**EUROPEAN UNIVERSITY INSTITUTE**
DEPARTMENT OF ECONOMICS

EUI Working Paper **ECO** No. 2003/6

# Polish Stabilization: What Can We Learn from the *I(2)* Cointegration Analysis?

Ekaterina Vostroknutova

**BADIA FIESOLANA, SAN DOMENICO (FI)**

Published in Italy in March 2003
European University Institute
Badia Fiesolana
I-50016 San Domenico (FI)
Italy

# Polish Stabilization: What Can We Learn from the I(2) Cointegration Analysis?[1]

Ekaterina Vostroknutova
vostrokn@iue.it
European Univerisity Institute
Department of Economics
Via dei Roccettini, 9
San Domenico di Fiesole
I-50016 Italy

March 5, 2003

[1] I am very grateful to Mike Artis, for his comments and support throughout this work. I owe a lot to Katarina Juselius for her extensive comments, long discussions and encouragement. The paper greatly benefited from discussions with Lusine Lusinyan and Ilian Georgiev. All mistakes remain my own.

**Abstract**

This paper is part of a larger project that questions the common notion of similarity in the Polish and Russian stabilization programs, which clearly brought about different results. It investigates an array of nominal systems for the Polish economy, of domestic price level, import prices, exchange rates, money stock, nominal wages, and real output, and conducts I(1) and I(2) cointegration analyses. Post-stabilization monthly data are used, 1991:5-1999:12.

A test for the presence of a price-wage spiral is performed, and the stabilization package is compared to its realization. The long-run homogeneity hypothesis, the impact of monetary and incomes policies, and of external sector variables on long and medium run price development are studied. It is found that in Poland, contrary to some earlier studies, the external sector is not important for the long run price development. On the contrary, very strong evidence is found of the cost-push inflation.

These results are very different from the Russian experience, where inflation has had mostly monetary roots. The paper concludes with a comparative policy analysis.

JEL codes: C32, E63, E64

Keywords: cointegration, I(2), monetary policy, incomes policy, stabilization, Poland

# 1 Introduction

The transition from plan to market has brought into macroeconomics a problem of creating efficient stabilization programs in countries where financial and monetary institutions have not been properly established. Liberalization started at different times in different countries but in all of them there was a subsequent period of high (or even hyper-) inflation and a slump in output. Some countries' stabilization packages gave a quicker and more sustainable cure, while others found themselves stagnating for years.

Russia and Poland provide the most striking examples of differences in achieving macroeconomic stabilization. It has become a received notion that the respective stabilization packages in these two countries were very similar (Frye and Shleifer, 1997; Fisher and Sahay, 2000), and their so apparently different results have thus been an economic puzzle. This paper is concerned with an analysis of the Polish post-stabilization data.

A wide range of often very controversial results concerned with Polish inflation factors is described in the literature (Christoffsen and Doyle, 2000; Brada and Kutan, 1999; Dibooglu and Kutan, 2001; Enev and Koford, 2000; Marcellino and Mizon, 2000).

It has been established that during transition periods many variables that are normally I(1) come closer to I(2) processes for considerable periods of time. In this paper I am trying to benefit from the structure of the cointegrated I(2) VAR model, in order to conduct more reliable econometric analysis. By considering an array of systems, it becomes possible to show the robustness of results and to choose a proper nominal-to-real transformation.

The rest of the paper is organized as follows. The next section reviews relevant literature and discusses particular features of the Polish transition. The third section continues with cointegration analysis of Polish data. The last section concludes and draws policy implications from the comparison of the Polish and Russian results. The Appendix is a sketch proof to argue for the relevance of tests results in the I(2) framework (due to Juselius, 2002); it compares the useful properties of I(1) and I(2) processes.

# 2 Theoretical Framework and Relevant Literature

Economic theory suggests that there are three main channels that fuel inflation: monetary, labor, and external sectors. These are supposed to generate inflation due to excess money supply, nominal wage increases above the rate of increase of productivity, or due to the transmission of foreign (dis)inflation (see, for example, Artis and Kontolemis, 1996). In the following subsections these channels are discussed in more detail and the existing literature is reviewed.

## 2.1 Monetary explanation

No consensus has been reached on whether monetary mechanisms were an important factor for inflation in Poland. The conclusion critically depends on the technique used, and the period under investigation. Most of the papers, however, argue in favor of "no effect" (Christoffsen, Sløk, and Wescott (2001), Kim (2001), Brada and Kutan (1999)).

In particular, Brada and Kutan (1999) argue that stabilization in Poland is not a result of effective monetary policy (as commonly believed), but is mostly due to the import price decrease at the time. They find that monetary policy has been relatively ineffective in controlling inflation, and that inflation would return should foreign prices increase again.

However, some authors mention the monetary sector as an important part of inflation formation in Poland (Wozniak, 1998; Dibooglu and Kutan, 2001).

## 2.2 Labor market explanation

Due to the importance of non-monetary (real) shocks in transition countries (Dibooglu and Kutan, 2001), heterodox[1] stabilization programs were advised by the international organizations for the transition countries, and for Russia and Poland in particular.

In the transition economies discussion, labor-market explanations of inflation have been extensively referred to. The belief in the importance of wages has probably made up the main feature of the Polish stabilization plan, the taxation of excessive (compared to the level set by the government) wage increases, the *popiwek* tax.

Interestingly, Enev and Koford (2000) argue that the Polish incomes policy was not efficient in reducing inflation (in contrast to, for example, Bulgaria, where they find it to have a fairly substantial inflation-reducing effect). The authors argue that Polish enterprises had too many means of keeping the *popiwek* constraint non-binding.[2]

Brada and Kutan (1999) find that wages did not play any role in explaining Polish inflation. Referring to Desai (1998), they note that inflation caused by initial over-depreciation of currency is not subject to the usual the wage-price spiral, but is rather a result of the law of one price. It is also known that there was an over-depreciation in Poland, and therefore the authors expect that there is no wage root in the Polish inflation (neither they find one).

On the contrary, Kim (2001) finds that the labor sector had a large impact on Polish inflation, even though it had opposite signs before and after 1994 (data studied 1990-1999). Excessive wage increases, he finds, have had a cost-push effect on inflation before 1994, and prevented inflation from decreasing afterwards. A support for the widely accepted evaluation of the too tight "scorched earth" policy with respect to wages is also found, based on the

[1] In contrast to orthodox (money-based) programs, heterodox programs combine an inflation target, a nominal exchange rate target in the form of a crawling peg, and incomes policy to be implemented through a concerted action of the government, trade unions, and enterprise managers (Buch, 1998). The Balcerowicz Plan was heterodox with two nominal anchors: the nominal wage and the exchange rate.

[2] These are high unemployment, high non-wage income, low labor hoarding and firing restrictions, frequent changes of the policy norms and subsequent forgiveness of accumulated tax obligations, non-participation of private firms, etc. (Enev, Koford, 2000)

analysis of equilibrium wages.

Thus, there is no consensus concerning the role of the incomes policies in Poland, and especially concerning the *popiwek* tax.

### 2.3 External sector

Almost all studies find exchange rate policy and foreign prices to significantly influence or even cause Polish inflation. Some researchers go further and argue that the Polish inflation was not stabilized by the Balcerowicz Plan but rather by imported disinflation only (Brada and Kutan, 1999).

Christoffsen, Sløk, and Wescott (2001) find effective exchange rates and foreign price indices to significantly Granger-cause all Polish inflation measures under consideration. They conclude that the strongest relationships between monetary policy variables and CPI inflation measures are found to come from the nominal effective exchange rate, and foreign inflation in zloty, while activity variables are rarely found to significantly affect inflation.

Kim (2001) concludes that inflation was imported into Poland in 1990-1993, while external disinflation had a significant downward pressure after 1994.

Thus, there is more consensus about the importance of the external sector for the Polish inflation.

### 2.4 Output-Inflation relationship

The relationship between output and inflation has been extensively investigated for transition economies. Christoffsen and Doyle (2000) examine a panel of transition countries up to 1997. They suggest that inflation was strongly associated with weaker output initially, but that it stimulated higher growth thereafter. Therefore, the kinked relationship[3] between inflation and growth is found for transition economies as well as for developed countries.

Fischer and Sahay (2000) show that the output decline antendated the start of the stabilization program, and (averaged by groups of countries) output started to grow in the two years following liberalization. This finding suggests that the large output losses are likely to have been associated more with the transition process (disorganization and adverse initial conditions) than with the stabilization policies.

Brada and Kutan (1999) argue that while the long run effect of monetary policy is to be found in movements of prices rather than real output, there are important short-term links between the real and monetary spheres in transition economies. Also, the effectiveness of monetary policy depends on the behavior of the real sector. Soft budget constraints of firms allow them not to react to interest rates changes, and privatization by foreign firms reduces the power of monetary policy over them.

[3] The kinked relationship between inflation and growth implies that inflation impairs output only above a certain inflation threshold. According to Christoffsen and Doyle (2000), doubling inflation above the threshold (13% approx) decreases output by 0.2 points.

Enev and Koford (2000) suggest that Polish inflation was influenced not only by traditional factors. Indeed, in their analysis they included a term in industrial output growth, which turned out to have a large positive significant coefficient. It might be that nominal and real rigidities in transition are such that real variables have an impact on nominal variables (or are influenced by them, even in the long run). This is connected with the indexation of wages, the fact that minimum wages are often binding, the large share of public sector employment, and the high degree of labor market segmentation.

### 2.5 Motivation

The analysis of transition economies has been rather extensive. However, policy papers (like Fischer and Sahay (2000) or Christoffsen and Doyle (2000)) that simply regress variables that are very probably I(2) on index variables (that are constructed to be I(0)) are unlikely to be good econometric specifications, and their predictions must be considered with great care. Moreover, the data used are usually yearly, and the country panels considered are unbalanced. Nevertheless, the authors often draw very strong conclusions, on which the policy-making in the transition countries is based. If cointegration analysis is done, it at best uses differenced data, which have been shown to lose some important information (see Juselius, 1999). Therefore, stricter econometric analysis, which tries to use all the properties of the data available is definitely needed.

The period under consideration is the time just after macroeconomic stabilization. Before this period, the Polish economy experienced high inflation and other problems of transition. The Balcerowicz stabilization plan in Poland was announced in 1990:1 and was practically effective until 1995:1, when the wage controls were finally lifted. It included the following main policies:

1. Wage control: the so-called *popiwek* tax on $\Delta w_{t-1}$ was introduced to reduce wage growth;

2. Budget control: the government cut subsidies, and introduced a profits tax of 40%;

3. Restrictive monetary policy: credit ceilings;

4. The *zloty* was anchored to the dollar at a competitive rate, and declared convertible (from 1990:1 - fixed to a USD, from 1991:11 - crawling peg, from 1995:5 - crawling band).

The plan was successful, but has been heavily criticized for being over-restrictive. Many researchers (Blejer et al. 1993, Bruno, 1992) argued that the local costs of reform were unnecessarily high, lowering wages too much and causing recession and unemployment. Ellman (1993) and Winiecki (1993) point out that, additionally, "the nominal anchor caused too much devaluation, which embodied in overshooting and inflation had become counter-productive"[4]. Because of its harsh social consequences, the plan was called the 'scorched earth' policy, and it was generally argued that the relaxation of some constraints would have been beneficial.

## 3 Econometric Model and Data

To describe the data, first, the standard VAR(k) model is used to conduct an I(1) analysis. The error correction form of this model is

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Phi D_t + \epsilon_t,\ \ t = 1, .., T, \tag{1}$$

where $\Pi = \sum\limits_{i=1}^{k} \Pi_i - I$, $\Gamma_i = -\sum\limits_{j=i+1}^{k} \Pi_j$, and $D_t$ is the deterministic term. Errors are assumed to be *i.i.d.* in this model.

The I(2) model[5] is described by the following equation:

$$\Delta^2 X_t = \Pi X_{t-1} - \Gamma \Delta X_{t-1} + \sum_{i=1}^{k-2} \Psi_i \Delta^2 X_{t-i} + \Phi D_t + \epsilon_t,\ \ t = 1, .., T \tag{2}$$

where $\Gamma = I - \sum\limits_{i=1}^{k-1} \Gamma_i$, as above, and $\Psi_i = -\sum\limits_{j=i+1}^{k-1} \Gamma_j, i = 1, .., k-2$. The I(2) model has two reduced rank conditions (for $\Pi$ and $\Gamma$ matrices), while the I(1) model has just one, $\Pi = \alpha\beta'$. See Johansen (1999).

All calculations in this paper are performed in PcFiml (Doornik, Hendry, 1997), PcGive (Hendry, Doornik, 1996), Cats in Rats (Hansen, Juselius, 1995), and the I(2) procedure for Cats is used (Jørgensen, Kongsted, Rahbek, 1999). The appendix contains the explanation of why the I(1) software packages are used for the I(2) data, and what should be taken into account while doing so.

The graphs in Fig. 1 and Fig. 2 demonstrate the levels and differences for the data. It can be seen from the pictures that $\Delta pp$, $\Delta w$ and $\Delta s$ might not be stationary, and nor might $\Delta pi$ (see the unit root test in the next subsection). Trends in the differences could have been modelled explicitly, accumulating to the quadratic trends in the levels; however, an economic interpretation of such a model would have been difficult.[6]

In what follows, an array of different systems for the Polish economy is considered (see Table 2). A main reason for doing so is to check the results for

[4] Indeed, it might have been the case that wages grew slower than the currency was devaluated, and therefore inflation has become "too low", in comparison to its theoretically optimal level. However, in this situation inflation can hardly be called counter-productive, but on the contrary, higher inflation would have been beneficial for output growth.

[5] See Appendix for a more detailed review.

[6] An attempt was made to include quadratic trends in the levels. However, the resulting system still showed strong signs of I(2), and therefore this idea was abandoned.

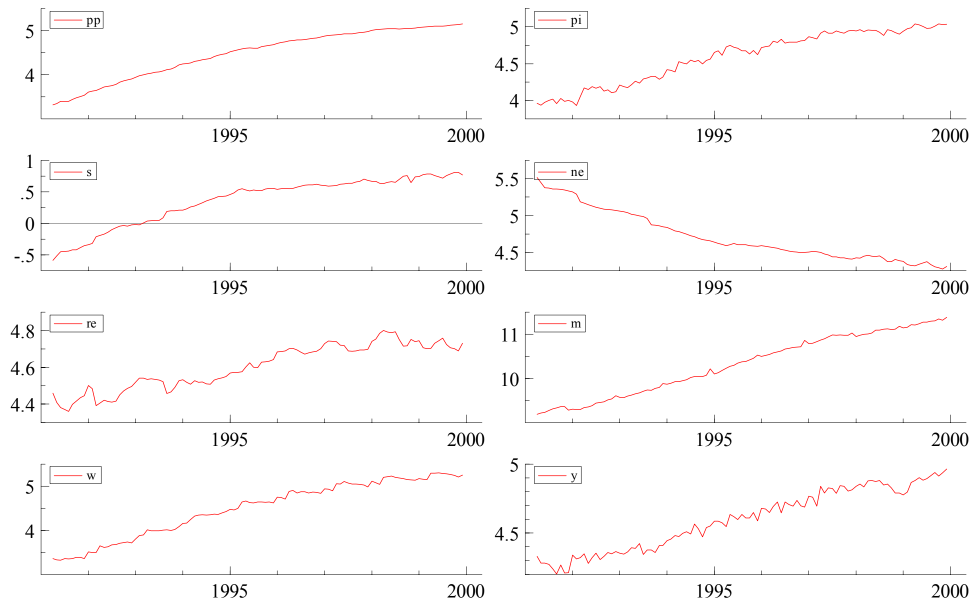


Figure 1: Data for all systems considered in the paper, levels.

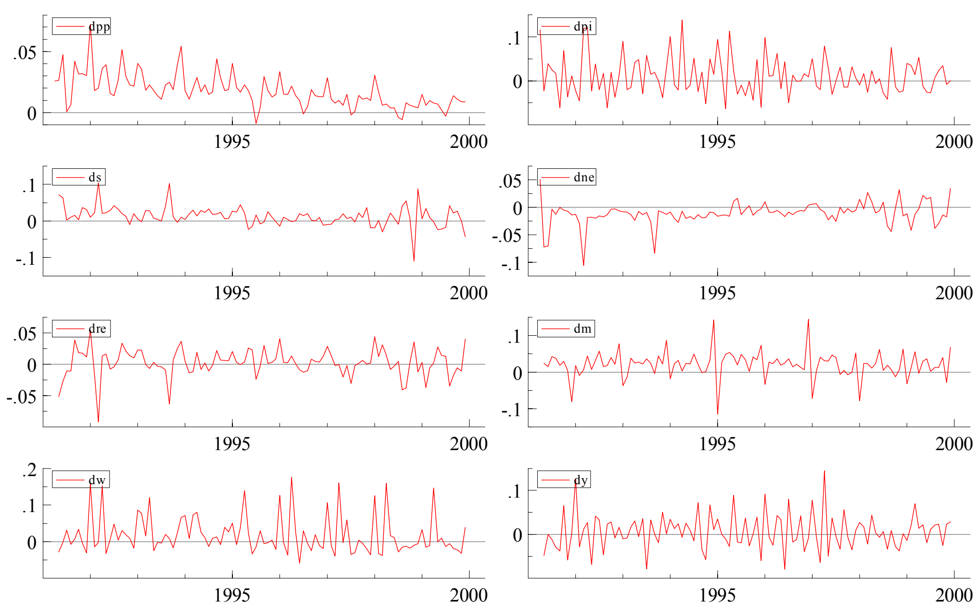


Figure 2: Data for all systems considered in the paper, differences.

robustness. It is found that all reported results hold throughout the analysis of all systems. Finally, a nominal to real transformation of the system is made, the best system is reduced to an I(1) model where the same results hold.

Table 2. Systems analyzed.

| System | Restricted variables | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. | $pp$ | $pg$ | $s$ | $m$ | $w$ | $y$ | $t$ |
| 2. | $pp$ | $pi$ | $s$ | $m$ | $w$ | $y$ | $t$ |
| 3. | $pp$ | | $s$ | $m$ | $w$ | | $t$ |
| 4. | $pp$ | $pi$ | $ne$ | $m$ | $w$ | $y$ | $t$ |
| 5. | $pp$ | $\Delta pi$ | $re$ | $m$ | $w$ | $y$ | $t$ |
| 6. | $pp$ | $\Delta ne$ | $re$ | $m$ | $w$ | $y$ | $t$ |
| 7. | $pp$ | | $re$ | $m$ | $w$ | $y$ | $t$ |
| 8. | $\Delta pp$ | $\Delta ne$ | $re$ | $m - b_1 t$ | $w - pp$ | $y - b_2 t$ | |

Unrestricted dummy variables were used in some of the systems ($dp941$, $dm9112$, $dre923$, $d951c$,and $d9612$),[7] which accounted for the following important policy interventions: major tax increases, change in the exchange rate regime, end of the Balcerowicz plan (in particular, the termination of the *popiwek* tax). Eleven centered seasonal dummies were also fitted.

The data are taken from the International Monetary Fund International Financial Statistics database and from the OECD Statistical Compendium (output). The data are monthly, from 1991:5 to 1999:12. The domestic price series ($pp$) is a logarithm of the consumer price index, ($pg$) is a logarithm of the German consumer price index, import price ($pi$) is a logarithm of the import price in zloty,[8] exchange rate ($s$) is a logarithm of exchange rate (zloty/DM), money ($m$) is a logarithm of nominal money stock,[9] the wage series ($w$) is a logarithm of the nominal wage rate, and output ($y$) is the logarithm of real GDP (OECD definition), real effective exchange rate ($re$) is logarithmized real effective exchange rate index,[10] ($ne$) is the logarithm of the analogously

[7] All dummies are centered impulse dummies that equal 1 at 1994:1, 1991:12, 1992:3, 1995:1, and 1996:12, correspondingly, and equal −1 in the subsequent period, with the rest of the observations equal to zero. The dummies correspond to the following important policy interventions. 1994 : 1, tax relief for producers, lowering of VAT threshold, rise in the income taxes, increase in budgetary sphere wages by 9%. 1991 : 12, change of the exchange rate regime, from fixed to crawling peg with daily devaluation against the basket of currencies. 1992 : 3, first devaluation against the basket, by 12%. 1995 : 1, redenomination, final lift of wage restrictions (Tripartite Comission, December 16, 1994 law goes into action). 1996 : 12, OECD membership, major tax regime changes, end of privatization certificates retrieval, over-the-counter stock market launch.

[8] Import prices for Poland are derived as a ratio of turnover in zlotys to turnover volume (IFS compendium).

[9] According to the IMF IFS compendium, the stock of narrow money is the sum of currency outside deposit money banks and demand deposits other than those of the central goverment.

[10] This index is a CPI-based REER indicator that is computed as a weighted geometric average of the level of consumer prices in the home country relative to that in its trade

defined nominal effective exchange rate. By definition, an increase in both *re* and *ne* indicates an appreciation of the zloty.

In Table 2, the unit root tests are reported. The null hypothesis is that of the unit root, the tests are conducted in PcGive, and the standard procedure for lag determination is used (see Hendry and Doornik, 1996). Trend and constant were fitted into the level series, and a constant alone to the differences and second differences.

Table 2. ADF tests for unit root.

| Variable | t-adf | Lag | Variable | t-adf | Lag |
|---|---|---|---|---|---|
| $pp$ | $-1.42$ | 6 | $m$ | $-1.39$ | 1 |
| $\Delta pp$ | $-1.04$ | 11 | $\Delta m$ | $-2.17$ | 11 |
| $\Delta^2 pp**$ | $-7.54$ | 10 | $\Delta^2 m**$ | $-6.48$ | 10 |
| $pi$ | $-0.12$ | 8 | $w$ | 2.55 | 11 |
| $\Delta pi**$ | $-5.52$ | 5 | $\Delta w$ | $-1.36$ | 11 |
| $\Delta pi$ | $-2.45$ | 11 | $\Delta^2 w**$ | $-11.47$ | 10 |
| $\Delta^2 pi**$ | $-6.83$ | 10 | | | |
| $s$ | $-1.75$ | 13 | $y$ | $-2.08$ | 2 |
| $\Delta s$ | $-2.16$ | 12 | $\Delta y**$ | $-12.23$ | 1 |
| $\Delta^2 s**$ | $-5.38$ | 11 | $\Delta^2 y**$ | $-19.58$ | 1 |

It can be seen that not all the variables can be conveniently considered to be I(1), but rather: for the first differences of $pp, s, m, ne$ and $w$ the unit root hypothesis cannot be rejected, and, marginally, for $\Delta pi$. This can explain the difficulties other researchers have experienced analyzing nominal monthly data for Poland (Wozniak (1998) and Enev and Koford (2000) had to change to the quarterly data, and others analyzed differenced series). Therefore, after considering the I(1) model, I must look for signs of I(2), as it is obvious that they are present in this system.

### 3.1 Analysis

We first consider a system with the German price index. This would have been the best to analyze, if not for the fact that the German price is too stationary for the Polish system, and therefore does not allow for proper cointegration analysis. Interestingly, the PPP does "hold"[11] between Germany and Poland; however, the system exhibits strong signs of I(2), and therefore more detailed analysis is needed. Unfortunately, due to the "strange" coefficient of the German price (too large coefficients in the stationary relations that made system non-analyzable), this was not possible, and nominal-to-real transformation

partners. Therefore, it is an analog of the *currency/zloty* type of index. See Zanello and Desruelle (1997).

[11] The test for one of the $\beta$-vectors being the *ppp* relation is accepted with $\chi^2(3) = 2.01[p = 0.57]$. The tests were conducted on a well-specified VAR(2) model, with 6 variables $\{pp, pg, s, m, w, y, t\}$ and 6 impulse dummies, with rank restricted to 3. However, this would indicate that *ppp* relation is I(1), instead of being I(0), because the system exhibited strong signs of I(2). This might be considered a relative *ppp* measure.

would not make economic sense. The results of system 1 are the following: the external sector does exhibit the expected relationships (relative *ppp* holds with correct signs); however, another system has to be found for the analysis of other sectors.

Therefore, instead of the German price an analogous system with Polish import price is considered. The tests show the following: (1) system is I(2); (2) money stock appears to be I(1); (3) real wages are probably also I(1); (4) $w$ is the main factor of disinflation; (5) $pi$ and $y$ are weakly exogenous in the very long run.

We then look at system 4, as the import price in system 2 is in *zloty*, and therefore cannot be used to check traditional parities. Inclusion of the nominal effective exchange rate might therefore be beneficial. The analysis gives the following results: (1) the system is I(2); (2) external sector variables display the signs predicted by theory; (3) real wages are probably I(1); (4) $pi$ and $y$ might be weakly exogenous; however, $pi$ enters an equation for itself and $y$; (5) $ne$ is significant only for the equation for $pi, ne$, and $w$; (6) $pp, m$, and $w$ significantly influence each other; (7) $pp$ and $m$ are not error-correcting, while $w$ is very strongly error-correcting.

Therefore, this analysis clearly demonstrates that wages were the most important instrument of bringing inflation down in Poland. Inflation would probably be explosive, if the *popiwek* had not been introduced,[12] as the money stock was growing and contributed to inflation formation, like the price level itself. The nominal effective exchange rate, as many other studies find, is weakly exogenous to the system of prices, money, and wages, but nevertheless stresses the relationships among these variables.

Still checking the robustness of results and looking for other signs of the importance of wages, let us look at system 5 with real effective exchange rates and imported inflation rate, in order to account for external trade effects and inflation in the neighboring countries. We obtain the following results: (1) system is I(2); (2) real wages are probably I(1); (3) $pp$ and $m$ are not error-correcting; (4) $w$ is strongly error correcting; (5) $\Delta pi$ and $y$ are probably weakly exogenous; (6) external variables enter stable (or I(1)) relationships; (7) $\Delta w = -0.7(w - pp)_{t-1} - 0.33re + 0.24m$, i.e. nominal wages are adjusting to the real wages. Therefore, once again, wage dynamics turns out to have been the decisive factor of disinflation.

The next nominal system under consideration is system 6. Before moving to the nominal-to-real transformation, the results of this last system are summarized: (1) the system is I(2); (2) $w$ and $pp$ can never be excluded from the system; (3) for low ranks, either $\Delta ne$ or $y$ might be excluded; (4) trend is significant only for the rank not greater than 2, and therefore might be excluded; (5) money is I(1); (6) $m$ is weakly exogenous for the ranks not exceeding 2; (7) $r = 2$ is the preferable choice; (8) $\Delta w$ is an error correction

[12] This statement is actually a speculation, without a causality test. However, the natural experiment could not be constructed, and therefore we interpret this result with care and look for other signs of the importance of wages for the Polish economy.

mechanism for the price increases, $\Delta pp$; (9) $\Delta ne$ might also have played a role in the disinflation process; however, this result must be verified further; (10) real wages are I(1); (11) the inclusion of the $\Delta ne$ is not justified in this I(2) system, as it shows weak exogeneity and possible exclusion of this variable, and distorts economic interpretation of the results. We should consider an I(2) system without including $\Delta ne$, and include it in the real transformation, in order to cointegrate with $re$ (which is supported by the system 6 analysis).

Finally, nominal system 7 is considered. From the previous analysis, it follows: (1) that the real exchange rate is at most I(1) between Poland and Germany (or, that *ppp* is a C(2,1) relation), (2) that wages seem to play the most important role in explaining price movements,[13] and (3) that money and the external sector play a comparatively weak role in the nominal price movements. It seems very probable that I(2) tests on a proper nominal system would reveal that the I(2) trend is cancelled out in the real wage variable, and the system can be transformed to I(1), and then analyzed.

### 3.2 Nominal System 7

Let us now consider in more detail nominal System 7, i.e. VAR(2) $\{pp, re, m, w, y, t\}$ with deterministic variables represented by eleven centered seasonals and five impulse dummies $dp941$, $dm9112$, $dre923$, and $d951c$, which are described in more detail in the data section. The system is well specified, as the normality failure is not due to asymmetric measures,[14] see Table 4. All dummies were found significant for at least one of the variables (tests not reported).

Table 4. Misspecification tests.

| | autocorrelation $F(6,70)$ | ARCH $F(6,64)$ | Skewness | Normality $\chi^2(2)$ |
|---|---|---|---|---|
| $sys$[15] | 1.33 [0.03] * | 365.5 [0.09] | | 47.82 [0.00] ** |
| $pp$ | 1.5112 [0.1872] | 0.98 [0.45] | -0.19 | 17.6 [0.00] ** |
| $re$ | 0.60286 [0.7271] | 0.18 [0.98] | -0.30 | 5.88 [0.05] |
| $m$ | 0.71495 [0.6388] | 0.33 [0.92] | 0.22 | 8.82 [0.01] * |
| $w$ | 1.0023 [0.4309] | 0.75 [0.61] | 0.06 | 1.73 [0.42] |
| $y$ | 2.1639 [0.0568] | 0.38 [0.89] | -0.48 | 10.65 [0.01] ** |

In Table 5, the trace test results are shown. In what follows, the choice between rank of 3 and 2 is being made.

[13] In all the systems above, we found real wages $w - pp$ to be $C(2,1)$, and $w$ to be the most error-correcting variable.

[14] See Juselius (2002).

[15] The system test statistics are distributed like $F(150, 212)$ for autocorrelation, $\chi^2(330)$ for ARCH, and $\chi^2(10)$ for the normality test.

Table 5. Trace test results

| $Ho: rank \leq r$ | $eigenvalue$ | $-T\backslash SumLog$ | 95% |
|---|---|---|---|
| $r = 0$ | 0.49 | 147.6** | 87.3 |
| $r \leq 1$ | 0.35 | 84.1** | 63.0 |
| $r \leq 2$ | 0.22 | 43.82* | 42.4 |
| $r \leq 3$ | 0.13 | 20.28 | 25.3 |
| $r \leq 4$ | 0.08 | 7.43 | 12.3 |

In order to see if the system is I(2), one should restrict the largest root to one, and look at how the other roots change (Table 6). Because the unit root is not eliminated by restriction to 1, the system has one common trend.

Table 6. Largest roots of $C$.

| $unrestricted$ | **0.98** | 0.98 | 0.65 | 0.65 | 0.39 | 0.39 | 0.33 |
|---|---|---|---|---|---|---|---|
| $r = 4$ | 1 | **1.00** | 0.66 | 0.66 | 0.37 | 0.37 | 0.34 |
| $r = 3$ | 1 | 1 | **0.98** | 0.56 | 0.42 | 0.42 | 0.36 |
| $r = 2$ | 1 | 1 | 1 | **0.94** | 0.40 | 0.32 | 0.32 |
| $r = 1$ | 1 | 1 | 1 | 1 | **0.91** | 0.50 | 0.19 |

The I(2) trace test is shown in Table 7. We take the conventional order of acceptance, and see that indeed the case of one I(2) trend, $r = 3$, and one independent I(1) trend is the most probable. This is also suggested by the theory.

The power of the trace test has been found to be quite low, especially in a system with dummy variables (Johansen, 1998; Jorgensen, 1998; Juselius, 1999). Therefore, the marginal acceptance should not matter too much. In the following analysis, I sometimes report the case of $r = 2$, in order to show the robustness of this result.

Table 7. Trace test for I(2) model.

| $r$ | $S(r\|s_1)$ | | | | | $Q(r)$ |
|---|---|---|---|---|---|---|
| 0 | 597 | 444 | 339 | 257 | 190 | 163 |
| | *(192)* | *(162)* | *(137)* | *(115)* | *(96)* | *(83)* |
| 1 | | 418 | 268 | 175 | 103 | 93 |
| | | *(132)* | *(108)* | *(88)* | *(71)* | *(59)* |
| 2 | | | 235 | 131 | 62 | 48 |
| | | | *(82)* | *(64)* | *(50)* | *(40)* |
| 3 | | | | 110 | **33** | **22** |
| | | | | *(44)* | *(32)* | *(23)* |
| 4 | | | | | 34 | **8** |
| | | | | | *(18)* | *(11)* |
| $s_2$ | 5 | 4 | 3 | 2 | 1 | 0 |

Table 8 reports the tests for long run exclusion, I(1)ness of the variables, and zero rows in the adjustment matrix $\alpha$. The last test is an approximation of the weak exogeneity: the desired test for weak exogeneity in the I(2) space would include complex restriction on the matrices $\alpha_{\perp 1}$ and $\beta_{\perp 1}$. Weak exogeneity cannot be interpreted in the same way in the I(2) model as it is in the I(1) world (see Paruolo, Rahbek, 1998). These test would only mean (non)adjustment of a variable to the long run relations, and not necessarily its weak exogeneity in the classic definition.

The long run exclusion test is also not exactly the analog of its I(1) version, but is equivalent to the testing for a unit vector in the $\beta_{\perp 2}$ space. Instead, I test the exclusion from $\beta$, and therefore each rejection means the rejection of the initial hypothesis, while each acceptance would not necessarily mean acceptance of the initial hypothesis.

The I(1)ness test in I(2), in addition to restrictions on $\beta$ would include restrictions on $\beta_{\perp 1}$ The acceptance of our test will imply acceptance of the initial hypothesis, while rejection would not necessarily mean rejection of the initial hypothesis.

It must be kept in mind that these tests are single-variable tests, and therefore the hypotheses of several variables being I(1) or excluded altogether should be tested separately.

Table 8. Tests.

| $r$ | $d$ | $\chi^2(d)$ | $pp$ | $re$ | $m$ | $w$ | $y$ | $trend$ |
|---|---|---|---|---|---|---|---|---|
| long run exclusion, $\chi^2(r)$ | | | | | | | | |
| 2 | 2 | 5.99 | 22.35 | 9.47 | 20.06 | 21.09 | **4.7** | 6.76 |
| 3 | 3 | 7.81 | 33.28 | 9.79 | 20.93 | 31.85 | 15.83 | 7.87 |
| I(1)ness, $\chi^2(p-r)$ | | | | | | | | |
| 2 | 4 | 9.49 | 15.06 | **6.91** | 9.99 | 13.75 | 14.42 | |
| 3 | 3 | 7.81 | 8.87 | **2.78** | **3.19** | 7.39 | **2.64** | |
| Zero coefficient in $\alpha$, $\chi^2(r)$ | | | | | | | | |
| 2 | 2 | 5.99 | 33.18 | 12.13 | **3.69** | 27.34 | 10.58 | |
| 3 | 3 | 7.81 | 43.50 | 14.41 | **4.32** | 37.85 | 19.39 | |

It is easy to see in Table 8 that money is not adjusting to the long run relations, and that the real effective exchange rate and money must be I(1), and probably also output. In the case of the simultaneous acceptance of these hypotheses, the I(2) trend would be solely driven by prices and wages, and therefore it would be possible to make a nominal-to-real transformation of the system. Output is shown to be possibly excluded from the long run relations, which should be expected from a real variable in the nominal system; however, this is not so in the system with $r = 3$, which is our preference.

Making the choice between rank of 2 and 3, I generally decide whether to treat money as an I(1) or as an I(2) variable, and this choice must be based on the I(2) analysis of the whole system. In such a way, if I can find a nominal-to-real transformation of the system that includes $m$, it would imply that $m$ is best approximated by I(1) process. Thus, I should first consider vector $\beta_{\perp 2}$, and if the I(2) trend is mostly led by variables other than money, I should choose $r = 3$. The obtained real system should also have economic meaning.

In Table 9 the cointegrating space basis is shown, unrotated. It is easy to see that the hypothesis about the real wages being I(1) might be accepted, as prices and wages are cointegrating (more or less) one-to-one in all three $\beta$-vectors.

Table 9. Cointegration space basis $\beta_0$

| *pp* | *re* | *m* | *w* | *y* | *trend* |
|---|---|---|---|---|---|
| -0.91 | 0.49 | -0.26 | 1 | -0.30 | 0.003 |
| 1 | 0.02 | 0.42 | -1.1 | -0.33 | -0.002 |
| 0.52 | -0.14 | 0.04 | -0.7 | 1 | -0.002 |

and adjustment matrix $\alpha_0$.

| | | | |
|---|---|---|---|
| *pp* | **-0.12** | **-0.07** | **-0.04** |
| *re* | **-0.16** | -0.02 | **0.10** |
| *m* | -0.06 | 0.11 | -0.05 |
| *w* | **-0.28** | **0.47** | 0.03 |
| *y* | 0.03 | **0.61** | **-0.30** |

The long run weak exogeneity of money is supported by both Table 9 and Table 10.

Table 10. The $\Pi$ matrix.

| | *pp* | *re* | *m* | *w* | *y* | *t* |
|---|---|---|---|---|---|---|
| *dpp* | -0.02 | **-0.05** | -0.00 | -0.01 | 0.02 | -0.000 |
| *dre* | **0.18** | **-0.09** | 0.04 | **-0.21** | **0.15** | -0.001 |
| *dm* | 0.15 | -0.02 | 0.06 | -0.15 | -0.07 | -0.000 |
| *dw* | **0.74** | **-0.13** | **0.27** | **-0.82** | -0.04 | -0.002 |
| *dy* | **0.43** | 0.07 | **0.24** | **-0.43** | **-0.51** | -0.000 |

From the matrix $\Pi$, Table 10, one can see that money is not error-correcting, while output, exchange rate and (most of all, and very strongly and significantly) wages are error-correcting. Significant values are in bold.

Let us now look at the basis of the I(2) space. Even without rotation, it is easily seen that the I(2) trend is mostly driven by the prices and wages, and that these two must cointegrate $CI(2,1)$. However, other variables also contribute to the I(2) trend, and therefore, it might be necessary to use polynomial cointegration or detrending while transforming the system to I(1).

Table 11. The I(2) space, $r = 3, s_1 = 1, s_2 = 1$[16]

| | $\hat{\beta}_0$ | | $\hat{\beta}_{1.1}$ | $\hat{k}_1$ | $\hat{\beta}_{\perp 1.1}$ | $\hat{\beta}_{\perp 2}$ |
|---|---|---|---|---|---|---|
| *pp* | -0.98 | 1 | 0.21 | -10.03 | -1.28 | -1.12 |
| *re* | -0.09 | -0.24 | 1 | -1.16 | -0.30 | -0.13 |
| *m* | -0.51 | 0.27 | 0.09 | -3.77 | 3.34 | -0.42 |
| *w* | 1 | -1.17 | -0.46 | -10.07 | -0.03 | -1.13 |
| *y* | 0.98 | 0.56 | 0.54 | -1.79 | 0.46 | -0.20 |
| *trend* | 0.001 | -0.003 | 0.002 | | | |

and adjustment coefficients.

| | $\alpha_0$ | | $\alpha_1$ | | $\alpha_{\perp 1.1}$ | $\alpha_{\perp 2}$ |
|---|---|---|---|---|---|---|
| *dpp* | 0.02 | 0.04 | -0.04 | | -0.07 | -0.05 |
| *dre* | 0.04 | **0.23** | -0.03 | | -0.02 | **0.18** |
| *dm* | -0.10 | 0.06 | -0.02 | | **0.22** | 0.01 |
| *dw* | **-0.29** | **0.47** | -0.04 | | -0.01 | -0.08 |
| *dy* | **-0.50** | -0.06 | 0.01 | | -0.04 | 0.06 |

The Kongsted condition for the possibility of nominal-to-real transformation (Kongsted, 2000) holds, and even though the test for transformation is marginally rejected,[17] I transform the system into the real one, taking additional measures[18].

### 3.2.1 Identification

Even though in the next subsection a real system is considered, identification of the $\beta_0$-space could be beneficial for economic analysis. The following hypothesis about the $\beta_0$-space basis cannot be rejected with $\chi^2(5) = 10.27[p = 0.07]$: real wages are I(1), $m - y$ is I(1) (see Table 12).

[16] If $(r > s_2)$, then $r_0 = r - s_2 = 2, r_1 = s_2 = 1$.

[17] The statistics are: $\chi^2(3) = 10.8[0.01]^*$; and $\chi^2(2) = 5.7[0.06]$, correspondingly.

[18] We detrend money and output, in addition to taking real instead of nominal wages. As variables in system 8 are very different with respect to the trend component, it might be a reason for marginal rejection of the transformation. By excluding trend from "borderline cases" we might get closer to the I(1) framework. We will see in the next subsection that the signs of I(2) are indeed eliminated from the system by these measures.

Table 12. Identified cointegration space $\beta_0$

| $pp$ | $re$ | $m$ | $w$ | $y$ | $t$ |
|---|---|---|---|---|---|
| 1 | 0 | 0 | $-1$ | 0 | $-0.001$ (0.0005) |
| 1 | 0 | $-1$ | $-1$ | 1 | 0.002 (0.002) |
| 0 | $-0.3$ | $-0.27$ (0.03) | $-0.06$ (0.02) | 0.63 | 0.00 |

and adjustment matrix $\alpha_0$.

| | | | |
|---|---|---|---|
| $pp$ | 0.07 | -0.03 | **0.13** |
| $re$ | **0.43** | **-0.25** | **0.62** |
| $m$ | 0.24 | -0.04 | -0.05 |
| $w$ | **1.04** | **-0.38** | **0.56** |
| $y$ | **0.61** | -0.13 | -0.17 |

It should be noted, however, that this test, in the I(2) framework, shows the relations to be at most I(1), and not necessarily I(0), as in the I(1) framework:

$(w - pp) + 0.001t \sim I(1)$;

$(w - pp) + (m - y) - 0.002t \sim I(1)$;

$0.3re + 0.27m + 0.06w - 0.63y \sim I(1)$

The first equation shows that the relation $(w - pp)$ is indeed C(2,1), and therefore real transformation must be possible. It is also discovered that: the last relation displays homogeneity of the coefficients, and therefore good convergence to the long run equilibrium in the system; money is weakly-exogenous in the long run, and this is also accepted when tested statistically. If the second equation turned out to be I(0) instead of I(1), then in the real system one should see that excessive money supply and real wages cointegrate C(1,0). I proceed to the transformed system, in order to find stationary relations.

### 3.3 Real System 8

System 8 consists of the real variables, with the money and output expansions above the trend, $\{\Delta pp, \Delta ne, re, m - b_1 t, w - pp, y - b_2 t\}$. It includes unrestricted impulse dummy variables $dp941$, $d9612$, $dm9112$, $dre923$, $d951c$, and also eleven seasonal centered dummies. It is well specified, as shown in Table 13.

Table 13. Single equation misspecification tests

| | autocorrelation $F(6,68)$ | ARCH $F(6,62)$ | Skewness | Normality $\chi^2(2)$ |
|---|---|---|---|---|
| $sys$[19] | 1.10 [0.24] | 0.73 [0.99] | | 19.31 [0.08] |
| $\Delta pp$ | 0.86 [0.53] | 1.38 [0.24] | 0.06 | 6.81 [0.03] * |
| $\Delta ne$ | 1.15 [0.34] | 0.25 [0.95] | -0.26 | 5.05 [0.08] |
| $re$ | 0.54 [0.77] | 0.27 [0.95] | -0.33 | 5.56 [0.06] |
| $m - b_1 t$ | 0.60 [0.73] | 1.45 [0.21] | -0.41 | 4.99 [0.08] |
| $w - pp$ | 1.13 [0.35] | 0.69 [0.66] | 0.28 | 2.79 [0.25] |
| $y - b_2 t$ | 3.10 [0.01] * | 0.42 [0.86] | -0.43 | 4.97 [0.08] |

Table 14 represents results of the trace test, it is likely that rank is equal to 3.

Table 14. Trace test results

| $Ho: rank \leq r$ | $eigenvalue$ | $-T \backslash SumLog$ | 95% |
|---|---|---|---|
| $r = 0$ | 0.56 | 190** | 94.2 |
| $r \leq 1$ | 0.40 | 105.4** | 68.5 |
| $r \leq 2$ | 0.25 | 53.11* | 47.2 |
| $r \leq 3$ | 0.14 | 23.53 | 29.7 |
| $r \leq 4$ | 0.07 | 8.16 | 15.4 |
| $r \leq 5$ | 0.00 | 0.21 | 3.8 |

Table 15 represents a check for the remains of the I(2) in the real system, and it shows that all the I(2)ness has been eliminated. It also argues in favor of $r = 3$.

Table 15. Largest roots of $C$.

| $unrestricted$ | **0.99** | **0.99** | **0.67** | **0.67** | 0.58 | 0.58 |
|---|---|---|---|---|---|---|
| $r = 5$ | 1 | **0.99** | **0.67** | **0.67** | 0.58 | 0.58 |
| $r = 4$ | 1 | 1 | **0.68** | **0.68** | 0.57 | 0.57 |
| $r = 3$ | 1 | 1 | 1 | 0.59 | 0.58 | 0.58 |
| $r = 2$ | 1 | 1 | 1 | 1 | 0.58 | 0.58 |
| $r = 1$ | 1 | 1 | 1 | 1 | 1 | 0.58 |

Table 16 shows the test results for exclusion, stationarity, and weak exogeneity. None of the variables is found to be stationary. All variables are important for the long run. Exchange rates show signs of weak exogeneity, which is a usual behavior: joint tests are very likely to fail. The weak exogeneity of the real wages is actually not significant, if compared to the model of $r = 2$.

[19] The system test statistics are distributed like $F(216, 204)$ for autocorrelation, $\chi^2(504)$ for ARCH, and like $\chi^2(12)$ for normality tests correspondingly.

Table 16. Tests.

| $r$ | $d$ | $\chi^2(d)$ | $\Delta pp$ | $\Delta ne$ | $re$ | $m - b_1 t$ | $w - pp$ | $y - b_2 t$ |
|---|---|---|---|---|---|---|---|---|
| | | | | Exclusion, $\chi^2(r)$ | | | | |
| 3 | 3 | 7.81 | 34.31 | 33.39 | 17.17 | 12.71 | 8.85 | 20.96 |
| 4 | 4 | 9.49 | 41.71 | 40.80 | 24.46 | 14.85 | 16.05 | 27.15 |
| | | | | Stationarity, $\chi^2(p-r)$ | | | | |
| 3 | 3 | 7.81 | 19.86 | 18.74 | 20.46 | 29.27 | 21.02 | 16.46 |
| 4 | 2 | 5.99 | 7.48 | 7.50 | 7.77 | 15.10 | 7.07 | 10.48 |
| | | | | Weak exogeneity, $\chi^2(r)$ | | | | |
| 3 | 3 | 7.81 | 59.90 | 8.77 | 10.28 | **4.90** | **5.71** | 17.01 |
| 4 | 4 | 9.49 | 67.12 | **8.78** | 10.77 | **8.07** | 12.31 | 20.50 |

The matrix $\Pi$ is reported in Table 17. All variables are error-correcting, apart from money, which is (significantly) not. Money influences all variables in the system. At the same time, inflation rate and nominal exchange rate enter money equation, while a large excess money supply causes bigger increase in the money supply over the trend.

Table 17. The $\Pi$ matrix.

| | $\Delta pp$ | $\Delta ne$ | $re$ | $m - b_1 t$ | $w - pp$ | $y - b_2 t$ |
|---|---|---|---|---|---|---|
| $\Delta^2 pp$ | -0.76 | 0.48 | **-0.05** | -0.01 | **-0.04** | **0.04** |
| $\Delta^2 ne$ | -0.35 | -0.91 | -0.03 | **-0.03** | **0.07** | **0.11** |
| $\Delta re$ | -0.44 | 0.28 | **-0.08** | **-0.04** | 0.03 | **0.15** |
| $\Delta(m - b_1 t)$ | **-2.93** | **-3.19** | -0.01 | **0.03** | -0.03 | -0.08 |
| $\Delta(w - pp)$ | 0.06 | 0.44 | **0.07** | **0.05** | **-0.10** | **-0.20** |
| $\Delta(y - b_2 t)$ | -2.03 | -2.90 | **0.19** | **0.14** | **-0.16** | **-0.50** |

Thus, wages had a stabilizing impact on inflation, and real appreciation was associated with lower inflation:

$\Delta pp_t = \Delta pp_{t-1} - 0.05 re_{t-1} - 0.04((w - pp)_{t-1} - (y_{t-1} - b_2 t))$.

Real wages grew along with appreciation, increase in money stock over the trend, and turned out to provide the strongest error-correcting mechanism (see the diagonal of the $\Pi$ matrix in Table 17):

$\Delta(w - pp)_t = 0.07 re_{t-1} + 0.05(m - b_1 t) - 0.1(w - pp)_{t-1} - 0.2(y - b_2 t)_{t-1}$.

Money growth had positive impact on output, as did real appreciation, and decrease in the real wages was associated with output growth:

$\Delta(y - b_2 t)_t = 0.19 re_{t-1} + 0.14(m - b_1 t)_{t-1} - 0.16(w - pp)_{t-1} - 0.5(y - b_2 t)_{t-1}$.

### 3.3.1 Identification

In this subsection, let us look at the tests for the cointegrating space basis, and present a just-identified space for $r = 3$, which has been chosen as a preferred rank in the previous analysis. Table 18 displays the identified space, along with the non-zero standard errors in parentheses. The lower part of the table represents the $\alpha$ matrix, with significant values in bold face. The test has been accepted with $\chi^2(5) = 5.95$ $[p = 0.31]$.

Table 18. Identified cointegration space $\beta$

| $\Delta pp$ | $\Delta ne$ | $re$ | $m\_t$ | $w-pp$ | $y\_t$ |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0.09 (0.005) | 0 |
| 0 | 0 | 1 | 0.5 (0.15) | $-1$ | $-2$ (0.03) |
| 1 | 1 | 0.01 (0.00) | 0 | 0 | $-0.01$ (0.001) |

and adjustment coefficients $\alpha$.

| | | | |
|---|---|---|---|
| $\Delta pp$ | **-1.16** | **-0.04** | 0.55 |
| $\Delta ne$ | 0.57 | -0.04 | -0.9 |
| $re$ | -0.62 | **-0.08** | 0.36 |
| $m\_t$ | 0.15 | 0.05 | **-3.6** |
| $w-pp$ | -0.56 | **0.09** | -0.11 |
| $y\_t$ | 1.10 | **0.24** | -2.68 |

The test for cointegration between $w-pp$ and $m-y$ failed, and therefore the differences are needed to bring the second basis vector of the identified nominal system to stationarity. I conclude that none of the $\beta$-vectors of the identified nominal system 7 was stationary. In this system the following long run relations hold:

$\Delta pp + 0.1(w-pp) \sim I(0)$, or $\Delta pp = -0.1(w-pp)$;

$re + 0.5(m - b_1 t) - (w-pp) - 2(y - b_2 t) \sim I(0)$;

$\Delta pp + \Delta ne + 0.01re - 0.01(y - b_2 t) \sim I(0)$, or $\Delta pp = -\Delta ne - 0.01re + 0.01(y - b_2 t)$.

From the first relation, it is seen that wages were the most important factor of inflation formation. An increase in real wages brought inflation down.

The second equation is considered as an equation for output: output grew above its trend along with (trend) monetary easing, appreciation, and real wages decrease; increase in nominal price level was beneficial for output in the long run.

The third equation shows the impact of the external sector on the inflation in the long run: real and especially nominal depreciation contributed to the increase in inflation.

Thus, it seems from the first equation that incomes policy was over-restrictive, and actually had an overshooting effect on inflation (as Ellman(1993) argues). However, this had a positive impact on the output, promoted by the higher inflation level, and from this point of view, this restriction was beneficial in the long run.

## 4 Conclusions

The long run and short run processes in the Polish economy, which led to the following main conclusions: (1) Polish inflation had a cost-push nature, and therefore it can be reasonably argued that the *popiwek* tax was one of the main instruments of stabilization in Poland;[20] (2) while the wage level positively influences prices in the long run, its medium-run changes are negatively and one-to-one transmitted into the inflation; (3) import prices are important only in the medium-run, and do not enter the long run relationships;[21] (4) in the medium-run, output is negatively affected by imported inflation and money supply growth; (5) output is important in the medium-run, and does not influence the (nominal) system in the long run (expected); (6) the Balcerowicz plan has indeed been crucial for the Polish stabilization, and the CB has had some power in controlling prices in the long run using monetary instruments, a finding that contradicts the bulk of empirical research on Poland.

This paper is compared with the literature in the following way. The result of Brada and Kutan (1999) that Polish stabilization was the result of foreign disinflation, and that it was the only reason of the successful stabilization, is not supported. On the contrary, I find that wages and prices were equal and the most important drivers of the I(2) trend. This finding explicitly points to the presence of a wage-price spiral in Poland, the existence of which was rejected by such senior and policy-making authors as Desai (1998). I do agree on this point with Fischer and Sahay (2000), who mention Poland as a good example of dedollarization resulting from wage policies that constrained the price-wage spiral. The data shows that prices grew along with wages, and, knowing that the growth of wages was severely constrained, it can be concluded that this was the reason for prices not growing further[22].

The importance of monetary policy for the exchange rate dynamics (Dibooglu and Kutan, 2001) is supported. However, the money never mattered alone, and all equations that include both $m$ and $re$ (or $ne$), always include $w$ and $y$ as well. This suggests a more complex relationship between incomes, monetary and exchange rate policies than the authors argue for.

Unlike Enev and Koford (2000), I do not find that, in the Polish heterodox stabilization plan, the most important nominal anchor was the exchange rate. The authors mention low labor hoarding as one of the reasons for this. However, low labor hoarding should have promoted the efficiency of the wage anchor, and not the other way around. The same holds for low firing restrictions and high unemployment: they would have increased the efficiency of the nominal wage anchor, as opposed to the Russian experience, where due to high labor hoarding, low official unemployment, and firing restrictions, the

[20] Importantly, this finding contradicts Desai (1998), Brada and Kutan (1999), according to whom wage-price spiral is not possible in Poland (see pg 2-3 of this paper for discussion).

[21] This can be interpreted meaning that they are important as long as the institutions of the economy are unchanged, while the long-run change of the institutional structure of the Polish economy has eliminated their influence on the domestic variables, along with the strengthening of growth and independence of the Polish economy.

[22] It is true that there is no natural experiment here, i.e. an identical economy where wages were not constrained, to see what would have happened to prices. However, the VAR model gives us a framework for making "everything else equal" statements. Therefore, it can be confidently concluded that, if wages had grown, prices would have followed. Thus, we can actually make the point that the main feature of the Polish stabilization plan was the *popiwek* tax.

wage anchor was not binding, as the workers had developed other means of support.

It is found that more inflation would be beneficial for the growth of output. This might be an indication in favor of Kim's (2001) argument for the 'scorched earth' policy being too restrictive. Winiecki (1993) and Ellman (1993) also noted that the nominal wage anchor caused too much devaluation, which embodied in counter-productiveness of inflation. As was mentioned before, they might refer to a situation when wages grew slower than currency was devaluated (exchange rate was fixed at that time), and therefore inflation has become "too low", in comparison to its theoretically optimal level. However, in this situation higher inflation would be beneficial for output growth. Given the method and data available, it is difficult to pinpoint the direction of the causality.

Concerning the discussion of an impact of real variables on inflation, in the real system one basis vector was found that includes both inflation and output with a significant positive coefficient, like in Enev and Koford (2000).

## 5 Policy Implications

This section compares these results to the analogous analysis of the Russian economy (Vostroknutova, 2002).

It turns out that money was endogenous in the short run and exogenous in the long run for both Poland and Russia. In Poland, $re$ was led by both monetary and real shocks. In Russia, its dynamics were most influenced by monetary shocks in the long run and by shocks to the domestic price level in the short run. Appreciation of the $re$ was good for the Polish producers, while it was detrimental for the Russian output, which is consistent with the fact that there was initial over-depreciation in Poland, and initial over-appreciation in Russia. Price level growth benefited Polish production, while it was harmful in Russia. Whereas in Russia real variables significantly influence the dynamics of nominal systems, in Poland this is true only for the $re$.

It is postulated that for the CB to be able to control inflation, its independence, along with stable money-price relationship, and exogeneity of money, are required. Having analyzed two different transition economies, it is argued that money can be assumed to be exogenous for both of them. In Russia, the existence of a stable long run money-price relationship is undermined, while money does have a very large impact on the dynamics of stochastic component of prices. In Poland, money did not play the most important role in price dynamics, and had only an indirect effect on the real system, through the exchange rate. In both countries, an I(1) relation between money and prices was found, which contradicts classical theory, and might be an indication of the dependence on institutional changes during the transition period. These findings generally support previous research on transition countries that has not discovered a stable direct relationship between money and prices. However, I argue that in Russia money had a greater effect on the overall nominal price performance than in Poland, and that inflation had monetary roots in Russia as opposed to the wage-driven inflation in Poland.

Fischer and Sahay (2000) mention Poland and Russia as two examples of on-time and "too late" exiting from the peg regime correspondingly. This can be also seen in the data, as the exchange rate is a binding constraint in the Russian system (and has a strong impact on prices), while it is weakly exogenous to the Polish system and does not influence stochastic dynamics (although it enters stable relations with correct sign). It is an interesting result that in Poland real appreciation had a positive effect on the output, while in Russia it had a negative effect.[23] This finding is generally consistent with the theory that claims over-depreciation in Poland, and over-appreciation in Russia before 1998 (see, for example, Fischer and Sahay, 2001).

The issue of long run effect of monetary policy on prices seems to be resolved in favor of "no effect". However, I do find a positive relationship between money and output: for both countries monetary easing was good for their output in the long run.

One can see that the policies implemented in Poland did, in fact, worked, and stabilized the economy, while in Russia the ability of the CB to control the money stock and exchange rate is doubtful in the long run. The main ingredient of the Polish stabilization remains the *popiwek* tax on wage increases, while in Russia the external sector and money stock are the main channels of nominal price growth).[24]

If one compares the results for Russia with the results for Poland obtained by previous studies (and on the earlier period of Polish transition), they look similar. This might suggest that during the early stages of stabilization, before the financial and monetary institutions were established and the CB had seized control over its monetary instruments, it appears that the CB did not have enough power, and inflation is mainly imported. In this case, one should wait until some more data is available for Russia. However, given the number of years since stabilization in Russia (seven), and comparing it to the years since stabilization in Poland (one), when this result was found, one can afford to be sceptical.

Two stabilization policies were compared. The Polish one has been called the "scorched earth" policy, because of its harmful social effect, and due to the belief that a much less restrictive monetary (and especially incomes) policy would have had the same stabilizing effect. I found that the Polish

[23] The fact that we used nominal output for Russia should not matter, as the real output can be extracted by summation.

[24] It is interesting, when reading the reports about Russian transition, 90 percent of the government announcements promise to increase the minimum wage, but no similar promises are made in Poland. This might be dependent on the severe political constraints that took place in Russia during the whole period of transition, and supplied a reason for the prolonged stabilization in the country.

government 'scorched the earth' for a reason: the analysis shows that the *popiwek* tax on wage increases was the main and, indeed, almost the only instrument of stabilization, without which inflation would probably have been of an explosive nature. However, it also follows from the data that more inflation would have been beneficial for output growth.

The Russian stabilization was also assumed to be a Big Bang policy, until it was realized that the reforms and stabilization packages were not implemented fully and were often reversed (Buch, 1998, among others). It is beyond the scope of this paper to understand the reality of the threats of the Russian ex-ante political constraints, and what would have happened if a Polish-type policy had indeed been implemented fully there. It is obvious, however, that the inertia in stabilization caused by the reversals and procrastinations in the stabilization measures caused a decade of stagnation not only in Russia but in many countries of the CIS as well.

## References


[1] Artis, M., Kontolemis, Z. (1996) Inflation in the UK in the 1980s. In (eds.) P. de Grauwe, S. Micossi, and G. Tullio, Inflation and Wage behaviour in Europe, Oxford University Press

[2] Berg, A., E. Borensztein, R. Sahay, J. Zettelmeyer (1999) The Evolution of Output in Transition Economies, IMF WP 99/73

[3] Blejer M., Skreb, M. (1993) Macroeconomic Stabilization in Transition Economies. Cambridge University Press, 1997

[4] Brada J. (1998) Introduction: Exchange rates, Capital Flows, and Commercial Policies in transition economies, Journal of Comparative economics, 26, 4:613-620, Dec. 1998

[5] Brada, J., M. Kutan (1999) The end of moderate inflation in three transition economies, The William Davidson Institute, Working Paper No 230

[6] Buch C. (1998) Russian Monetary Policy - Assessing the track record, Economic Systems, v.22, 405-145

[7] Christoffsen and Doyle (2000) From Inflation to Growth. Eight years of transition, Economics of Transition, vol. 8(2), 421-451

[8] Christoffsen, Sløk,Wescott (2001) Is Inflation Targeting Feasible in Poland? Economics of Transition, vol. 9 (1), 153-174

[9] Desai P. (1998) Macroeconomic Fragility and Exchange rate Vulnerability: A Cautionary Record of Transition Economies, Journal of Comparative Economics, V.26, N 4, December

[10] Dibooglu, S., A. Kutan (2001) Sources of real exchange rate fluctuations in transition economies: the case of Poland and Hungary, Journal of Comparative Economics, v. 29, 257-275

[11] Doornik, Jurgen A., Hendry David F. (1997) Modelling dynamic systems using PcFiml 9.0 for Windows, International Thomson Business P, London

[12] Ellman, M. (1992) Shock Therapy in Russia: Failure or Partial Success?, RFE/RL Research Report, 1, 34:48-61, August 28, 1992

[13] Ellman, M. (1993) General Aspects of Transition, in M. Ellman, Gaidar and G.W. Kolodko, Economic Transformation in Eastern Europe, Basil Blackwell

[14] Enev, T., Koford, K. (2000) The effect of income policies on inflation in Bulgaria and Poland, Economics of Planning, v. 33, 141-169

[15] Fischer S., Sahay, R. (2000) The transition Economies after Ten Years, IMF working paper WP/00/30

[16] Frye T., Shleifer A. (1997) The Invisible Hand and the Grabbing Hand, *American Economic Review*, 87, 2, 354-358

[17] Hansen, Henrik, Juselius, Katarina (1995) CATS in RATS : cointegration analysis of time series, user's manual Evanston: Estima

[18] Hendry David F., Doornik, Jurgen A. (1996) Empirical econometric modelling using PcGive 9 for Windows, International Thomson Business P, London

[19] Hoen, H. (1998) The transformation of economic systems in CE. EEUK Studies in Comparative Economic Systems

[20] Johansen S. (1995).Likelyhood-Based Inference in Cointegrated VAR models, Oxford University Press

[21] Jørgensen, C., Kongsted, H.C., Rahbek, A. (1999) Trend Stationarity in the I(2) Cointegration Model, *Journal of Econometrics*, Vol. 90 (1999), 265-289

[22] Juselius K. (1992) Domestic and Foreign Effects on Prices in an open economy: The case of Denmark, Journal of Policy Modeling, 14, 4, 401-428

[23] Juselius K. (1999) Price Convergence in the medium and long run. An I(2) analysis of six price indices. Institute of Economics, University of Copenhagen, mimeo

[24] Juselius K., Gennari, E. (2000) European Integration and MOnetary Transmission Mechanisms: The Case of Italy. European Unievrsity Institute, mimeo

[25] Juselius, K. (2002) The Cointegrated VAR Model: Econometric Methodology and Macroeconomic Applications, unpublished book, University of Copenhagen

[26] Kim B.-Y. (2001) Determinants of Inflation in Poland: A Structural Cointegration Approach, BOFIT Discussion Papers, No. 16

[27] Kongsted H.-C.(2000) Testing the Nominal-to-Real Transformation, Discussion Paper 02-06, Institute of Economics, University of Copenhagen

[28] Korhonen, I. (1998) An error-correction model for prices, Money, Output and interest rate in Russia, Bank of Finland, Review of Economies in transition, v.5, 33-44

[29] Marcellino, M., G. Mizon (2000) Modeling shifts in the wage-price and unemployment-inflation relationship in Italy, Poland and the UK, Economic Modelling, v.17, 387-413

[30] Nikolic, M. (2000) Money growth - Inflation relationship in Postcommunist Russia, Journal of Comparative Economics, v.28, 108-133
[31] OECD (1999) Country Reports. Poland
[32] Paruolo, Rahbek (1998)
[33] UNECE (1995)
[34] Vostroknutova, E. (2002) 'Scorched Earth' versus 'Inertia': A Comparative Cointegration Analysis of Polish and Russian Post-Stabilization Performances, European Unievrsity Institute, mimeo
[35] Winiecki (1993)
[36] Wozniak P. (1998) Relative Prices and Inflation in Poland 1989-1997 (The special role of administered price increases), World Bank, mimeo
[37] Zanello, A., Desruelle, D. (1997) A Primer on the IMF's Information Notice System, IMF Working Paper WP/97/71, May 1997

## 6 Appendix: I(1) versus I(2)

A stochastic process integrated of order one, $x_t \sim I(1)$, is a process that can be made stationary by taking first differences: $\Delta x_t \sim I(0)$. Such a process can be described by equation (1), see page 6 of this paper. Much recent research on the monetary transmission mechanism in Europe and the US has been done using I(1) analysis. However, it has been generally accepted that during abnormally volatile periods (like the transition from a planned to a market economy), many variables can be integrated of order greater than one. It has also been noticed that nominal prices are I(2) in almost all countries. Therefore, authors were bound to study differenced systems, where variables that might be I(2) entered in their first differences. This shifted the analysis to a shorter-run, as researchers refrained from studying nominal systems.

The development of the I(2) procedure (Jørgensen, Kongsted, Rahbek, 1999) and of software for it (I(2) for CATs in RATs), made it possible to actually include the I(2) variables in the analysis, and study nominal systems. This approach seems very promising for transition countries, given that enough data were accumulated. A stochastic process integrated of order two, $x_t \sim I(2)$, is a process that is made stationary only by differencing it twice: $\Delta x_t \sim I(1)$, $\Delta^2 x_t \sim I(0)$.

In the analysis above, it might sometimes be unclear why it is possible to use the tests from the I(1) framework in order to make inferences in the I(2) model. Under certain conditions, explained below, it is however possible. The I(1) VAR framework is described by equation (1). Let us assume that the system is actually I(2) (i.e. it is best described by equation (2)). Then, the concentrated model of the I(1) analysis looks like this (see Juselius, 2002, Johansen, 1995):

$$\underbrace{R_{0t}}_{I(0)} = \alpha\beta' \underbrace{R_{1t}}_{I(2)} + \epsilon_t, \tag{3}$$

where

$$\underbrace{R_{0t}}_{I(0)} = \underbrace{\Delta x_t}_{I(1)} - \widehat{B_0} \underbrace{\Delta x_{t-1}}_{I(1)},$$

$$\underbrace{R_{1t}}_{I(2)} = \underbrace{x_{t-1}}_{I(2)} - \widehat{B_1} \underbrace{\Delta x_{t-1}}_{I(1)}.$$

In order to be found as a cointegrating relation, $\beta' R_{1t}$ has to be I(0):

$$\beta' R_{1t} = \underbrace{\beta' x_{t-1}}_{I(1)} - \underbrace{\beta' \widehat{B_1} \Delta x_{t-1}}_{I(1)} \sim I(0) \text{ via } CI(1,0) \text{ cointegration.}$$

Thus, if $x_t \sim I(2)$, then $\beta' x_t \sim I(1)$, and still $\beta' R_{1t} \sim I(0)$, and one can still use the tests provided by the I(1) procedure for making an inference in the I(2) model. Then, tests for stationarity will become test for I(1)ness. Standard weak exogeneity tests will actually test long run weak exogeneity, i.e. zero columns in the $\{\alpha_0, \alpha_1\}$ space only. Exclusion tests will become tests for long run exclusion from stationary cointegrating relations and from levels part of the polynomially cointegrating ones.

More detailed theoretical background for this analysis can be found in Johansen (1995), Juselius (2002), and Jørgensen, Kongsted, and Rahbek (1999).