

where:

$$\Pi_y = -\Gamma_0 + \Gamma_1 + \cdots + \Gamma_k \ ,$$

$$\Pi_x = B_0 + B_1 + \cdots + B_k \ ,$$

$$\widetilde{\Gamma}_i = -(\Gamma_{i+1} + \Gamma_{i+2} + \cdots + \Gamma_k) \quad , \ i = 1, 2, \ldots k - 1 \ ,$$

$$\widetilde{B}_0 = B_0 \quad ,$$

$$\widetilde{B}_i = -(B_{i+1} + B_{i+2} + \cdots + B_k) \quad , \ i = 1, 2, \ldots k - 1 \ .$$

(see for example Johansen, 1991, Lütkepohl, 1991).

From the perspective of an empirical modeller, (3) can be developed either from the *VAR* model (1), or from a *SE-L* model of type (2). Whether a researcher starts from (1) or (2) determines his/her allegiance; he/she is either the '*VAR*-modeller' or the 'Cowles Commission modeller'. However, it seems that a lot of researchers loyal to structural econometrics actually start directly from (3) disregarding the 'foundation' models (1) and (2). Aware of the nonstationarity problems related to inference of a model in levels with *I*(1) variables, they tend to formulate models directly in stationary forms, that is in first differences. At the same time, with a possible cointegrating relationship present in the system, they complement the model by an error correction term. Another reason might be that empirical economists tend to have better understanding of the short-run adjustment parameters and long-run parameters which appears directly in (3) rather than the parameters in the *SE-L* reparametrisation which are difficult to interpret under nonstationarity. Generally, if only Γ_0 is non-diagonal, (3) is also a simulataneous equations (or recursive) model, but with simultaneity for the first differences rather than levels of variables. By analogy, it is abbreviated here as a *SE-D* model.

The *SE-D* representation (3) has been the basis for all the *LAM* models produced so far. The innovation introduced to *LAM*-3 is that we allow for a bilinear rather than a linear error correction mechanism. Let assume that all matrices $\widetilde{\Gamma}_i$ and $\widetilde{B}_i$ are matrices of constant parameters and matrices Π_y and Π_x depend on some stochastic $G \times G$ dimensional matrix-process W_t^y. More accurately, let:

$$\Pi = \left[\Pi_y , \Pi_x\right] = \Pi^{const} + W_t^y \Pi^W ,$$

where Π^{const} and Π^W are matrices of (constant) parameters and:

$$\Pi^{const} = \left[\Pi_y^{const}, \Pi_x^{const}\right] , \qquad \Pi^W = \left[\Pi_y^W, \Pi_x^W\right] .$$

In this notation equation (3) has the form:

$$\Gamma_0 \Delta y_t = \left(\Pi_y^{const} + W_t^y \Pi_y^W\right) y_{t-1} + \left(\Pi_x^{const} + W_t^y \Pi_x^W\right) x_{t-1} + \sum_{i=1}^{k-1} \widetilde{\Gamma}_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \widetilde{B}_i \Delta x_{t-i} + \nu_t^y$$

$$= \left(\Pi_y^{const} y_{t-1} + \Pi_x^{const} x_{t-1}\right) + W_t^y \left(\Pi_y^W y_{t-1} + \Pi_x^W x_{t-1}\right) + \sum_{i=1}^{k-1} \widetilde{\Gamma}_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \widetilde{B}_i \Delta x_{t-i} + \nu_t^y \quad . \qquad (4)$$

Assume now that $rank\left(\Pi^{const}\right) = rank\left(\Pi^W\right) = r$ $(1 \le r < G)$. Hence, there exist such $G \times r$ vectors α_c, α_W and $(G+K) \times r$ vectors β_c, β_W of full rank that:

$$\Pi^{const} = \alpha_c \beta_c{}' , \quad \text{and} \quad \Pi^W = \alpha_W \beta_W{}' .$$

Decomposing vectors β_c, β_W for two parts corresponding to y's and x's

$$\beta_c = \begin{bmatrix} \beta_{cy} \\ \beta_{cx} \end{bmatrix} , \quad \beta_W = \begin{bmatrix} \beta_{Wy} \\ \beta_{Wx} \end{bmatrix} ,$$

we can rewrite (4) in the form:

$$\Gamma_0 \Delta y_t = \left(\alpha_c \beta_{cy}' + W_t^y \alpha_W \beta_{Wy}'\right) y_{t-1} + \left(\alpha_c \beta_{cx}' + W_t^y \alpha_W \beta_{Wx}'\right) x_{t-1} + \sum_{i=1}^{k-1} \tilde{\Gamma}_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \tilde{B}_i \Delta x_{t-i} + \nu_t^y$$

$$= \alpha_c \left(\beta_{cy}' y_{t-1} + \beta_{cx}' x_{t-1}\right) + W_t^y \alpha_W \left(\beta_{Wy}' y_{t-1} + \beta_{Wx}' x_{t-1}\right) + \sum_{i=1}^{k-1} \tilde{\Gamma}_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \tilde{B}_i \Delta x_{t-i} + \nu_t^y \quad . \qquad (5)$$

Under the additional condition that there exists such an $r \times r$ matrix q that $\beta_c = \beta_W q$ (note that if matrix q exist, it is necessarily of full rank), equation (5) becomes:

$$\Gamma_0 \Delta y_t = \left(\alpha_{cy} q' + W_t^y \alpha_{Wy}\right)\left(\beta_{Wy}' y_{t-1} + \beta_{Wx}' x_{t-1}\right) + \sum_{i=1}^{k-1} \widetilde{\Gamma}_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \widetilde{B}_i \Delta x_{t-i} + \nu_t^y \quad .$$

For practical applications, it is important to formulate the appropriate process W_t^y. An interesting proposition seems to be to formulate W_t^y as the diagonal matrix $W_t^y = diag(\nu_{1,t-1}^y, .\nu_{2,t-1}^y, \ldots, \nu_{G,t-1}^y)$, where $\nu_{i,t}^y$, *i* = 1,2, …, *G*, are the error terms of i-th equation.

For instance, consider the simplest case, which only two *I*(1) variables, y_t and x_t are involved and related by a cointegration relationship:

$$y_t = \theta \cdot x_t + u_t \quad ,$$

where the normalised cointegration vector is $[1, -\theta]$ and u_t is an *I*(0) process of the type:

$$u_t = u_{t-1}(a + b\nu_{t-1}) + \nu_t \quad ,$$

where a and b are constant coefficients. It can be shown that the short-run adjustment equation, which in fact constitutes the *SE-D* model, is:

$$\Delta y_t = \theta \cdot \Delta x_t + (y_{t-1} - \theta \cdot x_{t-1})(a - 1 + b\nu_{t-1}) + \nu_t \quad .$$

Moreover, the conditional process of y_t for x_t, (provided that x_t is a martingale process), becomes:

$$\Delta y_t = \theta_1 \Delta x_t + (y_{t-1} - \theta \cdot x_{t-1})(a - 1 + b\nu_{t-1}) + \nu_t^* \quad ,$$

where θ_1 is a short-run coefficient and ν_t^* is a part of orthogonal residuals corresponding to y_t (see Charemza and Makarova, 1998). For a linear model, such a representation was introduced by Philips and Loretan, 1991. Charemza and Makarova, 1998 analyse the stationarity and dynamics of u_t under the above condition and (Peel and Davidson, 1998) demonstrate its practical usefulness. It is shown in the literature (see e.g. Brockett, 1976) that the above bilinear process satisfactorily approximates complicated autoregressive processes and hence might correspond to a vast range of error correction schemes encountered in practice.

3. The derivation of long-run relationships

The restrictions in matrices Π_y and Π_x are such that the *LAM*-3 model includes three long-run (cointegrated) relationships. While one is a straightforward Keynesian relation stating that the long-run income elasticity of consumption is unitary, two others, for output and real-monetary dependencies, are more complex. The long-run full-capacity output is derived under the assumption of oligopolistic competition, with additional assumptions regarding the concepts of vintage capital and non-reformable labour. As in the putty-clay analysis, the capital is divided into retrofittable and non-retrofittable, while only the retrofittable and new non-retrofittable capital can be optimised. The concept of non-reformable labour is closely related to the pattern of the privatisation processes in CEEE's. It is well-known that, especially at early stages of transformation, excessive and non-productive employment in the industries inherited from communist times, especially heavy industry and agriculture, has proven to be particularly difficult to restructure (see e.g. Ananev, 1995, Basu, Estrin and Svejnar, 1997, Blanchard, 1994, Burda, 1997). Hence, by the non-reformable labour we understand workers employed in those difficult to restructure industries. It is assumed that the oligopolists' cost function cannot be, in the short-run, maximised for the non-reformable labour. The rationale of this approach can be partially justified by Roland (1994), who advocates delaying privatisation and the restructuring of large post-communist industrial enterprises. Generally, It is asserted that a representative firm minimises its cost function:

$$\cos t = wL_R + p_K K_R + p_{EN} EN \quad ,$$

where L_R and K_R represent respectively the full-capacity reformable labour and retrofittable capital, EN denotes the energy input and w, p_K and p_{EN} are prices of labour, capital and energy. The technological constraints are given by a three-factor Cobb-Douglas type production function with constant returns to scale:

$$Y_R = A \cdot L_R^{\alpha} \cdot K_R^{\beta} \cdot EN^{1-\alpha-\beta} \;, \qquad \alpha > 0, \beta > 0, \alpha + \beta < 1 \,.$$

where Y_R is output related to full-capacity reformable labour and retrofittable capital. Minimisation of the cost function for output conditional on labour with the technological constraints gives, through the first-order conditions:

$$Y_R = F_Y \cdot L_R \quad ,$$

where $$F_Y = A \cdot \left(\frac{w}{\alpha}\right)^{1-\alpha} \left(\frac{\beta}{p_K}\right)^{\beta} \cdot \left(\frac{1-\alpha-\beta}{p_{EN}}\right)^{1-\alpha-\beta} \,.$$

Let us define non-reformable labour L_N as the difference between total full-capacity labour, L, and reformable labour. It is assumed that, in the short-run, the only inflow to reformable labour is through an outflow from non-reformable labour:

$$L_R = L_{R,-1} + \rho_L L_{N,-1} \quad ,$$

where the second subscript '-1' refers to the previous period of time and ρ_L is the labour outflow coefficient. Analogously, output related to non-reformable labour denoted by Y_N can, under typical conditions of East European transformation, be expressed as:

$$Y_N = (1-\rho_Y) Y_{N,-1} \quad ,$$

where ρ_Y is the 'decay' coefficient, that is the coefficient which measures the fall in non-reformable output due to the outflow of labour from the non-reformable to the reformable sector and, possibly, changes in productivity. Denoting total output by Y, we have:

$$Y_N = (1-\rho_Y) Y_{N,-1} = (1-\rho_Y)(Y_{-1} - Y_{R,-1}) = (1-\rho_Y)(Y_{-1} - F_Y \cdot L_{R,-1}) \quad .$$

After aggregation and substitution, the formula for output becomes:

$$\begin{aligned} Y = Y_R + Y_N &= F_Y \cdot (L_{R,-1} + \rho_L \cdot L_{N,-1}) + (1-\rho_Y) \cdot (Y_{-1} - F_Y \cdot L_{R,-1}) \\ &= \rho_Y \cdot F_Y \cdot L_{R,-1} + (1-\rho_Y) \cdot Y_{-1} + \rho_L \cdot F_Y \cdot L_{N,-1} \end{aligned} \quad .$$

The long-run solution is:

$$Y^* = F_Y \cdot \left(L_R^* + \frac{\rho_L}{\rho_Y} \cdot L_N^* \right) \quad . \tag{6}$$

The specification above seems to have some advantages for the empirical analysis of East European transformation. The F_Y function is log-linear and this should not cause problems in maximisation of the objective function in the process of parameter evaluation and simulation. Moreover, for most East European countries, data exist which allows for identification of the reformable and non-reformable labour. Data on employment in heavy industry and large state enterprises are usually reliable. A more important problem might be with the identification of the ρ_L/ρ_Y ratio. However, it is worth noting that if:

a) productivity of labour in the reformable and non-reformable sectors was identical, and
b) productivity of those leaving and remaining in the non-reformable sector was identical,

then the ρ_L/ρ_Y ratio would have been equal to unity. Hence, cross-section studies (econometric and surveys) regarding differences in productivity in both sectors can help in identification of this ratio. Since the above notions of labour and output correspond to the 'full capacity' situation, it is necessary to adjust the data observed with the use of the capacity utilisation index. Due to the short- to medium run nature of the model, the capacity utilisation index is assumed to be exogenous and estimated externally, using fragmentary information and business surveys data.

The third long-run relationship in *LAM*-3 is the following:

$$p_t^* = \alpha_0 + \alpha_1 m_t + \alpha_2 x_t + \alpha_3 d_t \quad , \tag{7}$$

where p_t denotes consumers' prices, m_t high-powered money, x_t industrial production, and d_t is the exchange rate of the domestic currency to the US dollar. All variables are in their natural logarithms. Stars denote the long-run value of the particular variables. All parameters of the model are assumed to be varying in time; however the time subscripts for the parameters have been dropped for simplicity of notation. Relationship (7) generally can be respecified as:

$$m_t - p_t^* = (1-\alpha_1) m_t - \alpha_2 x_t - \alpha_3 d_t - \alpha_0 \quad . \tag{8}$$

If (8) is to be interpreted as a money demand equation, the expected sign of α_2 is negative. If $\alpha_1 = 1$, then this relation expresses long-run money neutrality. The relationship where $\alpha_1 \neq 1$

helps to identify particular stages of the economic transformation. In particular, it is possible to identify two stages of economic transformation of a post-communist economy: high-inflation financial liberalisation (*HIFL*) and high-inflation financial stabilisation (*HIFS*). During *HIFL*, full endogenisation of official prices gives rise to the annihilation, through higher inflation, of excess monetary balances accumulated during the previous period of repressed inflation. Inflation expressed with the use of parallel market prices (and the black market currency was usually the US dollar) becomes smaller than that expressed through official prices (see Lipton and Sachs, 1990, Lane, 1992). Income velocity of money increases dramatically while, especially at the beginning of the hyperinflationary process, the money stock increase is slower, due to the rapid activation of idle money accumulated in the period of repressed inflation and also due to developed hyperinflationary expectations (the so-called 'hot money' syndrome). Increases in income velocity of money are further stimulated by a decrease in real incomes and unsuccessful attempts to endogenise interest rates. This results in an increased role for foreign currencies which, in some extreme cases, becomes a primary rather than secondary means of exchange, producing an anti-inflationary effect on the domestic currency consumption market (see Auerbach, Davidson and Rostowski, 1992). Since prices rise faster than nominal money balances, this resulted in *the negative non-neutrality of money*. The process of prices rising faster than nominal money balances causes m_t being negatively related to $m_t - p_t^*$, giving $\alpha_1 > 1$.

During *HIFS,* due to the development of early financial markets, foreign currencies become less the subject of speculation and more the means of direct foreign exchange. Thus, their direct impact on the internal price-money-output relation is negligible and official prices become effectively equilibrium prices. Inflation stabilises at a lower level than that of the *HIFL* and annihilation of forcibly accumulated money balances brings the period of rising income volatility of money to an end. However, money neutrality might not be achieved. The economy enters a period of privatisation (though usually more gradual than rapid) accompanied by a rather slow development of non-monetary financial institutions. Income velocity of money stabilises at a rather high level. Together with a usually negative real interest rate and ineffective credit control this leads to substantial capital formation. Lack of non-monetary financial instruments and progress in privatisation increases nominal money balances faster than prices. This causes *the positive non-neutrality of money* to reappear. Unlike the previous period of repressed inflation, this is not the effect of monetary disequilibrium, but rather endogenisation of supply, which, due to a progress in the privatisation process becomes, for the first time, price-elastic. Therefore, positive non-neutrality of money is expressed by $\alpha_1 < 1$.

4. Short-run relationships

The short-run part of the model consists of 21 relationships. There are 9 identities in the model, describing the aggregation in the short-run income-expenditure relationship, budgetary, money and income aggregates and labour costs definition. Among 12 stochastic relationships there are one of an approximate nature (government incomes) three direct behavioural equations without any correction mechanisms (energy price, *GDP* deflator and the mark-up nominal wage formula) and 8 stochastic equations involving the bilinear correction mechanisms as described in Section 1 of this paper.

The essence of the short-run dynamics of the model is the specification of the relationship between prices and wages within the framework of the non-accelerating inflation rate of unemployment (*NAIRU*) theory. It is assumed that in the short-run, prices and wages are set on the imperfect, oligopolistic competition, market. Within the oligopolistic competition framework, it is usually assumed that wages result from a bargaining process between workers unions and firms. This gives wages being set relative to expected prices, while prices are set as a mark-up on expected costs (see Carlin and Soskice, 1990), Layard, Nickell and Jackman, 1991). These assumptions essentially mean that there is imperfect competition on both markets, for goods and labour and that trading is taking place outside an equilibrium. This line is generally followed by the specification of *LAM*. However, in the *LAM* model, the oligopolistic power of firms and workers unions is assumed to be uneven. While the wage setting scheme is essentially consistent with the imperfect competition assumption, with the equilibrium real wage depending on labour productivity and competitiveness (real exchange rate), short-run inflation is determined also by monetary frictions and wage 'surprises'. The underlying assumption is that, apart from oligopolistic price-setters, there are also free-competitors regarding wage surprises as supply shocks for whom the wage surprises are instantaneously transferred into a change in price. For a full listing of short-run equations see Appendix.

5. Evaluation of parameters

It was decided that the number of observations was too small and the data are not heterogeneous enough to merit estimation of the *LAM*-3 model by an econometric method. Therefore, and as in the previous LAM models, the parameters have been evaluated with the use of the *Repetitive Stochastic Guesstimation* (*RSG*) algorithm. However, the original algorithm, described in detail in Charemza, (2002) has to be modified, due to the inclusion of the bilinear error correction equations. The entire evaluation procedure can be summarised, in a somewhat simplified way, as follows:

The entire model based on *n* observations is represented by the function:

$$y_t = f(y_t, x_t, \varepsilon_t; \varepsilon_0, \theta) \quad , \tag{9}$$

where y_t, $t = 1, 2, \ldots, n$, is the vector of current, observed, endogenous variables, x_t contains all other relevant and observable variables (at least weakly exogenous) and lagged endogenous variables, θ is the vector of K parameters which are to be guessed, ε_t is the random and unpredictable (in mean) process with the vector of initial values ε_0. Unlike a traditional econometric model, the structural restrictions may not necessary give result in identification restrictions and, in particular, the number of observations can be smaller than the number of unknown parameters. Moreover, the prior (initial) beliefs concerning the parameters (the priors) have to be formulated. The prior beliefs are defined as a vector of K intervals, Θ^0, which are proportional to the intervals initially assumed for the parameters and defined by their mean values, $\theta^{(0)}$, and length, $\overleftrightarrow{\Theta}^0$. At first, the model (9) is solved using the initial values of the parameters, $\theta^{(0)}$, equal to the mean of initial intervals given $\varepsilon_0^{(0)}$, say, $\varepsilon_0^{(0)} = 0$. This solution depends on $\theta^{(0)}$ and $\varepsilon_0^{(0)}$. Let us denote it as: $\hat{y}_t^{(0)} = \bar{f}^{-1}(x_t, \varepsilon_{t-1}^{(0)}; \varepsilon_0^{(0)}, \theta^{(0)})$. Its computation requires using residuals $\varepsilon_0^{(0)}, \varepsilon_1^{(0)}, \cdots \varepsilon_{t-1}^{(0)}$ recursively, in order to recover the series $\varepsilon_1^{(0)}, \varepsilon_2^{(0)}, \cdots \varepsilon_t^{(0)}$ for the bilinear processes. This makes the entire computation procedure recursive. First, this solution is needed in order to make an h-step ahead forecast for y_t, that is, finding:

$$\hat{y}_{t+h}^{(0)} = \bar{f}^{-1}(\hat{x}_{t+h}, \varepsilon_{t+h-1}^{(0)}; \varepsilon_0^{(0)}, \theta^{(0)}), \qquad h = 1, 2, \cdots H,$$

where $\hat{x}_{t+h}^{(0)}$ is a forecast for x_{t+h}. Next, compare the predictions $\hat{y}_{t+h}^{(0)}$ with the observed realisations of y_{t+h} by computing an initial value of the unweighted criterion function, which is the sum of squares of joint $1, 2, \ldots, H$-step ahead prediction errors:

$$\varphi^{(0)} = \sum_{h=1}^{H} \sum_{t=1}^{T-h} \sum_{y_{t+1}} (y_{t+h} - \hat{y}_{t+h}^{(0)})^2 \quad ,$$

where the symbol $\sum_{y_{t+1}}(\bullet)$ means the summation of all elements of vector y_{t+h} (that is, for all endogenous variables of the model). With these initial values, the computational algorithm is the following:

1) In every iteration j (where 'iteration' relates to achieving an improvement in the criterion function) the previously obtained (or initial) set of admissible parameters intervals is modified through an application of the following learning function $\lambda_{\Theta}(j)$:

$$\Theta^{(j)} = \theta^{(j-1)} \pm \tfrac{1}{2}\overleftrightarrow{\Theta}^{(j-1)}\lambda_{\Theta}(j) \quad .$$

2) From the set $\Theta^{(j)}$ draw (that is, randomly generate) a sample of K parameters, $\theta_i^{(j)}$. Also, recalculate recursively vector $\varepsilon_0^{(j)}$ and compute model solutions:

$$\hat{y}_t^{(j)} = \overline{f}^{-1}(x_t\ , \varepsilon_{t-1}^{(j)}; \varepsilon_0^{(j)}\ , \theta^{(j)}) \quad .$$

   Next, forecasts $\hat{y}_{i,h}^{(j)}$ (analogously to $\hat{y}_h^{(0)}$) and calculate unweighted and weighted criterion functions, defined respectively as:

$$\varphi^{(0)} = \sum_{h=1}^{H}\sum_{t=1}^{T-h}\sum_{y_{t+1}}(y_{t+h} - \hat{y}_{t+h}^{(j)})^2 \quad ,$$

   and:

$$\widetilde{\varphi}^{(0)} = \sum_{h=1}^{H}\sum_{t=1}^{T-h}\sum_{y_{t+1}}(y_{t+h} - \omega(\theta_i^{(j)}, \lambda_{\varphi}(j))\hat{y}_{t+h}^{(j)})^2 \quad ,$$

   where $\hat{y}_{i,h}^{(j)} = \{\hat{y}_{i,t+1}^{(j)}\ , \hat{y}_{i,t+2}^{(j)}\ , \cdots\}$, and $\lambda_{\varphi}(j)$ is the learning function analogous to $\lambda_{\Theta}(j)$, and is an argument of the penalty weight function $\omega(\bullet)$ (for more details and formulae see Charemza, 2002). For linear models with negative degrees of freedom (that is, not identified), the limit value for such defined $\varphi_i^{(j)}$ is obviously zero. The random drawing of parameters within an iteration, identified by subscript i, is called *replication*.

3) In each replication the value of the function $\varphi_i^{(j)}$ is compared with that obtained in the previous iteration $\varphi^{(j-1)}$ and the value of the function $\widetilde{\varphi}_i^{(j)}$ is compared with $\widetilde{\varphi}^{(j-1)}$, with $\widetilde{\varphi}^{(0)} = \varphi^{(0)}$ as the initial value. If $\varphi_i^{(j)} \leq \varphi^{(j-1)}$ and $\widetilde{\varphi}_i^{(j)} < \widetilde{\varphi}^{(j-1)}$, then the algorithm moves to next iteration ($j = j + 1$) and steps 1 - 3 are repeated starting from $i = 1$. While repeating step 1) the priors are modified by imposing $\theta^{(j)} = \theta_i^{(j)}$ (this is the so-called *non-constant mean RSG*). If $\varphi_i^{(j)} > \varphi^{(j-1)}$, or if $\varphi_i^{(j)} \leq \varphi^{(j-1)}$ but $\widetilde{\varphi}_i^{(j)} \geq \widetilde{\varphi}^{(j-1)}$, then the admissible

intervals do not change and steps 2 - 3 are repeated for unchanged j and $i = i + 1$; the algorithm moves to the next replication within the same iteration. A new set of potential parameters is drawn from the same intervals as before, and this is repeated until there is an improvement on the objective function, or the stopping rule is fulfilled.

5. Some applications

(a) Forecasting

During the period 1994-1999 the *LAM* models were used for systematic forecasting of CEEE's economies. Starting form a single model for Poland, the number of countries included in *LAM* modelling has been gradually expanded, covering in 1997-1999 Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic and Romania. Every quarter forecast for price and wage inflation, *GDP*, foreign trade, industrial production and monetary aggregates were published in *Bulletins* of the Macroeconomic and Financial Data Centre. Two times a year a research workshop (called the *forecasting round*) took place, where the *LAM* model forecasts were evaluated by academics and practitioners from participating countries. There was no systematic evaluation of the quality of the forecasts, nevertheless occasional comparisons revealed a relatively high degree of forecasts accuracy (see, for instance, M&FDC, 1995). Due to the lack of funds, systematic forecasting activities stopped in 2000. After that, models have been sporadically updated and used for occasional forecasting, mainly of Polish economy.

(b) Simulation of the EU accession adaptability

After the end of systematic forecasting with the use of *LAM* models, the emphasis switched into simulation and policy analysis. In particular, after 1993, one of the most important topic of CEEE's has become the question of accession into the European Community and, in this context, the problem of business cycle convergence and robustness to asymmetric shocks. It is generally argued that high correlation between relevant indicators of business cycles should reduce costs of unification and therefore act as an indicator of a conducive economic situation for unification (for a general approach see e.g. Kennen, 1969 and, in a unification context, see Angeloni and Dodola, 1999 and Fatas, 1997).

One of the simple measures of the business cycles symmetry and potential asymmetric shock absorption is correlation of inflation (see Barrios *at al.*, 2001). It seems, however, that a correlation of headline inflation might not be entirely appropriate here, since a part of inflation might be country-specific and cannot be passed on another country and would rather be absorbed through changes in capacity utilisation. Hence, the country-specific (non-transferrable) inflation should be eliminated from the headline measure before it is used for testing business cycles symmetry. Denoting by $\rho(\pi)$ the correlation coefficient between inflation of two aggregates (for instance, countries A and B) that is: $\rho(\pi) = corr(\pi_A, \pi_B)$, the headline inflation of country A can be decomposed as:

$$\pi_A = \pi_A^c + \pi_A^n \quad , \tag{10}$$

where π_A^c is the transferable and π_A^n is not-transferable inflation of country A. If the inflation variable is a part of system (3) (that is, one of the elements of vector Δy_z is defined as $\pi_A = p_t - p_{t-1}$, where p_t is the logarithm of consumers' prices), then stationarity of (3) ensures the existence of the following Wald decomposition:

$$\pi_A = \sum_i \varphi_{\pi,i}\varepsilon_{\pi,-i} = \sum_i \varphi_{\pi,i}^c \varepsilon_{\pi,-i}^c + \sum_i \varphi_{\pi,i}^n \varepsilon_{\pi,-i}^n \quad , \tag{11}$$

where ε_π, ε_π^c, ε_π^n are shocks of the headline inflation and its two components, respectively, symbol $-i$ refers to time lags and $\varphi_{\pi,i}$, $\varphi_{\pi,i}^c$ and $\varphi_{\pi,i}^n$ are the corresponding impulse response coefficients derived from (5) (for computational details see Parkhomenko, 2002). Hence, $\pi_A^c = \sum_i \varphi_{\pi,i}^c \varepsilon_{\pi,-i}^c$, $\pi_A^n = \sum_i \varphi_{\pi,i}^n \varepsilon_{\pi,-i}^n$. Under the assumption that $corr(\pi_A^c, \pi_A^n) = 0$, we have:

$$\rho(\pi) = \omega \cdot corr(\pi_A^c, \pi_B) + (1-\omega)\cdot corr(\pi_A^n, \pi_B), \tag{12}$$

where $\omega = \dfrac{s(\pi_A^c)}{s(\pi_A^c) + s(\pi_A^n)}$ and $s(\,)$ denotes the standard error.

Clearly, a problem lies here in identifying the elements ε_π^c, from ε_π^n. Bearing in mind the limited number of information in any *VAR* model, such identification is always going to be, to some extent, arbitrary. In Blangiewicz, Charemza and Strzala, (2002) it was done by simulating *LAM* under the assumption of constant capacity utilisation, unchanged since 1995. In this paper a slightly more general approach is adopted. In addition to keeping the capacity utilisation variable constant, the nominal exchange rate has also been kept unchanged in relation to US dollar. This experiment simulates the market conditions closer to that of a fixed exchange rate regime.

The analysis was conducted on the *LAM*-3 models estimated for the period 1996-2001 for the Czech Republic (CZE), Estonia (EST), Hungary (HUN), Poland (POL), Slovak Republic (SLR) and Ukraine (UKR). Except for Ukraine, all these countries are engaged, at various stages, in talks on the EU accession.

Results of this simulation are summarised in Table 1. In the upper-triangular of the correlation matrix presented in Table 1 simple pairwise correlation coefficients for headline inflations of the countries analysed and also with inflation of the European Union. The lower triangular (the shaded area) shows also pairwise correlation coefficients, but computed for the transferable rather than headline inflation, as in (12).

Table 1: Correlations between inflation

		CZR	**EST**	**HUN**	**POL**	**SLR**	**UKR**	**EU**
		headline						
CZR	transferable	×	0.64	0.70	0.67	-0.79	0.18	0.10
EST		0.78	×	0.92	0.89	-0.68	0.64	0.60
HUN		0.38	0.80	×	0.98	-0.61	0.58	0.38
POL		0.78	0.82	0.61	×	-0.47	0.66	0.46
SLR		-0.81	-0.73	-0.33	-0.68	×	0.05	-0.16
UKR		-0.13	042	0.35	0.47	0.14	×	0.54
EU		0.37	0.55	0.40	0.61	-0.23	0.29	×

While using the headline inflation data it can be noticed that inflation correlation of the Czech Republic with the *EU* is very low. At the same time, such correlation for Ukraine is strikingly high. This might suggest that the Czech Republic might be exposed to severe asymmetric shocks, since its business cycle is not strongly related to that of the *EU*. The high correlation of the Ukrainian and *EU* inflations is likely to be spurious, due to a recovery of the Ukrainian economy of hyperinflations of 1993-1996 (at the same time, the *EU* inflation was also in decline). However, if the transferable rather than headline inflation is taken into account, the picture becomes different. For the Czech Republic inflation correlation with *EU* increases and, for Ukraine, it decreases markedly. A possible explanation of this might be the fact that the Czech Republic is the only country here, which actually experienced a severe supply shock. The year 1998 was the year after a currency crisis in the Czech Republic; in May 1997 the Czech currency lost about 30% of its value, which generated 11% inflation and caused negative economic growth. According to the results shown in Table 1, about 30% difference in inflation correlation can be attributed to this crisis. It is likely that inflation correlation for the Czech

Republic would be of a similar magnitude to that of Estonia, Hungary and Poland, if such an asymmetric shock did not happen.

(c) Evaluation of the Aghion-Blanhard optimal speed of privatisation

Another example of an application of *LAM* models is that of assessing the optimal speed of privatisation for *CEEE*'s. There are numerous definition and approaches of optimal speed of, widely understood, restructuring during transition (see, e.g. Coricelli, 1998, Castanhiera and Roland, 2000). Following Aghion and Blanchard, (1994) in this paper the optimal speed of transition is understood as a maximum level of an outflow of unemployed to private sector (reallocation of labour) which corresponds to the optimal level of unemployment (see also Roland, 2000). The optimal level of unemployment solves the intertemporal maximisation of the net present value of output, is negatively affected by cost of unemployment and positively by productivity differentials (between the private and state sectors).

With these in mind, Aghion and Blanchard arrived at the following maximisation problem:

$$\dot{N}_p(t) = \frac{a \cdot U(t)}{U(t) + c \cdot a}\left[1 - r \cdot c - \frac{b}{1 - U(t)}\right] \quad , \tag{13}$$

where:

$\dot{N}_p(t)$ speed (rate of growth) of reallocation of labour from unemployment to private sector,

a scaling coefficient,

b per capita level of unemployment benefit,

r discount rate,

c efficiency wage wedge,

$U(t)$ equilibrium level of unemployment.

The relationship between the private sector wage rate, $w(t)$, and market unemployment is given by:

$$w(t) = b + c\left[r + \frac{\dot{N}_p(t)}{U(t)}\right] \quad . \tag{14}$$

In empirical applications, the problem is in unobservability of c and, to a large extent, of b, which has to account not only for the unemployment benefit, but also for other costs incurred by the government in relation to retraining and/or re-allocation of labour force. Moreover, in CEES's, during the transformation period, market unemployment (that is, unemployment with a relatively high short-run wage elasticity) is also at least partly unobservable, since the total figure covers also non-reformable (structural) unemployment (see Section 3 of this paper).

In simulation experiment described here it has been decided to treat b and c as unobservable parameters. Market unemployment is assumed to be a part of total, observable, unemployment, that is:

$$u = u^m + u^n \quad ,$$

where u^m is unemployment which respond to changes in nominal wages (market unemployment), and u^n is the remaining part of unemployment rate (structural unemployment). Market unemployment u^m can be recovered from u in analogously to that described by (11), that is by applying Wald decomposition to the *LAM* model:

$$u = \sum_i \varphi_{u,i}\varepsilon_{u,-i} = \sum_i \varphi^m_{u,i}\varepsilon^m_{u,-i} + \sum_i \varphi^n_{u,i}\varepsilon^n_{u,-i} \quad ,$$

where $\varepsilon_{u,-i}$ are the past shocks cumulated into the current observed unemployment rate, $\varepsilon^m_{u,-i}$ and $\varepsilon^n_{u,-i}$ are the shocks resulted in the components u^m and u^n respectively and $\varphi_{u,i}$, $\varphi^m_{u,i}$ and $\varphi^n_{u,i}$ are the corresponding impulse response coefficients. Hence, u^m can be computed as $u^m = \sum_i \varphi^m_{u,i}\varepsilon^m_{u,-i}$. Identification of $\varphi^n_{u,i}$ coefficients was made by dynamic simulation on the *LAM* models, where price and nominal wage variables were held constant at their 1995 level. This results in identification of structural unemployment u^n and leads to evaluation of u^m as $u^m = u - u^n$.

Parameters b and c have been recovered through identification of the relationship (14) from *LAM*, that is:

$$\Delta w = \sum_i \varphi^r_{w,i}\varepsilon^r_{w,-i} + \sum_i \varphi^u_{w,i}\varepsilon^u_{u,-i}\,\frac{\rho_L}{1-\rho_Y} + R \quad ,$$

where $\varphi^r_{w,i}$ and $\varphi^u_{w,i}$ are impulse response coefficients from interest rate and unemployment into the nominal wage, $\varepsilon^r_{w,-i}$ and $\varepsilon^u_{w,-i}$ are corresponding shocks, ρ_L is the labour outflow coefficient. and ρ_Y is the 'decay' coefficient, as defined in Section 3. R is the remaining part of the Wald decomposition of Δ*w*. Following (14), parameters b and c are identified as $c = \sum_i \varphi^u_{w,i}$ and $b = \overline{R}$ (arithmetic average of R) , with the restriction that $\varphi^u_{w,i} = \varphi^r_{w,i}$ for each i.

Having u^m, b and c recovered, it is possible to optimise (13), substituting u^m for $U(t)$ and using an average of commercial interest rate for r. In place of $\dot{N}_p(t)$ we use the average rate of growth of the private sector share, for 1996-2000 (see *EBRD*, 2001). The scaling coefficient a has been arbitrary fixed at 0.01 level (its change does not affect the outcome in a significant way). Results are given in Table 2. It gives the estimates of b and c described above, average rate of growth of the privates sector in percentages, $\overline{g}$, optimal rate of growth of the private sector, g^{opt}, computed by optimisation of (13), average unemployment rate for 1996-2000, $\overline{u}$, average rate of market unemployment $\overline{u}^m$ and optimal unemployment rate, u^{opt}.

Table 2: Speed of privatisation and unemployment, 1996-2000

	b	c	$\overline{g}$ %	g^{opt} %	$\overline{u}$ %	$\overline{u}^m$ %	u^{opt} %
CZE	0.0067	0.0098	1.0	1.8	6.9	5.1	9.3
EST	0.0215	0.0011	1.0	1.2	11.2	8.1	8.5
HUN	0.0157	0.0101	2.0	1.6	10.5	7.3	6.6
POL	0.0087	0.0238	2.0	3.1	12.0	11.3	12.1
SLR	0.0318	0.0412	2.0	1.4	15.6	17.3	11.6
UKR	0.1139	0.0074	2.0	3.3	3.2	5.6	7.0

The results show that, according to our estimates, the closest to the optimum privatisation path seems to be Estonia, for which the difference between the observed and optimal speed of privatisation, 0.2%, is within the margin of the measurement error. For Czech Republic, Poland and Ukraine actual speed of privatisation seems to be much below the optimal one. This might be related, respectively, to the problem of industrial restructurisation in Czech Republic, agriculture restructuring in Poland and huge hidden unemployment in Ukraine. In fact Ukraine and Slovak Republic are the only countries for which the market level of unemployment is above the actual one, which suggest hidden unemployment. For Hungary and Slovak Republic the speed of privatisation appears to be too fast. Finally, it should be stressed that full comparability of the results might be distorted here by different definitions of unemployment used in particular countries, different unemployment financing policies and scaling.

6. Concluding remarks

As it was mentioned before, the paper does not attempt to give a full description of the *LAM*-3 model. In particular, the derivation of the short-run equations is not discussed here since it can be found in earlier papers. The main important features of the new *LAM*, namely the bilinear error correction mechanisms and the long-run output function conditional on the reformable labour, seem to enrich the dynamics of the model in a significant way. This is, at least partially, confirmed by sensible results of policy simulation experiments. Simultaneously, it helps to keep the model dimensions small, both in terms of the number of lags used and the number of equations. In particular, the concept of reformable labour helps avoiding the cumbersome division of output and labour equations into those of the state and private sectors and, at the same time, allows the simulation of changes in types and speed of privatisation policies through the manipulation of the 'decay' and labour outflow coefficients.

One of the problems with *LAM* models is the fact that short and not reliable data series are used for their empirical evaluation. Formally, this problem is overcome by using the *RSG* method, but this, in turn, depends heavily on the choice of initial parameters values. Although nearly a decade of experimenting with *LAM* models provides a significant experience in finding good initial values, nevertheless such dependence on prior information affects, to some extent, the reliability of the results. Hence, in future, works should be focused on reformulating the entire set of the *LAM* models into a panel data model with fixed effects. This might allow for applying an estimation method, which uses prior information to a lesser extent.

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Appendix

Equation listing of a quarterly *LAM* model

Notation

- Types of equations: A approximation ,
  I identity,
  S stochastic.
- Symbols of variables beginning with **RS** denote observable (non-estimable) residuals (usually due to measurment or balancing errors).
- Symbols of variables beginning with **e** denote residuals of stochastic (estimated) equations.
- Symbols **Q1, Q2, Q3** denote the differences:
  $$\mathbf{Q1=Q_1 - Q_4}\ , \quad \mathbf{Q2=Q_2-Q_4}\ , \quad \mathbf{Q3=Q_3-Q_4},$$
  where $\mathbf{Q_1, Q_2, Q_3, Q_4}$ are seasonal dummy variables.
- The interest rate variable, **IntR,** is defined as a unit plus interest rate.

LONG-RUN EQUATIONS

1. Long-run relationship for GDP:

$$\mathbf{LnGDP_t^{LR} - lnCUI_t = \beta(1) + (\beta(2)+ \beta(3))lnLcost_t - \beta(2)lnIntR_t - \beta(3)lnPrEn_t + \beta(4) lnLabE_t^{LR} + \beta(5)Q1 + \beta(6)Q2 + \beta(7)Q3}$$

CUI capacity utilisation index,
GDP^{LR} long-run gross output, constant prices,
IntR interest rate,
$LabE^{LR}$ long-run effective employment (number of occupancies),
Lcost labour cost,
PrEn domestic energy price index.

2. Long-run potential effective employment:

$$\mathbf{LabE_t^{LR} = (Lab_t - LabN_t) / CUI_t + RFlow_t \times LabN_t / CUI_t}$$

CUI capacity utilisation index,
Lab total number of occupancies in national economy,
$LabE^{LR}$ effective employment (number of occupancies),
LabN non-reformable employment,
RFlow rate of the labour outflow coefficient to the 'decay' coefficient (see Section (3)).

3. Long-run relationship for price:

$$\mathbf{lnConPI_t^{LR} = \beta(8) + \beta(9)lnMON_t + \beta(10)lnGDP_t + \beta(11)lnExRat_t + \beta(12)Q1 + \beta(13)Q2 + \beta(14)Q3}$$

$ConPI^{LR}$ long-run consumers' price index,
ExRat domestic exchange rate,
GDP gross domestic product, constant prices,
MON narrow money stock, end of period (M0).

4. Long-run relationship for consumption:

$$\mathbf{lnConsI_t^{LR} = lnIncD_t - lnConPI_t}$$

$ConsI^{LR}$ individual consumption, constant prices,
IncD disposable (net) income, current prices,
ConPI consumers' price index,

SHORT-RUN EQUATIONS

5. Short-run relationship for income - expenditure:

$$\mathbf{GDP_t = ConsI_t + InvI_t + Expr_t - Imp_t + GovExP_t / DefGDP_t + RSGDP_t} \qquad (\ I\ )$$

ConsI	individual consumption, constant prices,
DefGDP	GDP deflator,
Expr	export of goods and services, constant prices,
GDP	gross domestic product, constant prices,
GovExP	government expenditures, current prices,
Imp	imports of goods and services, constant prices,
InvI	non-governmental fixed investment, constant prices.

6. Individual consumption :

$$\begin{aligned}\Delta \ln ConsI_t = {} & \beta(15) + \beta(16)\Delta(\ln IncD_t - \ln ConPI_t) \\ & + \beta(17)\Delta(\ln IncD_{t-1} - \ln ConPI_{t-1}) \\ & + (\beta(18) + \beta(19)\, eConsI_{t-1})(\ln ConsI_t - \ln ConsI_t^{LR})_{-1} \\ & + \beta(20)\Delta(\ln IntR_t - \Delta \ln ConPI_t) + \beta(21)\ln Mon2_{t-1} + \beta(22)Q1 \\ & + \beta(23)Q2 + \beta(24)Q3 + eConsI_t \end{aligned} \qquad (\ S\ )$$

ConPI	consumers' price index,
ConsI	individual consumption, constant prices,
$ConsI^{LR}$	long-run individual consumption,
IncD	disposable (net) income, current prices,
IntR	interest rate,
Mon2	broad money stock, end of period, (M2).

7. Government income equation:

$$\mathbf{GovInc_t = \beta(25) + \beta(26) IncT_t \times TaxR_t + eGovInc_t} \qquad (\ A\ )$$

GovInc	government incomes, current prices,
IncT	gross income, (gross earning), current prices,
TaxR	average effective (composite) tax rate.

8. Domestic budget deficit:

$$\mathbf{\ln BDef_t = \ln GovExP_t - \ln GovInc_t} \qquad (\ I\ )$$

BDef	relative budget deficit (ratio of government expenditures to incomes).
GovExP	government expenditures, current prices,
GovInc	government incomes, current prices.

9. Total Investment:

$$\mathbf{InvT_t = InvI_t + InvG_t} \qquad (\ I\ )$$

InvG	governmental fixed investment, constant prices,
InvI	non-governmental fixed investment, constant prices,
InvT	gross fixed investment, total, constant prices.

10. Public consumption:

$$\mathbf{ConsP_t = GovExP_t / DefGDP_t - InvG_t + RSConsP_t} \qquad (\ I\ )$$

ConsP	public consumption, constant prices,
DefGDP	GDP deflator,
GovExP	government expenditures, current prices,
InvG	governmental fixed investment, constant prices.

11. Non-governmental investment:

$$\Delta \ln InvI_t = \beta(27) + (\beta(28)+ \beta(29)eInvI_{t-1})(\ln GDP_t - \ln GDP_t^{LR})_{-1} + \beta(30)\Delta \ln GDP_t + \beta(31)\Delta(\ln IntR_t - \Delta \ln Lcost_t) + \beta(32)\Delta \ln CUI_{t-1} + \beta(33)Q1 + \beta(34)Q2 + \beta(35)Q3 + eInvI_t \qquad (S)$$

CUI	capacity utilisation index,
GDP	gross domestic product, constant prices,
GDP^{LR}	long-run gross output, constant prices,
IntR	interest rate,
InvI	non-governmental fixed investment,
Lcost	labour cost, constant prices.

12. Imports:

$$\Delta \ln Imp_t = \beta(36) + (\beta(37)+ \beta(38)eImp_{t-1})(\ln GDP_t - \ln GDP^{LR})_{-1} + \beta(39)\Delta \ln Imp_{t-1} + \beta(40)\Delta \ln GDP_t + \beta(41)\Delta \ln ExRat_t + \beta(42)\Delta \ln ExRat_{t-1} + \beta(43)\Delta \ln ExRat_{t-2} + \beta(44)\Delta \ln CUI_{t-1} + eImp_t \qquad (S)$$

CUI	capacity utilisation index,
ExRat	domestic exchange rate,
GDP	gross domestic product, constant prices,
GDP^{LR}	long-run gross output, constant prices,
Imp	imports of goods and services, constant prices.

13. Export:

$$\Delta \ln Expr_t = \beta(45) + \beta(46)\ln Expr_{t-1} + \beta(47)\Delta \ln GDP_t + \beta(48)\ln Lcost_t + \beta(49)\Delta \ln WPrice_t + \beta(50)\Delta \ln ExRat_{t-1} + \beta(51)\ln ExRat_{t-2} + \beta(52)\Delta \ln CUI_{t-1} + eExpr_t \qquad (S)$$

CUI	capacity utilisation index,
Expr	export of goods and services, constant prices,
ExRat	domestic exchange rate,
GDP	gross domestic product, constant prices,
Lcost	labour cost, constant prices,
WPrice	world price index.

14. Industrial production:

$$\Delta \ln IndsP_t = \beta(53) + (\beta(54)+ \beta(55)eIndsP_{t-1})(\ln GDP_t - \ln GDP_t^{LR})_{-1} + \beta(56)\Delta \ln GDP_t + \beta(57)\Delta \ln Imp_{t-1} + \beta(58)Q1 + (59)Q2 + \beta(60)Q3 + eIndsP_t \qquad (S)$$

GDP	gross domestic product, constant prices,
GDP^{LR}	long-run gross output, constant prices,
Imp	imports of goods and services, constant prices.
ndsP	industrial production, constant prices.

15. Narrow money:

$$\Delta(\ln MON_t - \ln ConPI_t) = \beta(61) + \beta(62)\Delta(\ln MON_{t-1} - \ln ConPI_{t-1}) + \beta(63)\Delta(\ln IncD_t - \ln ConPI_t) + (\beta(64)+ \beta(65)eMON_{t-1})(\ln ConPI_t - \ln ConPI_t^{LR})_{-1} + (\beta(66)+ \beta(67)eMON_{t-1})(\ln GDP_t - \ln GDP_t^{LR})_{-1} + \beta(68)\Delta \ln IntR_t + \beta(69)\Delta \ln IntR_{t-1} + \beta(70)\frac{1}{4}\sum_{i=1}^{4} \Delta \ln Bdef_{t-i} + \beta(71)Q1 + \beta(72)Q2 + \beta(73)Q3 + eMON_t \qquad (S)$$

Bdef relative budget deficit,
ConPI consumers' price index,
$ConPI^{LR}$ long-run consumes price index,
GDP gross domesic product, constant prices,
GDP^{LR} long-run gross output, constant prices,
IncD disposable (net) income, current prices,
IntR interest rate,
MON narrow money stock, end of period (M0).

16. Broad money:

$$\mathbf{Mon2_t = MON_t + MonRes_t} \qquad (\ I\ )$$

MON narrow money stock, end of period (M0),
Mon2 broad money stock, end of period, (M2),
MonRes monetary residuals (approx. to saving).

17. Labour cost:

$$\mathbf{Lcost_t = 3(1 + TaxR_t)(1 + TSSR_t)WagN_t / ConPI_t + RSLcost_t} \qquad (\ I\ )$$

ConPI consumers' price index,
Lcost labour cost, constant prices,
TaxR average effective (composite) tax rate,
TSSR social security rate ,
WagN average net earnings or net monthly wage, current prices.

18. Consumers' prices:

$$\begin{aligned}\Delta(\ln ConPI_t - \ln WagN_t) = {} & \beta(74) + \beta(75)\Delta(\ln ConPI_{t-1} - \ln WagN_{t-1}) \\ & + \beta(76)\ln ExRat_t + \beta(77)\Delta\ln CUI_t \\ & + (\beta(78)+\beta(79)\varepsilon ConPI_{t-1})(\ln ConPI_t - \ln ConPI_t^{LR})_{-1} \\ & + \beta(80)\Delta\ln Mon2_t + \beta(81)\Delta\ln IntR_t + \beta(82)\Delta\ln IntR_{t-1} \\ & + \beta(83)\Delta\ln WPrice_{t-1} + \beta(84)\Delta\ln UnR_t + \beta(85)\Delta\ln UnR_{t-1} \\ & + \beta(86)Q1 + \beta(87)Q2 + \beta(88)Q3 + \varepsilon ConPI_t \qquad (\ S\ )\end{aligned}$$

ConPI consumers' price index,
CUI capacity utilisation index,
ExRat exchange rate,
IntR interest rate,
Mon2 broad money stock, end of period, (M2),
UnR unemployment rate,
WagN average net earnings or net monthly wage, current prices.
WPrice world price index.

19. Energy price:

$$\begin{aligned}\Delta \ln PrEn_t = {} & \beta(89) + \beta(90)\Delta\ln PrEn_{t-1} + \beta(91)\Delta\ln DefGDP_t \\ & + (92)\Delta\ln DefGDP_{t-1} + \beta(93)\Delta\ln WPrice_t + \beta(94)\Delta\ln WPrice_{t-1} \\ & + \varepsilon PrEn_t \qquad (\ S\ )\end{aligned}$$

DefGDP GDP deflator,
PrEn domestic energy price index,
WPrice world price index.

20. GDP deflator:

$$\begin{aligned}\ln DefGDP_t = {} & \beta(95) + \beta(96)\ln ConPI_t + \beta(97)\ln ConPI_{t-1} \\ & + \beta(98)\ln PrEn_t + \beta(99)\ln PrEn_{t-1} + \varepsilon DefGDP_t \qquad (\ A\ )\end{aligned}$$

ConPI consumers' price index,

DefGDP GDP deflator,
PrEn domestic energy price index.

21. Real wage equation:

$$\begin{aligned}\Delta(\ln WagN_t - \ln ConPI_t) = {} & \beta(100) + \beta(101)\Delta(\ln WagN_{t-1} - \ln ConPI_{t-1}) \\ & + (\beta(102)+ \beta(103)eUnR_{t-1})(\ln GDP_t - \ln GDP_t^{LR})_{-1} \\ & + \beta(104)\Delta(\ln GDP_{t-1} - \ln Lab_{t-1}) + \beta(105)\Delta\ln(1-LabN_t / Lab_t) \\ & + \beta(106)\Delta(\ln ExRat_{t-1} + \ln ConPI_{t-1} - \ln WPrice_{t-1}) \\ & + \beta(107)\Delta\ln UnR_t + \beta(108)\Delta\ln UnR_{t-1} + \beta(109)\Delta\Delta\ln ConPI_t \\ & + eUnR_t \qquad (S)\end{aligned}$$

ConPI consumers' price index,
ExRat domestic exchange rate,
GDP gross domestic product, constant prices,
GDP^{LR} long-run gross output, constant prices,
Lab total number of occupancies in national economy,
LabN non-reformable employment,
UnR unemployment rate,
WagN average net earnings or net monthly wage, current prices,
WPrice world price index.

22. Mark-up nominal wage formula:

$$\Delta\ln WagN_t = \beta(110) + \beta(111)\Delta\ln ConPI_t + \beta(112)\ (\ln GDP_t - \ln Lab_t) + eWagN_t \qquad (S)$$

ConPI consumers' price index,
GDP gross domestic product, constant prices,
Lab total number of occupancies in national economy,
WagN average net earnings or net monthly wage, current prices.

23. Gross income:

$$IncT_t = Lcost_t \times ConPI_t \times Lab_t + RSIncT_t \qquad (I)$$

ConPI consumers' price index,
IncT gross income, (gross earning), current prices,
Lab total number of occupancies in national economy,
Lcost labour cost, constant prices.

24. Disposable income:

$$IncD_t = IncT_t(1-TaxR_t) + IncRes_t + RSIncD_t \qquad (I)$$

IncD disposable (net) income, current prices,
IncRes non-labour income,
IncT gross income, (gross earning), current prices,
TaxR average effective (composite) tax rate.

25. Employment (total):

$$Lab_t = PopW_t\ (1 - UnR_t - NUnR_t + MoR_t) - LabS_t \qquad (I)$$

Lab total number of occupancies in national economy,
LabS number of self-employed,
MoR_t multi-occupancy rate,
NUnR non-registered unemployment rate,
PopW economically active population,
UnR unemployment rate.

LIST OF VARIABLES

No. of variable	Symbol	variable name	explained in	type of eq.	current expl. in:	lagged expl. in:
1.	BDef	Relative budget deficit (ratio of government expenditures to incomes) current prices	8	I		15
2.	ConPI	consumers' price index,	18	S	6, 15, 17. 18,20, 21,22,23	6, 15, 18, 20, 21, 22, 23
3.	$ConPI^{LR}$	long-run consumers'price index	3	long-run	3	15,18
4.	ConsI	individual consumption, constant prices,	6	S	5, 6	6
5.	$ConsI^{LR}$	long-run individual consumption	4	long-run		6
6.	ConsP	public consumption, constant prices,	10	I		
7.	CUI	capacity utilisation index			2, 18	11, 12, 13, 18
8.	DefGDP	GDP deflator,	20	A	5, 10, 19	19
9.	Expr	export of goods and services, constant prices	13	S	5	13
10.	ExRat	domestic exchange rate,			3, 12, 18, 21	12, 13, 18, 21
11.	GDP	gross domestic product, constant prices	5	I	3, 11, 12, 13,14, 22	11,12, 13, 14,15, 21
12.	GDP^{LR}	long -run gross output, constant prices	1	long-run		11,12, 14,15, 21
1.	GovExP	government expenditures, current prices			5, 8, 10	
2.	GovInc	government incomes, current prices	7	A	8	
3.	Imp	imports of goods and services, constant prices	12	S	5, 14	12, 14
4.	IncD	disposable (net) income, current prices	24	I	4, 6, 15	6, 15

No. of variable	Symbol	variable name	explained in	type of eq.	current expl. in:	lagged expl. in:
5.	IncRes	non-labour income			24	
6.	IncT	gross (total) income, current prices	23	I	7,24	
7.	IndsP	industrial production	14	S		14
8.	IntR	interest rate,			1, 6, 11, 15, 18	6, 11, 15, 18
9.	InvG	governmental fixed investments, constant prices			9, 10	
10.	InvI	non-governmental fixed investment, total (M&E + B),	11	S	5, 9	11
11.	InvT	gross fixed investments, total, constant prices	9	I		
12.	Lab	total number of occupancies in national economy,	25	I	2,21, 22, 23	21
13.	LabS	number of selfemployed			25	
14.	$LabE^{LR}$	effective employment	2	long-run	1	
15.	LabN	non-reformable employment			2, 21	21
16.	Lcost	Nominal labour cost per head (gross wages + overheads), constant prices	17	I	1, 11, 13, 23	11, 13
17.	Mon	money stock, end of period, (M0)	15	S	3,16	15
18.	Mon2	broad money stock, end of period, (M2),	16	I	18	4
19.	MoR	Multi-occupancy rate			25	
20.	MonRes	monetary residuals (approx to savings),			16	
21.	NUnR	non-registered unemployment rate			25	
22.	PopW	economically active population,			25	

No. of variable	Symbol	variable name	explained in	type of eq.	current expl. in:	lagged expl. in:
23.	PrEn	domestic price index of energy,	19	S	1, 20	19, 20
24.	RFlow	Rate of labour outflow coefficient to the 'decay' coefficient (see Section 3)				
25.	TaxR	average tax rate of natural persons,			7, 17, 24	
26.	TSSR	average tax rate for social security fund			24	
27.	UnR	unemployment rate	21	S	18, 21, 25	18, 21
28.	WagN	average net earnings, or net monthly wage, current prices	22	S	17, 18,22	18, 21
29.	WPrice	world price' index			13, 18, 19, 21	13, 18, 19, 21