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Inflation in the Transition Economy of Poland:

An Application of SVEqCM

Summary

The aim of the paper is to investigate the long-run relationships between wages, prices, labour productivity, exchange rate and other variables in the Polish economy in the period of transition by applying recent developments in the field of multivariate cointegration analysis. In particular it draws heavily on the results obtained by Greenslade, Hall and Henry (1999) and follows similar modelling strategy. We present all stages of the analysis, which leads to the fully economically identified system representing long-run relationships.

The investigation is based on the monthly data from 1993.02 to 2000.06. The empirical results allow to conclude that costs were one of the main forces driving inflation in Poland in this period. On the other hand the data confirmed that long-run price elasticity of wages is very close to unity what is postulated by many theories.

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1. Introduction[1]

It is a well-documented phenomenon that most of the macroeconomic variables are non-stationary while some of them tend to drift together over time. This means that the discrepancy between such variables cannot grow indefinitely. This reasoning leads to the statistical concept of equilibrium relationship as something from which the variables involved can deviate, but not by ever-growing amount. Very good examples of this kind of relationship are prices, wages, and productivity or real interest rate, and inflation. Therefore it is clear why the cointegration analysis was applied to identify the long-run relationships, distinguish them from the short-run dynamics, and test in the view of the statistical data variation (see Mizon (1995)).

2. Structural identification of VAR

The algebraic transformation of the VAR

$$\mathbf{y}_{(m)t} = \sum_{s=1}^{S} \mathbf{y}_{(m)t-s} \Pi_s + \xi_{(m)t} \tag{1}$$

leads to an unrestricted vector equilibrium correction model, VEqCM:

$$\Delta \mathbf{y}_{(m)t} = \mathbf{y}_{(m)t-1} \Pi + \sum_{s=1}^{S-1} \Delta \mathbf{y}_{(m)t-s} \Gamma_s + \xi_{(m)t}\,, \tag{2}$$

where:

$\mathbf{y}_{(m)t} = [y_{1t} ... y_{Mt}]$ - vector of M variables,

[1] We are grateful to Stephen Hall and Katarina Juselius for valuable discussions concerning modelling strategy which leads to the structural model.

$\Pi_s = [\pi_{ij}^{(s)}]$ - MxM matrices of parameters,

$\xi_{(m)t} = [\xi_{1t} ... \xi_{Mt}]$ - vector of white noise disturbances,

$\Pi = \sum_{s=1}^{S} \Pi_s - \mathbf{I}$, $\Gamma_i = -\sum_{s=i+1}^{S} \Pi_s$,

$m = 1,...,M$; $s = 1,...,S$; $t = 1,...,T$.

Given the cointegrating rank of the system, R, where $0 \le R < M$, the total impact multipliers matrix Π can be decomposed as $\Pi = \mathbf{BA}^T$ which allows to rewrite (2) in the form:

$$\Delta\mathbf{y}_{(m)t} = \mathbf{p}_{(m)t-1}\mathbf{A}^T + \sum_{s=1}^{S-1} \Delta\mathbf{y}_{(m)t-s}\Gamma_s + \xi_{(m)t} , \qquad (3)$$

where $\mathbf{p}_{(m)t-1} = \mathbf{y}_{(m)t-1}\mathbf{B}$, $\mathbf{B} = \lfloor \beta_{(m)1}\beta_{(m)2}...\beta_{(m)R} \rfloor_{MxR}$, $\mathbf{A} = \lfloor \alpha_{(m)1}\alpha_{(m)2}...\alpha_{(m)R} \rfloor_{MxR}$.

R independent cointegrating relationships between variables y_m implies that matrices Π and $\mathbf{B}$ are of rank R. By initial assumption $\mathbf{y}_{(m)t}$~I(1), therefore $\Delta\mathbf{y}_{(m)t}$~I(0), and $\mathbf{p}_{(m)t-1}$~I(0), because variables are cointegrated what means that (3) includes exclusively stationary variables.

Columns of matrix $\mathbf{B}$ represent cointegrating vectors while rows of matrix $\mathbf{A}$ - loading weights related to the cointegrating vectors. Zero weight proves insignificant influence of the cointegrating relationship on particular variable.

The model represented by (3) is a reduced form of the structural vector equilibrium correction model (SVEqCM):

$$\Delta\mathbf{y}_{(m)t}\mathbf{A}_0 = \mathbf{y}_{(m)t-1}\widetilde{\Pi} + \sum_{s=1}^{S-1} \Delta\mathbf{y}_{(m)t-s}\mathbf{A}_s + \varepsilon_{(m)t} . \qquad (4)$$

where $\widetilde{\Pi} = \Pi\mathbf{A}_0$, $\mathbf{A}_s = \Gamma_s\mathbf{A}_0$ and $\varepsilon_{(m)t} = \xi_{(m)t}\mathbf{A}_0$.

The identification of the above system includes identification of contemporaneous coefficients $\mathbf{A}_0$ and the short-run dynamic coefficients $\mathbf{A}_s$. However, the identification of the short-run is not directly connected with the identification of the long-run structure of the model (see Grenslade at all (1999)). Since $\Pi = \mathbf{BA}^T$ and $\widetilde{\Pi} = \mathbf{BA}^T\mathbf{A}_0$ cointegrating matrix $\mathbf{B}$ does not depend on the short-run structuralisation. The estimation of VEqCM gives total impact multipliers included in matrix Π. The problem of its decomposition into adjustments and cointegrating matrix is analogous to the classical problem of identification of simultaneous models.

For any nonsingular R-dimensional matrix $\mathbf{U}$, $\Pi = \mathbf{BUU}^{-1}\mathbf{A}^T = \mathbf{B}^*\mathbf{A}^{*T}$ where $\mathbf{B}^* = \mathbf{BU}$ and $\mathbf{A}^* = \mathbf{AU}^{-1}$, so at least R^2 restrictions are necessary to identify cointegrating matrix $\mathbf{B}$. The exact identification of the long-run structure requires R^2 independent restrictions ($R^2 - R$ restrictions after normalisation). An order condition for exact identification is the same, thus if the number of restrictions $k < R^2$ or if $k > R^2$ the system is respectively underidentified or overidentified. Overidentifying restrictions can be tested by the standard likelihood ratio statistic (wider discussion in Hendry, Mizon (1993), Pesaran, Shin (1994), Johansen (1995)):

$$Q = T[\sum_{r=1}^{R}\ln(1-\widetilde{\lambda}_r) - \sum_{r=1}^{R}\ln(1-\hat{\lambda}_r)], \qquad (5)$$

where $\hat{\lambda}_r$ $\widetilde{\lambda}_r$ are eigenvalues corresponding to respectively unrestricted and restricted cointegrating vectors.

The Johansen (1988) method identifies the cointegrating space choosing orthogonal cointegrating vectors $\mathbf{v}_i$ $(i=0,...,R)$. The orthogonality restrictions are

$$\mathbf{v}_j{}^T \mathbf{S_{10}} \mathbf{S_{00}^{-1}} \mathbf{S_{01}} \mathbf{v}_r = 0 \qquad \text{for} \qquad r \neq j \tag{6}$$

where:

$$\mathbf{S_{ij}} = \frac{1}{T}\sum_t (\mathbf{z}_{(m)it} - \mathbf{z}_{(g)2t}\mathbf{M_{22}}^{-1}\mathbf{M_{2i}})^T (\mathbf{z}_{(m)jt} - \mathbf{z}_{(g)2t}\mathbf{M_{22}}^{-1}\mathbf{M_{2j}}), \qquad i=0,1,$$

$$\mathbf{M_{ij}} = \frac{1}{T}\sum_t \mathbf{z}_{(l)it}^T \mathbf{z}_{(l)jt},$$

$\Delta\mathbf{y}_{(m)t} = \mathbf{z}_{(m)0t}$, $\mathbf{y}_{(m)t-1} = \mathbf{z}_{(m)1t}$,

$\Delta\mathbf{y}_{(m)t-s}$ $(s=1,...,S\text{-}1)$ and deterministic components are included in vector $\mathbf{z}_{(g)2t}$.

There are $R(R-1)/2$ orthogonality restrictions, thus additional $R(R+1)/2$ are necessary to identify the system. They take the form of normalisation conditions $\mathbf{v}_r{}^T \mathbf{S_{11}} \mathbf{v}_r = 1$ what altogether gives the just identified model. It is important to stress, that the orthogonality restrictions in the Johansen procedure are arbitrary and in most cases have no economic meaning (for advanced forms of restrictions see Johansen (1996)).

The results obtained by S.G.Hall and his co-authors (see Greenslade at all (1999)) show that asymptotically it does not matter if the overidentifying restrictions are tested before or after determining the dynamic structure of the model. In limited samples of the common sizes, however, the power of the tests is low in such circumstances. Moreover the distribution of the test statistic for cointegration rank is not known when the dynamics is restricted, thus the cointegrating rank should be tested before restricting the dynamics. Results of Monte Carlo experiments indicate that the cointegration test works better after determining the marginalisation, so this argues for fixing exogeneity early in the nesting procedure, however, there is no reason for a strict sequence. Taking into account all the above arguments, a particular general modelling strategy is suggested. Its modified version was applied in this paper (see Figure 1). The procedure consists of four steps.

Firstly, the cointegrating rank is found by the standard Johansen procedure. The number of independent cointegrating relationships is the same as the number of the common stochastic trends and there must be at most M-R weakly exogenous variables.

Secondly, weak (long-run) exogeneity hypotheses which should be congruent with the economic knowledge are tested. The exogeneity tests are sensitive to the cointegrating rank. Therefore the procedure is an iterative one. After the number of cointegrating vectors in the unrestricted system is found, the exogeneity of a particular variable is tested. Then, under the assumption that this variable is weakly exogenous the testing of cointegrating rank is repeated.

Thirdly the short-run structure is found. If estimates of gammas do not differ from zero, order of lag may be reduced.

Fourthly, at least R^2 restrictions are imposed (R of them are the normalisation ones) what defines the long-run structural model. If there are no cross-restrictions, the order condition requires at least $(R-1)$ restrictions in each equation. In case of the system estimation method, however, this condition may be relaxed and $(R-1)R$ non-normalising restrictions must be present in the whole model.

In the last step, the overidentifying restrictions are tested.

3. Economic development

The collapse of the old political system in 1989 in Poland enabled to start the transformation from centrally planned towards a market economy which was declared as a major goal of the new democratic government. On 1 January 1990 a plan named after its initiator, the 'Balcerowicz Plan' was implemented receiving enormous support in the West. There were three main ingredients of this plan. Firstly, nearly full liberalization of prices and liquidation of the subsidies paid by the state budget to the state-owned enterprises. Secondly, removal of the bureaucratic restrictions on the private sector, liberalization of production and trade, including the foreign trade. Thirdly, introduction of the restrictive monetary policy and tight credit ceilings due to high real interest rates (see also Hoen (1998)). These actions immediately brought about a hyperinflation: in two years 1990-91 cost of living index increased 12 times. Later, the inflation declined to 20% in 1996 and to 11% in 1998 which was the result of several anchors introduced under the so called "stabilization program". Among them the most important were wage indexation and, after draconian devaluation of the Polish zloty, the lock-up of the exchange rate against the US dollar. The wage control in the state sector was based on the regulation that wage increases exceeding productivity gains and inflation rates are subject to high and progressive taxes while the indexation coefficient set by the Council of Ministers was kept constant (at the level of 0.8) until 1995. It was the main economic instrument which helped to prevent from overcompensation for cost of living increase (the estimates show that in the years of centrally planned economy the elasticity of wages with respect to prices exceeded unity, see Welfe (1991)). From January 1990 the currency started to be convertible for current account transactions which forced Polish enterprises to compete with foreign producers and to adjust to the world market conditions.

As the result of the economic reform, within 6-8 quarters the equilibrium was regained in the most consumer goods markets. Increasing confidence in government and banking institutions additionally helped to suppress inflation (see analysis in Gomulka (2000)). Consequently the system changed from typical supply-driven shortage economy (see classical work of Kornai (1980)) into increasingly demand-constrained. However, very restrictive fiscal and monetary policies resulted in a 30% decline of the industry's output and GDP drop by 14% in the year 1990. It was the consequence of private consumption and investments decrease (by 18% and 10% respectively). The unemployment exploded from practically zero to the rates exceeding 15% at the end of 1994 and remained on the levels above 10% in the second half of 1990s. Furthermore, the variation of the officially reported unemployment rate was rather the result of frequently changed legal regulations (see Fig. 1).

All above explains why we limited the sample and omitted the first period of transformation of the economic system.

In the first period many institutional changes took place. On 1 January 1992 the income tax on personal incomes replaced wage taxation. At mid 1993 the value added tax substituted the turn over tax, and the import tax was introduced (abolished 1 January 1997). Also the banking system underwent serious changes. The NBP started to play the role of the central bank only while its branches were transformed into commercial banks. New private banks emerged. The stock exchange was re-launched in 1991, and since then a dynamic development of its infrastructure has taken place. At the beginning, the supply of stocks was mainly the result of privatisation of the previously state owned firms. Later the government started to be active in issuing bonds and treasury bills and new derivative instruments were introduced.

In October 1991, the nominal anchor was abandoned and a ‘crawling peg’ introduced with a monthly 1.8% devaluation against the currency basket (the US dollar 45%, German mark 35%, pound sterling 10%, French and Swiss frank 5% each). The percentage monthly devaluation was reduced in mid 1993.

Continuation of the stabilisation programme did not ensure the recovery from the recession caused by the transformation. Therefore, in the year 1994 a new government modified the economic policy concentrating on more expansionist, growth oriented measures. The GDP rates of growth exceeded 5% in the years 1994-97. High level of investment activity, expansion of exports, and individual consumption growth, much higher then predicted, stood behind it. After restrictive wage taxes were abolished, agreements between the representatives of the government, entrepreneurs and trade unions on the maximum level of the real wage growth started to operate since 1995. In those negotiations the change of cost of living index has been always used as the major argument.

The inflation rate systematically declined which was followed by the interest rates fall. However, the real interest rates remained high which attracted speculative foreign capital and ensured high increase in the reserves of foreign currencies. Nominal wages exceeded the targets declared in the government documents. Hence, in the years 1995-97 a notable increase of the real wages (and personal incomes) took place. Recent developments in Poland show that the economy still suffers from the cost-push inflation. Wages and costs of imported raw materials (oil among others) play the most significant role in this process.

The exchange rate policy has been further relaxed and the zloty was allowed to fluctuate within the certain range against the currency basket, although there were a few small devaluations.

The tightening of the fiscal policy in 1998 and during next years caused the decrease of the domestic final demand and limited the growth of the economy. It unabled also to suppres the inflation to under 10% in the year 2000.

During the last decade Poland was led by different governments representing opposite political options. Although the declared goals have been changing, basic strategies remained the same, and the macroeconomic policy was by and large maintained according to the path paved at the beginning of the process of transformation (similar view in Hoen (1998)). There were also many similarities in the instruments and the way they were applied by subsequent governments. It explains why the parameters of the appropriate functions my stay constant over the whole sample period.

3. The model

As a starting point, it was accepted that real earnings depend on productivity whilst themselves they can affect productivity and also inflation if their increases are not compensated by productivity growth. In additon, inflation reacts positively to other costs increases, which include costs of imported inputs (raw materials and intermediate products). The mark-up is assumed to be proportional to the costs. The wage indexation mechanism was generally considered as one of the main determinants of inflation, however, its impact is related to the power of the labour unions and the effectiveness of the negotiating process with employers or the existing indexation clauses. The costs of imported inputs are the product of the volume of imports and import prices. The later depend on the world prices and the exchange rate which follows the changes of purchasing power parity.

The long-run, structural (static) model embodying above postulates can be written as (see the short-run version of the similar model in: Osiewalski, Welfe (1998), and for the centrally planned economy of Poland: Marcellino, Mizon (2000)):

$$E[w_t - \delta_0^w - \delta_2^w p - \delta_6^w z] = 0 \,, \qquad (7a)$$

$$E[p_t - \delta_0^p - \delta_1^p w - \delta_6^p z - \delta_3^p km - \delta_7^p ko] = 0 \qquad (7b)$$

$$km = m + pm - s \qquad (7c)$$

$$E[pm - \delta_0^{pm} - \delta_5^{pm} ex - \delta_{10}^{pm} pw] = 0 \qquad (7d)$$

$$E[ex - \delta_0^{ex} - \delta_2^{ex} p - \delta_{10}^{ex} pw] = 0 \qquad (7e)$$

where δ_i, $i = 1,...,10$, are parameters to be estimated, small letters denote natural logarithms of the following variables:

W - average wages, current prices,

P - consumer's prices index (cost of living index),

Z - labour productivity, constant prices,

KM - import costs, index,

PM - import prices, index,

EX - exchange rate,

KO - other, non-wage costs, index,

M - intermediate goods imports,

S - sales of industrial output,

PW - world prices, index.

The first equation is the standard wage function (see Tobin (1995)) which can be also derived from the analysis of the compensation system in Poland and other institutional solutions (see Welfe (1991)). It neglects, however, the relationship between wages and unemployment. During economic transformation of the Polish economy from the centrally planned toward the market system the unemployment rose practically from zero to 16%. In the first two years it was mainly the result of the decline of economic activity. In the next years wide privatisation of the industry was followed by the cuts of employment eliminating labour hoarding what also effected labour productivity. The preliminary results (see also Welfe, Majsterek (2000)) showed that the long-run elasticity of wages with respect to unemployment rate was close to zero. Therefore the unemployment was excluded from the long-run system which is congruent with the hypothesis this relationship is significant only in the short-run.

A very similar wage function structure may result from the acceptance of the standard bargaining model of wages and prices (see Nickell (1984), Layard et. al. (1991)). Then, however, usually the real rather than the nominal wages are explained which assumes unit long-run wage elasticity with respect to prices. The Polish experience of transition period suggests that this parameter should be estimated not imposed (see results in Welfe (1996)).

The second equation originates from the cost-push inflation theory and follows the hypothesis that prices are influenced by the output costs increased by constant mark-up (see classic work of Tobin (1972)). Furthermore, this function may be treated as the reduced form of the price equation system for production sector in input-output approach. Since in this equation the import prices were replaced by non-wage costs, the share of the import-output ratio is allowed to vary in time, which was the case in Poland.

The third equation defines the import unit costs.

Import prices equation is the stochastic approximation of the identity in which the world export prices are transformed by the exchange rate into the import prices expressed in Polish zloty.

The exchange rate equation origins from the absolute version of purchasing power parity hypothesis.

4. The data. Order of integration

The data comes from the quarterly and monthly WK data bank (documentation in: Kelm, Sabanty [2000]) which generally includes two types of data.

The first group comes from Central Statistical Office (CSO) and National Bank of Poland (NBP) publications:

- *Statistical Information* – monthly review published by CSO from 04.1989 to 02.1991 r.;
- S*tatistical Bulletin* - monthly review published by CSO from 04.1989;
- *Information Bulletin* - monthly review published by NBP from 01.1990;
- *Foreign Trade* – monthly (from 1998 quarterly) review, published by CSO from 01.1991.

The main dificulty is related to the changes of indices definitions within the sample period (with exception of data in current prices coming from the banking system). This is the consequence of the Eurostat norms adjustment. As the result, the volumes (or deflators) calculated on the basis of nominal terms and dynamics of prices (or volumes) do not satisfy definitional identities. The raw data suffers also from changes of the national accounts system: from Material Product System (MPS) into System of National Accounts (SNA) in 1991, and from Classification of National Economy into NACE classification in 1996. Therefore the data had to be appropriately transformed to give desired time series.

The procedure includes the balancing algorithm which links quarterly and annual figures (wider discussion in: Kelm (1999)) and the conversion by matrices estimated on the basis of the input-output coefficients which were available exclusively for the years 1989, 1992 and 1993 (see Welfe, Kelm (1998)).

The second group of data includes quarterly (and monthly) figures which were not published and thus had to be estimated (for example GDP and its components for the period before 1996). The approach assumes the availability of quarterly (monthly) indicators which play the role of proxies (see Welfe, Kelm [1995], [1996]). The procedure can be summarized in three steps.

In the first, the following equations are estimated:

$$y_t^A = \mathbf{x}_{(k)t}^A \alpha_{(k)}^A + \xi_t^A , \tag{8}$$

where:

y_t^A - variable observed with the annual frequency only,

$\mathbf{x}_{(k)t}^A$ - vector of K indicators, observed both with the annual and quarterly frequency, $\mathbf{x}_{(k)t}^A = [x_{1t}^A x_{2t}^A \ldots x_{Kt}^A]$,

$\alpha_{(k)}^A$ - vector of K structural parameters, $\alpha_{(k)}^A = [\alpha_1^A \alpha_2^A \ldots \alpha_K^A]^T$,

ε_t - white noice.

In the second step the quarterly values for $y_{t,j}^Q$ are generated:

$$\hat{y}_{t,j}^Q = \mathbf{x}_{(k)t,j}^Q \hat{\alpha}_{(k)}^A \tag{9}$$

where:

$\mathbf{x}_{(k)t,j}^Q$ - vector of indicators (observed with the quarterly frequency),

$\hat{\alpha}_{(k)}^A$ - vector of the parameter estimates.

The procedure requires that $\alpha_{(k)}^Q = \alpha_{(k)}^A$. If (8) includes the constant then $\alpha_1^Q = \alpha_1^A / 4$ (assuming $\mathbf{x}_{1(t)}^A = [11 \ldots 1]^T$); in the case of deflators: $\alpha_1^Q = \alpha_1^A$.

In the third step the estimated quarterly data are sum up to the annual figures:

$$y_t^A = \sum_{j=1}^{4} \hat{y}_{t,j}^Q \ , \tag{10}$$

what is made in three stages. Firstly, from the identity (9) the starting values $\hat{y}_{t,j}^{Q(0)}$ are calculated, and the annual data is generated:

$$\tilde{y}_t^{A(1)} = \sum_{j=1}^{4} \hat{y}_{t,j}^{Q(0)}, \qquad (11)$$

where number in brackets denotes the iteration. Secondly, the ratios $\psi_t^{(1)} = \tilde{y}_t^{A(1)} / y_t^A$ are calculated. If $\psi_{(t)}^{(1)} \neq [11...1]^T$, then $\hat{y}_{t,j}^{Q(0)}$ is corrected. The weights $\gamma_{t,j}$ are defined as the function of ψ_t:

$$\gamma_{t,j}^{(2)} = W(\psi_{(t)}^{(1)}, \tau_{t,j}) \qquad (12)$$

where $W(\psi_{(t)}^{(1)}, \cdot)$ is the Lagrange interpolation polynomial, $\tau_{t,j}$ denotes coordinates of time axis in the *j*-th quarter of *t*-th year and $\tau_{t,j} = 4(t-1) + j$.

The iterative process is discontinued if $\psi_{(t)}^{(n)} < \varepsilon_{(t)}$, where $\varepsilon_{(t)}$ is a vector of convergence coefficients.

There are 8 variables used in the model.

Wages are measured in zlotys *per* employee and relate to the manufacturing sector (the enterprises employing less than 6 people are excluded). The official CSO figures for the years 1999-2000 were adjusted since they include the firms employing more than 7 people.

CPI is calculated on the basis of index of consumer goods prices. The base year is 1996.

The labour productivity measures total GDP *per* employee in manufacturing sector (the employment in the firms employing less than 6 people is excluded). The monthly figures are obtained by interpolation while seasonal effects are smoothed using moving average.

Imports and other costs are measured per unit of industrial production.

Industrial production relates to the manufacturing sector. The figures for 1999-2000 are adjusted to be comparable with the previous definition (the firms employing less than 6 employees are excluded)

Imports deflator is based on the official CSO's data. The base year is 1996.

Basket of currencies contains EURO and the US dollars with weights 0.55 and 0.45, respectively.

World price deflator is based on PPI's in Germany and USA with weights 0.55 and 0.45, respectively.

The results presented in Table 1 prove that all variables are I(1), except sales of the industrial output and intermediate imports which are trend stationary.

5. Cointegrating rank, weak exogeneity and structuralisation of the model

The Johansen (1988) procedure was used to determine the cointegrating rank (see Table 2). Two tests procedures were employed. The first one is based on the maximum eigenvalue, the second one – on the trace of the matrix (6). Also two different sets of critical values can possibly be used: asymptotic or small sample. The test based on the small sample critical values tends to underestimate the number of cointegrating vectors on the contrary to the large sample test usually suggesting too many of them (see Doornik (1998) and the results of Monte Carlo study reported by Greenslade at all. (1999)). Johansen (1988) argues that consequences of underestimation of cointegration rank are much serious than overestimation.

Firstly, if a particular vector is wrongly excluded from the cointegrating space, the significant information about the long-run dependencies between variables is omitted. Secondly, the number of stochastic trends in the system is overestimated. Additionally, the existence of I(2) variables in the system gives more unit roots in the relevant characteristic polynomial. These additional unit roots may cause the overestimation of the stochastic trends number and hence the underestimation of the cointegration rank (for wider discussion and empirical results see Juselius (1999)).

On the other hand, if too many vectors are included in the cointegrating space, the model may contain nonstationary variable(s) or the estimated cointegration space may include not independent cointegration relationship(s).

The correct testing sequence strategy assumes in the first step the maximum number of stochastic trends in the system, that is $H_0 : R = 0$ against the alternative $H_1 : R \geq 1$. If the null hypothesis is not rejected, it means that there are M stochastic trends in the system and variables do not cointegrated. If the null hypothesis is rejected, then $H_1 : R = 1$ is tested against $H_2 : R \geq 2$. The testing procedure is terminated if the $H_r : R = r$ is not rejected.

The cointegrating rank was tested for the set of 9 variables, since the import costs are uniquely defined as intermediate costs per unit of industrial output. The results of the tests (see Table 2) confirm the presence of five cointegrating vectors. In the next step the exogeneity under the assumption that there are five cointegrating vectors was tested. The results of the LR test lead to the conclusion that all variables in the system are endogenous in the long-run. This is in contrary to the economic knowledge which suggests that non-wage costs, labour productivity, intermediate imports, foreign prices and macroeconomic policy indicator shall be treated as weakly exogenous. Therefore we assumed exogeneity of these variables and tested again for cointegration rank which turned to be five.

It should be noted that after imposing the exogeneity restrictions (wider discussion in Greenslade at all (1999)) the true distribution of the test statistic is not known, so the critical values are not valid. However, the number of independent cointegrating relationships depends on the number of exogeneity restrictions.

Exemplary equation normalised with respect to wages coming from the unrestricted system is as follows

$$w = \delta_0^w + \delta_2^w p + \delta_3^w km + \delta_4^w pm + \delta_5^w ex + \delta_6^w z + \delta_7^w ko + \delta_8^w m + \delta_9^w s + \delta_{10}^w pw \tag{13}$$

On the basis of economic theory we hypothesise that the following exclusion restrictions hold (the subscripts denote the equations explaining relevant variables) :

in wage equation:

$$\delta_3^w = \delta_4^w = \delta_5^w = \delta_7^w = \delta_8^w = \delta_9^w = \delta_{10}^w = 0$$

in price equation:

$$\delta_4^p = \delta_5^p = \delta_8^p = \delta_9^p = \delta_{10}^p = 0$$

in import costs equation:

$$\delta_0^{km} = \delta_1^{km} = \delta_2^{km} = \delta_5^{km} = \delta_6^{km} = \delta_7^{km} = \delta_{10}^{km} = 0$$

in import prices equation:

$$\delta_1^{pm} = \delta_2^{pm} = \delta_3^{pm} = \delta_6^{pm} = \delta_7^{pm} = \delta_8^{pm} = \delta_9^{pm} = 0$$

in exchange rate equation:

$$\delta_1^{ex} = \delta_3^{ex} = \delta_4^{ex} = \delta_6^{ex} = \delta_7^{ex} = \delta_8^{ex} = \delta_9^{ex} = 0$$

The rise of labour productivity is the result of work intensity increase and technical progress. The latter usually leads to higher quality of products which gives producers the reasons to rise the prices. Consequently labour productivity increase can only partly contribute to inflation decline. Therefore the labour share restriction $\delta_1^p = -\delta_6^p$ was modified:

$b\delta_1^p = -\delta_6^p$ where $0.5 \le b \le 1$.

The homogeneity of prices means that the price increase proportionaly to the production cost change:

$$\delta_1^p + \delta_3^p + \delta_7^p = 1.$$

In the import costs equation from the identity:

$$\delta_4^{km} = \delta_8^{km} = 1 \quad \delta_9^{km} = -1$$

The import prices equation is based on the assumption that these prices are predetermined in foreign markets. The exchange rate is used to recalculate them into Polish zloty:

$$\delta_5^{pm} = \delta_{10}^{pm}$$

The acceptance of the purchasing power parity assumptions gives:

$$\delta_2^{ex} = -\delta_{10}^{ex}.$$

The preliminary estimates of δ_3^p tend to be undervalued. Therefore we imposed the following restriction:

$$\delta_3^p = 0.08.$$

The identification of the model requires at least 25 restrictions (5 of them are the normalisation ones). Having 21 more (46 altogether) allows for testing.

The restrictions imposed on parameters of the model were not rejected by the data at standard significance level ($\alpha = 0.05$) since the value of the LR statistic is 30.245 (the critical value for 21 degrees of freedom is 32.671).

6. Empirical results

The estimation results are[2]:

$$w = \underset{(30.429)}{5.728} + \underset{(21.152)}{0.959}p + \underset{(6.179)}{0.888}z \qquad (15a)$$

$$p = -\underset{(-35.255)}{3.624} + \underset{(39.367)}{0.597}w - 0.179z + 0.08km + 0.323ko \qquad (15b)$$

$$km = m + pm - s \qquad (15c)$$

$$pm = -\underset{(-72.153)}{1.166} + \underset{(66.773)}{1.010}ex + 1.010pw \qquad (15d)$$

$$ex = \underset{(316.963)}{1.159} + \underset{(70.030)}{0.685}(p - pw) \qquad (15e)$$

All long-run estimates are economically acceptable and significant.

The price elasticity of wages (0.959) is very close to one and congruent with the theory. This value confirms that in the long-run there is no significant over compensation for the price increase. The elasticity of wages with respect to labour productivity (0.888) is seemingly greater than obtained in the previous studies based on quarterly data (see Welfe, Majsterek (2000)), however, does not contradict our prior expectations. Both estimates may mean that the bargaining position of the trade unions is rather strong, but the role of “pure” economic factors steel increases.

The value of b was found in a series of experiments. The best results were obtained for $b = 0.3$. This value means that important part of labour productivity rise (approximately 70%) can be attributed to the change of the products quality which exerts pressure towards price increase.

The elasticity of prices with respect to wages equals 0.597 and is close to the average share of wages in total costs. It may mean that although the wage costs still remain the main force driving inflation, the role of other costs is significant. The elasticity of prices with respect to labour productivity equals –0.179 and seems to be acceptable.

In the import costs equation, the estimate of the δ_6^{pm} parameter is close to unity which confirms the prior expectations. The insignificant difference may be caused by the fact that world prices are approximated by German and US export prices with fixed weights while and the value of zloty is measured against the currency basket (with weigths 0.55 for Euro and 0.45 for USD).

The elasticity of the exchange rate with respect to relative prices is approximately 0.685, which reflects both Balassa-Samuelson effect and tight anti-inflationary policy of National Bank of Poland. Changes in fiscal policy are the additional source of disparity. It should be noted that domestic prices cover also non-tradeables.

7. Impact of policy and exogenous shocks

The properties of the model were investigated via multiplier analysis. In the first step the solution of the long-run part of the VEqC model was found

[2] Calculations have been performed by TSP, CATS and REG-X packages.

and the responses to exogenous shocks were analyzed. The simulation results (in terms of long-run elasticities) are reported in the Table 3.

The increase of wages induces less than proportional growth of prices (with elasticity 0.57). Moderate increase of the nominal exchange rate, import unit costs, and import deflator is also observed. The consequences of the unexpected prices increase are much more evident. Deviation of the nominal wages form the baseline solution exceeds unity while the exchange rate and import prices react with elasticities of about 0.7. The effect of zloty depreciation is relatively weak. Although a proportional increase of import deflator is observed, the responses of domestic prices and nominal wages are below 0.2. This result confirms potential efficiency of the active exchange rate policy during the transformation period. The consequences of foreign prices increase are also weak. The size of the import costs decline due to the appreciation of zloty and the increase of imported goods prices (expressed in the foreign currencies) is similar to each other. As a result the changes in domestic price level and nominal wages are insignificant.

In the second step the adjustment profiles of the system were analyzed within SVEqCM (see eq. (4)). The short-run parameters were estimated by OLS. Selection of the proper lag length and the lag structure was based on the classical *t*-Student tests; the latter were also used for identification of leading structural cointegrating vectors (see Grenslade et al. [1998]). Seasonal components in growth rates are captured by dummies (see Table 4).

Short-run multipliers indicate the same directions of change but there are noticeable differences of the speed of convergence to the baseline solution. Price shock by 10 per cent in the first period of simulation leads to the temporary increase of nominal wages, exchange rate and import deflator. In all cases deviations from the baseline do not exceed 2.0-2.5 per cent (with maximum values after 5-6 periods) and disappear after 12 months. It should be noticed that the values of cumulated multipliers are congruent with the previous results, however, the effects of the exogenous wage increase (by 10 per cent) are much stronger in the long run. Moreover adjustment processes are relatively slow after the maximum deviation observed between 6 and 10 period of simulation. The exchange rate depreciation (by 10 per cent) does not seriously accelerate inflationary processes. The increases of domestic prices and nominal wages only slightly differ from the baseline solution achieving stable level of about 0.2 per cent after half of the year. The reason is the relatively low elasticity of consumer prices with respect to import deflator. A significant increase of domestic prices follows the foreign prices shock (by 10 per cent). In the case of impulse multiplier the horizon of the adjustment is very short and the values of the analyzed variables achieve the initial levels after 2-3 periods.

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Table 1. Integration test

Variable	Diagnostic statistics		Conclusion
	DF	ADF	
w	-3.480		I(1)
p	-1.318		I(1)
z	-2.371		I(1)
km	-2.160		I(1)
ko	-1.894		I(1)
pm	-0.088		I(1)
m	-5.041		I(0)
ex	-2.479		I(1)
pw	-1.218		I(1)
s	-7.045		I(0)
Δw	-11.225		.
Δp	-6.985		.
Δz	-1.096	-4.812	
Δkm	-9.686		.
Δko	-8.044		
Δpm	-12.009		
Δex	-7.443		
Δpw	-6.099		

Note:

Critical values of DF and ADF tests for $\alpha = 0.05$ is –3.59 (critical values from Banerjee et all (1993), p. 103). Both DF and ADF test have been used for the deterministic trend augmented version:

DF: $\Delta y_t = \alpha_0 + (\alpha_1 - 1)y_{t-1} + \alpha_2 t + \varepsilon_t$

ADF: $\Delta y_t = \tilde{\alpha} + (\tilde{\alpha}_1 - 1)y_{t-1} + \tilde{\alpha}_2 t + \tilde{\alpha}_3 \Delta y_{t-1} + \tilde{\varepsilon}_t$

We test:

$H_0 : y_t \sim \mathrm{I}(1) \quad (\alpha_1 - 1 = 0)$

against the alternative:

$H_1 : y_t \sim \mathrm{I}(0) \quad (\alpha_1 - 1 < 0)$

Table 2. Cointegration tests, 4 exogenous variables, significance level = 0.05 sample: 1994.03-2000.06

R	$\lambda_{\max}$	λ_{trace}
0	69.30 (42.92)	224.91 (104.2)
1	46.97 (37.24)	155.61 (77.60)
2	38.80 (30.65)	108.64 (53.72)
3	38.08 (24.04)	69.83 (33.68)
4	31.75 (17.24)	31.75 (17.24)

Note: Critical values in brackets (see Pesaran et al. [1998]).

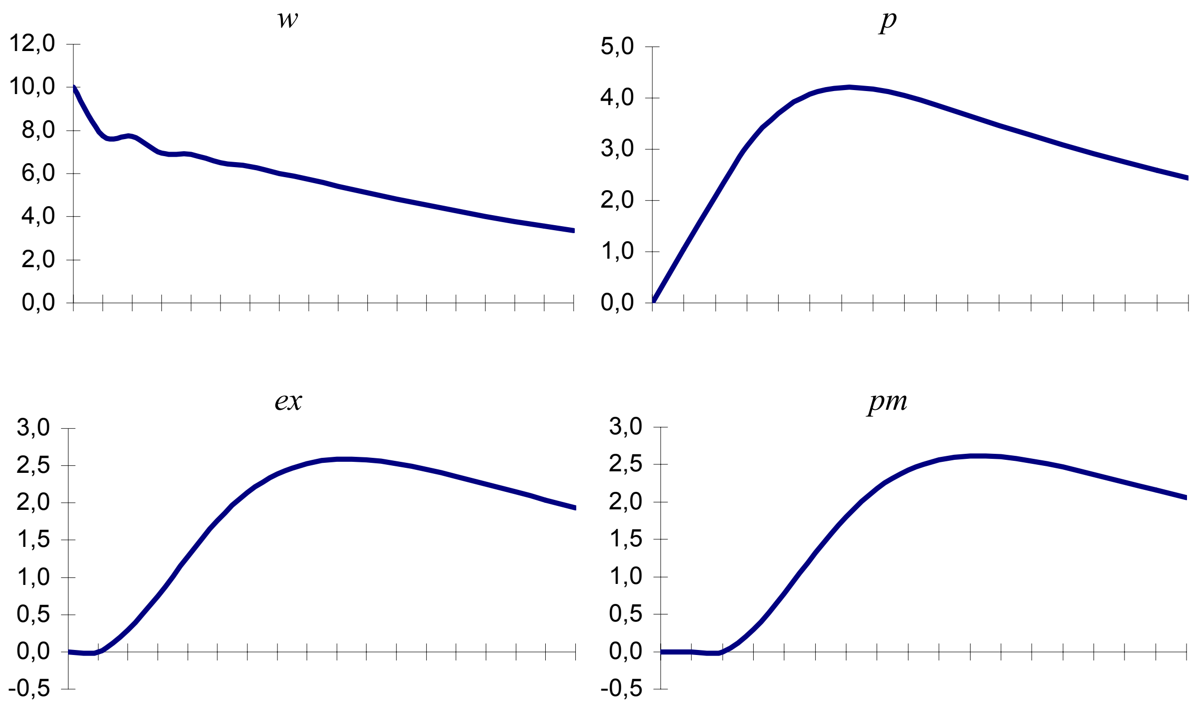
Table 3. Long-run elasticities

Exogenous shock	Long-run elasticities			
	w	p	ex	pm
w	1.00	0.57	0.39	0.40
p	1.03	1.00	0.67	0.69
pm	0.18	0.17	0.12	1.00
ex	0.18	0.18	1.00	1.03
kop	0.85	0.83	0.57	0.58
pw	0.06	0.06	-0.60	0.34
zn	2.07	1.00	0.69	0.70

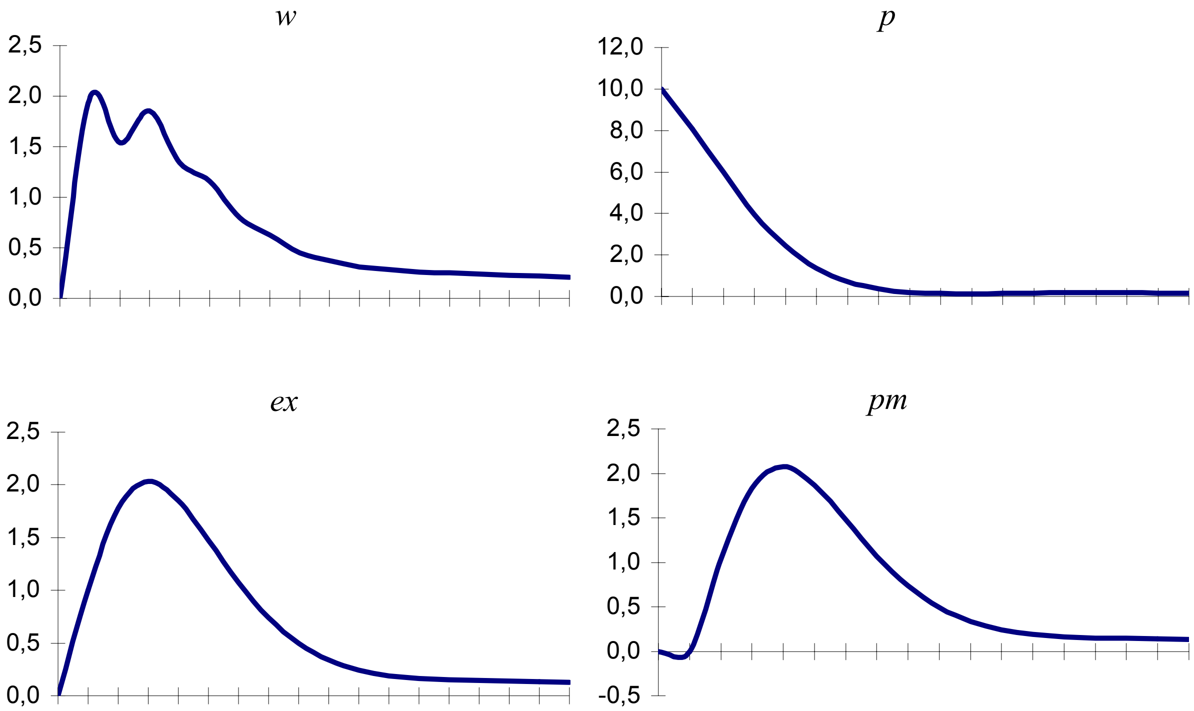
Table 4. Estimates of the short-run parameters

1. Nominal wages
$\Delta w_t = 0.127 - 0.442\Delta w_{t-1} + 0.430\Delta p_{t-1} + 0.085\Delta km_{t-1} + 0.833\Delta kop_{t-1} - 0.215 wkw_{t-1} +$
$-0.189 z_{1t} - 0.166 z_{2t} - 0.184 z_{3t} - 0.086 z_{4t} - 0.111 z_{5t} - 0.112 z_{6t} - 0.116 z_{7t} - 0.125 z_{8t} +$
$-0.101 z_{9t} - 0.119 z_{10t} - 0.060 z_{11t}$
where:
$wkw_t = w_t - 5.728 - 0.959 p_t - 0.888 zn_t$
2. Consumer prices
$\Delta p_t = 0.006 + 0.069\Delta w_{t-1} + 0.506\Delta p_{t-1} - 0.032\Delta km_{t-1} + 0.458\Delta pw_{t-1} - 0.184 wkp_{t-1} +$
$-0.169 wkw_{t-1} + 0.011 z_{1t} - 0.013 z_{7t}$
where:
$wkp_t = p_t + 3.625 - 0.598(w_t - 0.3 zn_t) - 0.080 km_t - (1 - 0.598 - 0.080) kop_t$
$wkw_t = lw_t - 5.728 - 0.959 lp_t - 0.888 lzn_t$
3. Exchange rate
$\Delta ex_t = 0.005 + 0.169\Delta p_{t-1} - 0.063\Delta km_{t-1} + 0.402\Delta ex_{t-1} - 0.153 wkex_{t-1}$
where:
$wkex_t = ex_t - 1.159 - 0.685(p_t - pw_t)$
4. Import prices
$\Delta pm_t = -0.0004 + 0.407\Delta ex_{t-1} + 0.910\Delta kop_{t-1} - 0.627 wkpm_{t-1} - 0.367 wkex_{t-1}$
where:
$wkpm_t = pm_t + 1.167 - 1.010(ex_t + pw_t)$
$wkex_t = ex_t - 1.159 - 0.685(p_t - pw_t)$

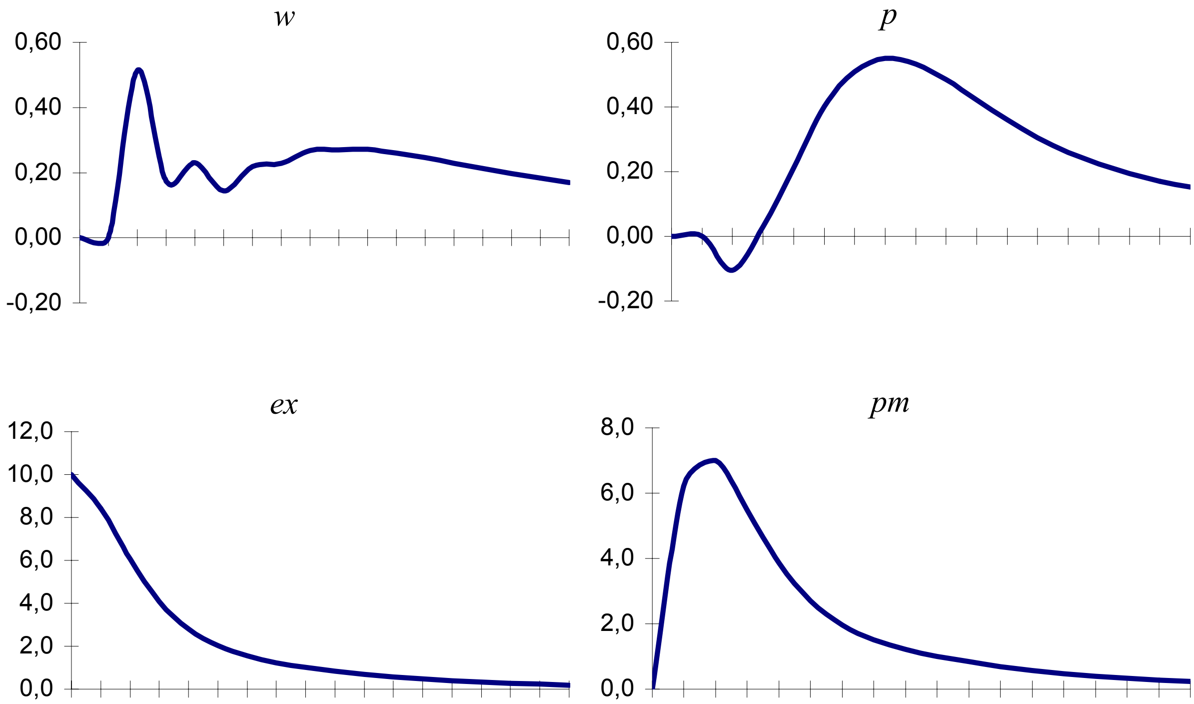
Graph 2. Short-run impulse multipliers; the increase of the nominal wages (w) by 10% (percentage differencies from the baseline solution)



Graph 3. Short-run impulse multipliers; the increase of the consumer prices (p) by 10% (percentage differencies from the baseline solution)



Graph 4. Short-run impulse multipliers; the increase of the nominal exchange rate (*ex*) by 10%
(percentage differencies from the baseline solution)



Graph 5. Short-run impulse multipliers; the increase of the foreign prices (*pw*) by 10% (percentage differencies from the baseline solution)