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Determinants of Inflation in Poland: A Structural Cointegration Approach

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ISBN 951-686-814-2 (print)
ISSN 1456-4564 (print)

ISBN 951-686-815-0 (online)
ISSN 1456-5889 (online)

Editor-in-Chief **Jukka Pirttilä**

Suomen Pankin monistuskeskus
Helsinki 2001

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All opinions expressed are those of the author and do not necessarily reflect the views of the Bank of Finland.

Byung-Yeon Kim[*+]

Determinants of Inflation in Poland: A Structural Cointegration Approach

Abstract

Using cointegration and error-correction models, this paper analyses the relative impacts of the monetary, labour and foreign sectors on Polish inflation from 1990 to 1999. Following the development of a theoretical framework, we use a structural system approach in which cointegration relationships are used to derive deviations from steady-state levels. The deviations are interpreted as excess demand pressure on inflation in a given sector and subsequently incorporated in order to determine the short-run dynamics of Polish inflation. The results suggest that the labour and external sectors dominated the determination of Polish inflation during the above period, but their effects have been opposite since 1994. The appreciation of the domestic currency contributed to reducing inflation, while excessive wage increases prevented inflation from decreasing to a lower level. The monetary sector appears not to have exerted influence on inflation, suggesting monetary policy has been passive.

Key words: inflation, cointegration, error correction mechanism, Poland

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[+] I would like to thank Jukka Pirttilä, Matti Virén, and participants in the workshop on transition economics, Institute for Economies in Transition, Bank of Finland, (BOFIT), 2001, for their valuable comments and suggestions. Part of this work was undertaken while I was visiting BOFIT as a visiting researcher. The excellent research environment offered by BOFIT is gratefully acknowledged.

Byung-Yeon Kim

Puolan inflaatiota määrittävät tekijät: Rakenteellinen yhteisintegroituvuusanalyysi

Tässä tutkimuksessa analysoidaan rahatalous- , työmarkkina- ja ulkomaankauppasektoreiden vaikutusta Puolan inflaatioon vuosina 1990–1999 käyttämällä yhteisintegroituvuus- ja virheenkorjausmenetelmiä. Teoreettisen mallinnuksen jälkeen tutkimuksessa käytetään rakenteellista systeemimallinnusta, jossa yhteisintegroituvuusrelaatioiden avulla tarkastellaan inflaation poikkeamia vakaasta tilasta. Poikkeamat voidaan tulkita talouden sektoreiden ylikysynnän vaikutuksesi inflaatioon, ja ne voidaan myöhemmin ottaa mukaan Puolan inflaation lyhyen aikavälin dynamiikan mallinnukseen. Tulokset osoittavat, että työmarkkina- ja ulkomaankauppasektorit dominoivat inflaation määräytymistä tutkittavana aikana, mutta näiden kahden sektorin vaikutukset ovat olleet vastakkaisia vuodesta 1994 lähtien. Kotimaanvaluutan revalvoituminen vaimensi osaltaan inflaatiota, mutta ylisuuret palkankorotukset taas estivät inflaation hidastumista. Rahatalous-sektorilla ei näytä olleen vaikutusta inflaatioon. Tämän perusteella voidaan päätellä, että rahapolitiikka on ollut passiivista.

Asiasanat: inflaatio, yhteisintegroituvuus, virheenkorjausmekanismi, Puola

I Introduction

Poland is known to be one of the most successful transition countries in Eastern Europe that have attempted a transition from a socialist economy towards a market economy. Among its several achievements, Poland managed to stabilise its economy within a relatively short period, which contributed to establishing momentum for relatively rapid and robust economic growth. A major stabilisation programme, which identified reductions in inflation as one of the key policy objectives, has been implemented in Poland since January 1990. Inflation at the initial stage of the transition was extremely high, amounting to 580% per annum in 1990. Since then, the inflation rate in Poland significantly decreased. Following moderate annual inflation below 20% during 1996-1998, inflation rates first decreased to a single-digit level, 7.3%, in 1999.

The analysis of the determinants of Polish inflation not only presents a valuable case study for investigating the inflationary dynamics of transition economies, but also highlights significant implications for Polish accession to the European Union (EU). Poland is one of the first-wave candidates for membership in the eastern enlargement of the European Union. At the Nice Summit in December 2000, the EU indicated that Poland would join the Union by 2003. Although Poland was largely successful in stabilising its economy, possible admission into the EU within a few years poses another problem for Polish policymakers. Polish inflation is still much higher than the average of the inflation rates of the fifteen EU member countries, which has been less than 3% per annum in recent years. Moreover, Polish inflation appears fairly persistent: annual inflation rates have remained at levels between 7% and 15% for the last four years.

Using quarterly data from 1990(1) and 1999(4), this paper sets out to investigate what determines Polish inflation. The results of such estimations are expected to provide some answers to the following questions: how has inflation been reduced or what policies proved to be effective in stabilising the economy?

Why is inflation persistent? What challenges will Polish policymakers will face in attempting to further decrease inflation?. Given the possibility that there are various potential sources of inflation, we use a system approach rather than a single-equation approach. In more detail, our analysis is based on three competing hypotheses on how inflation is generated: i) pure monetarist theories describing the effect of excess money on the inflation rate; ii) internal labour market theories relating wage increases to inflation; iii) external theories explaining the foreign transmission effects on the inflation rate. We estimate the system using cointegration and vector error-correction models, and evaluate the relative impact of these sources on actual inflation.

This paper is organised as follows. Section II reviews existing literature on the analysis of inflation in Poland and other transition countries, and discusses the concepts of a structural cointegration model of Polish inflation we employ in this paper. Section III presents a theoretical framework that is used to determine Polish inflation empirically. Section IV examines cointegration relationships between variables and derives deviations from the long-run relationships, which are interpreted as inflationary pressure from each sector. In addition, we conduct impulse response functions in order to understand the impact of shocks on prices. Using a vector error correction model, Section V analyses the determinants of Polish inflation that incorporate the excess demands derived from the previous section, and evaluates the significance of sectoral excess demands in the determination of Polish inflation. Section VI concludes the discussion.

We found that Polish inflation has been determined largely by the external transmission effect (imported (dis)inflation) and a cost push effect driven by higher wages. In the early transition period, during 1991-1993, an upward adjustment of Polish prices to world market levels through imported inflation was a main cause of inflation, while repressed wages due to high wage taxation helped to decrease inflation to a lower, double-digit level at the end of the period. Yet the effects became opposite after 1994. From 1994 to 1999, inflation in Poland declined, thanks to imported disinflation through the real appreciation of the do-

mestic currency, the zloty. However, rising wage bills above their equilibrium levels prevented inflation from decreasing further. These two counter-balancing effects contributed to moderate but persistent inflation in Poland. We found that monetary policy has not affected Polish inflation, implying that monetary policy is largely subordinate to exchange rate policy.

II Determinants of Inflation: Time-series Research on Transition Economies

In spite of the significant policy implications, the analysis of the determinants of Polish inflation has attracted limited attention from economists. There are only a small number of time-series studies of Polish inflation in the transition period. On the basis of a cointegration relationship between prices and wages, Welfe (2000) claims that an increase in wages was a dominant factor in generating inflation in Poland from 1991 to 1996. In their analysis of three transition countries including Poland, Brada and Kutan (1999) use causality tests and a variance decomposition method, and present results that are somewhat different from the above study: they argue that Polish inflation is determined largely by past inflation and foreign prices, while monetary policy is relatively ineffective.[1]

The number of time-series studies analysing inflation in transition countries is also limited. Nikolic (2000) and Buch (1998) estimate the determinants of Russian inflation in a single equation framework and find that money growth is a core determinant of Russian inflation. Using cointegration and a vector error correction model, Korhonen (1998) confirms that inflation in Russia is caused by money growth. All the above studies on Russia tend to rely on the assumption that there are no other sources of inflation or at least they are exogenous to

[1] An earlier study done by Pujol and Griffiths (1996) find that relative price adjustments contribute to modest but persistent inflation in Poland. However, Coorey et al (1998) argue that the

money. However, it can hardly be doubted that there are various potential sources of inflation apart from the monetary source and in this regard a system approach is desirable.

Several studies have attempted a system approach to modelling inflation in transition economies. Haderi et al (1999) investigate the determinants of inflation in Albania using vector autoregression (VAR) techniques and find that an external factor, namely huge remittance flows from Albanian emigrants, contributed to reducing inflation. Using various econometric techniques including Granger causality, cointegration and error-correction models, Domac and Elbirt (1998) argue that the roots of Albanian inflation are rather conventional: inflation is positively associated with money growth and exchange rates but negatively with real income. Karla (1998) also maintains that Albanian inflation is driven largely by money growth; on the basis of results of cointegration tests using four variables: prices, money, the exchange rate and interest rates, as well as a successful transformation into error-correction models, he finds that inflation is negatively correlated with disequilibrium in the money market. Ross (1998) estimates the determinants of inflation in Slovenia using a vector autoregression model and presents evidence that money growth and changes in the exchange rate affect inflation.

Although a system approach such as VAR is less likely to suffer from the problem of omitting variables, it has an important disadvantage, at least for policy-making purposes. As several endogenous variables are contemporaneously correlated in a system, it is difficult to understand what are causes and what are consequences. Cointegration relationships between prices and other variables convey information only about the long-run association between the variables. Although cointegration relationships may be successfully represented in short-run error correction dynamics, the error correction term in short-run dynamics, which includes the effects of several variables on prices, is not tractable enough

effect of relative price adjustment is confined to an early period of transition following price

to tell which sector is causing inflation. An ideal approach would be to determine inflation in a systemthat, at the same time, can be used to fully trace the causes of inflation. In this paper, we propose a new approach which is based on a structural co-integrating VAR model that allows for different sources of inflation but can fully trace the sectoral causes of inflation in a short-run dynamic equation.

Tracing sectoral causes of inflation using cointegration is not a new attempt in itself. Juselius (1992) and Metin (1995) use cointegration techniques to capture deviations from underlying steady-states in the different sectors of the economy such as the monetary, labour and foreign sectors, interpret those deviations as excess demand that might cause inflation, and incorporate them in the analysis of short-run dynamics for Danish and Turkish inflation, respectively. Our approach is fairly similar to the above in that regard. However, unlike our approach, their analyses were not based on a system approach. They identify a long-run equation in each sector separately in a single equation framework and estimate the inflation equation by incorporating error correction terms derived from each cointegration relationship into the short run model at a later stage. This method may result in biased estimations because there is no reason to believe that each sector can be treated independently and thus estimated separately using cointegration.

III A Theoretical Framework

In this section, we develop a theoretical framework which provides the background to empirical analysis concerning what variables have to be used and how many cointegration vectors are expected. It begins with deriving an empirically testable model for long-run prices. Then we discuss an inflation model in which

liberalisation.

the relative impacts of the money, labour, and foreign sectors on inflation are analysed.

The general price level (p_t) is the weighted average of the price of tradable goods (p_t^t) and non-tradable goods (p_t^n):

$$p_t = \theta p_t^t + (1-\theta) p_t^n \quad (1)$$

where $0 < \theta < 1$.

The price of tradable goods is determined in the world market and depends on the foreign price (p_t^f) and the exchange rate (e_t). That is,

$$p_t^t = \varphi e_t + \kappa p_t^f \quad (2)$$

We assume that the price of non-tradable goods is determined in the domestic money market, where the demand for non-tradable goods is assumed to move in line with the overall demand in the economy. Accordingly, the price of non-tradable goods is determined by the money market equilibrium condition that real money supply ($m_t^s - p_t$) equals real money demand ($m_t^d - p_t^n$).

$$p_t^n = \eta[m_t^d - (m_t^s - p_t)] \quad (3)$$

where η is a scale factor which illustrates the relationship between the overall demand in the economy and the demand for non-tradable goods.

It is assumed that the demand for non-tradable goods, and thus for nominal balance, changes in line with wages, output and interest rates.

$$m_t^d = \alpha + \beta w_t + \chi y_t + \delta r_t \quad (4)$$

Substituting and rearranging equations yield the following price equation:

$$p_t = f(e_t, p_t^f, m_t - p_t, w_t - p_t, y_t - p_t, r_t) \quad (5)$$

Although the above equation itself can be used to analyse the determinants of inflation, it has a limitation in capturing to what extent excess demand created in each sector of the economy has contributed to inflation. In particular, given the number of variables involved in the price equation as above, there might be more

than one cointegration vector. This suggests that it is difficult to disentangle causes from consequences in a system in which all endogenous variables are contemporaneously determined. Moreover, what is arguably important for policy design is not an 'absolute' association but a 'relative' correlation between independent variables and inflation. For example, it is not so useful to know whether changes in the money supply are associated with inflation (absolute association). Instead, it is valuable for policymakers to understand to what extent the money supply, in exceeding its appropriate level, for instance, the level of output (relative association), causes inflation.

Following Surrey (1989) and Juselius (1992), we assume that there are three sources of inflation in an open economy: wage inflation, monetary inflation, and imported inflation. The external theories of the inflation rate suggest that the transmission of import prices in a foreign currency leads to general domestic inflation. The openness of the domestic economy toward foreign markets and limited substitution possibilities between domestic and foreign goods are, therefore, key implicit assumptions in these theories. Monetary inflation occurs when the supply of money is greater than warranted by the growth of real productive potential. Lastly, wage inflation implies that excessive wage increases influence excess demand and unit costs and, in turn, inflation.

We assume that the determination of exchange rates takes place predominantly in the goods rather than in the capital markets partly due to the underdevelopment of the financial sector in transition economies like Poland. Thus we consider only the purchasing power parity (PPP) and exclude the interest rate parity. The PPP between foreign and domestic prices is reflected in equation (2) above. By assuming that the general price level changes in line with the price level of tradable goods and the strong PPP, we can modify and estimate the equation:

$$p_t = e_t + p_t^f \qquad (2')$$

The deviation from the PPP is, therefore, formulated as follows:

$$ecm(imp) = p_t - e_t - p_t^f \quad (6)$$

Inflation-generating excess demand can be also found in the domestic labour sector. If increases in real wages are greater than the levels warranted by productivity, inflation will occur. Using real output as a proxy for productivity, we can establish the following relationship:[2]

$$w_t - p_t = a + (y_t - p_t) \quad (7)$$

Note the homogeneity assumption between real wages and real output in the long-run. Excess wages can be then derived:

$$ecm(w) = (w_t - p_t) - (y_t - p_t) \quad (8)$$

Lastly, the pure monetary theory derives from the influential work of Friedman (1969), which claims that the expansion of the money supply in excess of the real productive potential of the economy leads to inflation. This suggests that effective policy to curb inflation should focus on containing the supply of money at an appropriate level. Pure monetarist theories were put into practice in several transition economies in Eastern Europe and Russia, with the support of international financial organisations such as the International Monetary Fund.

In order to derive excess money, it is necessary to find an appropriate money demand function in Poland. Combining equation (7) with equation (4), together with the homogeneity assumption between real money balance and real output, yields:

$$m_t - p_t = b + (y_t - p_t) - \zeta r_t \quad (9)$$

[2] This equation can be derived, by setting unemployment to zero, in a standard earnings equation which is a function of productivity and unemployment. Marcellino and Mizon (2000) suggest that the effect of unemployment on earnings has been insignificant in Poland.

Given the underdevelopment of Polish financial markets, we further assume that the effect of interest rates on money holding is negligible.[3] Thus the above equation changes to:

$$m_t - p_t = b + (y_t - p_t) \tag{9'}$$

The suggested excess money with an assumption of homogeneity between real money balance and real output is:

$$ecm(m) = (m_t - p_t) - (y_t - p_t) \tag{10}$$

The three error correction terms from the long-run equations, (2'), (7) and (9') imply that the error-correction type of model for inflation contains the conditional expectation of current inflation, given two information sets:

$$E(\Delta p / I_1, I_2)$$
$$I_1 = \{ecm(imp), ecm(w), ecm(m)\}$$
$$I_2 = (\Delta p_{t-1},..., \Delta e_t, \Delta e_{t-1},..., \Delta p_t^f, \Delta p_{t-1}^f,..., \Delta(w-p)_t, \Delta(w-p)_{t-1},...,$$
$$\Delta(y-p)_t, \Delta(y-p)_{t-1},..., \Delta(m-p)_t, \Delta(m-p)_{t-1},...)$$

As the model shows, all variablesthat are used to estimate cointegration relationships, are switched to differences to determine the short-run dynamics of Polish inflation.[4] Proxies for all excess demand also enter as explanatory variables for inflation. It thus makes it possible to understand which sector causes inflation in the short-run dynamics. Note that the error correction terms are obtained from a

[3] This assumption has some empirical support: Enev and Koford (2000), Brada and Kutan (1999) and Christoffersen et al (2001) suggest that interest rates are not important in determining inflation in Poland. We tried to estimate the model including interest variables but we arrived at the same conclusion, as the above studies imply.

[4] The weak exogeneity tests will be conducted to understand which variables are modeled for the inflation equation. If the test suggests that an endogenous variable in the cointegration model is not weakly exogenous to inflation, the variable will be modeled in a system and accordingly the contemporaneous form of the variable will disappear in the determination of the inflation equation.

system approach, suggesting that they reflect not only excess demand in each sector but also the roots of inflation rather than intermediate variables linked to inflation.

IV The Cointegration Analysis of Long-run Relations

Using quarterly data from 1990(1) - 1999(4), this section aims at investigating the long-run price structure in three different sectors of the Polish economy. In the following section, proxies for each sector's disequilibrium from steady-state relations are derived to determine the short-run dynamics of inflation.[5] For the purpose of having a larger degree of freedom, the restriction of a common coefficient was imposed on those of foreign prices and exchange rates before carrying out cointegration tests.

In order to understand the order of integration, we conducted augmented Dickey-Fuller (ADF) and Phillips-Perron tests on the five variables under consideration. Based on the result of the Akaike information criterion, we report the test results at the third lag.[6] Yet, the results of ADF tests should be interpreted with caution, because not only is the sample short, but there was also high volatility in the behaviour of the variables, especially for prices. Figures expressing the variables in levels and differences are presented in Appendix.

The test results suggest that real money ($m-p$), real wages ($w-p$), and real output ($y-p$) are I(1) variables. It is difficult to determine the order of integration regarding the other two variables, namely prices (p) and the sum of the exchange rate and foreign prices ($e+p^f$), on the basis of ADF. However, visual inspection as well as Phillips-Perron tests indicate that the sum of the exchange rate and foreign prices ($e+p^f$) can be considered as an I(1) variable (see the Appendix). The

[5] The detailed definitions and sources of the data are provided in Table 1.

[6] Given that our data set is quarterly, we conducted the ADF tests using five lags.

variable of change in prices (p) appears to have experienced two structural breaks, that is, around 1992 and 1995. Yet, the variable seems stationary between 1992 and 1994, and again between 1995 and 1999. We will conduct parameter stability tests later in order to understand whether these potential structural breaks have impacts on our results.

The results of the cointegration tests are provided in Table 2. The number of cointegration vectors was estimated using the Johansen method (1988, 1991). On the basis of the test result of the AIC that suggests that the appropriate lag length is three, the results are reported with three lags. We also include three period dummy variables in an unrestricted way: d1990, d1991, and d1998(4)-1999(4). The first two dummies intend to capture shocks that took place in the two initial years of transition: these shocks include a transition recession and hyperinflation due to price liberalisation in January 1990 and a monetary overhang inherited from the socialist era. The dummy from 1998(4) to 1999(4) is included to take into account the effects of financial crises in Asian countries and Russia on the Polish economy, particularly on the Polish exchange rate.

We denote p as the cointegration rank. For p=3 as an alternative, the statistics of the eigenvalue test for cointegration are marginally below the 90% critical value, while that of the trace test is higher than the 95% critical value. However, the hypothesis that p=4 is rejected by both tests. This outcome suggests that there are three cointegration vectors, which is consistent with our theory.

Our macroeconometric model comprises the following three long-run equilibrium relationships, as described in (2'), (7) and (9'). More specifically, following Johansen and Juselius (1990) and Johansen (1991), a vector of endogenous I(1) variables is analysed using the vector error-correction representation,

$$\Delta x_t = \mu + \sum_{i=1}^{k} \Gamma_i \Delta x_{t-i} + \pi x_{t-1} + \varepsilon_t$$

where the parameters μ and $\Gamma_1,...,\Gamma_k$ are allowed to vary without restrictions, k is the lag length of the model, and ε_t is a vector of normally distributed shocks with

a mean of zero. The presence of cointegration is tested by examining the rank of π. The matrix π can be written as $\pi = \alpha\beta'$, with β containing the rank of co-integrating vectors, and α describing the speed of adjustments to the long-run equilibria. If the number of ranks is 3, as suggested by the theory, identifying restrictions with homogeneity ones can be placed on the parameters in:

$$\pi x_{t-1} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} & \beta_{25} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} & \beta_{35} \end{bmatrix} \begin{bmatrix} p \\ e + p^f \\ w - p \\ m - p \\ y - p \end{bmatrix}_{t-1}$$

In view of the theory developed in the previous section, we estimate the model subject to the following restrictions on co-integrating vectors:[7]

$$\beta' = \begin{bmatrix} 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 1 & -1 \end{bmatrix}$$

The first vector (or the first row of β') relates to the PPP relationship defined by (2')[8]; the second relates to the wage equation defined by (7); the third relates to the money equation defined by (9'). The log-likelihood ratio statistic for jointly testing the six over-identifying restrictions takes the value of 11.05. The restrictions are accepted at a 90% critical value.[9] In other words, in spite of a relative

[7] We first estimated the model subject to six exact-identifying restrictions on the cointegration vectors and then tested the six over-identifying restrictions predicted by the long-run theory outlined in the previous section.

[8] We tested whether a strong PPP holds in the system as below. The coefficient on the variable of domestic price, *p*, in the equation of the relative exchange rate before the imposition of a homogeneity condition was –0.918, which is fairly close to homogeneity.

[9] The asymptotic *p*-values are 0.087, suggesting that the restrictions are rejected at 95% critical values. Given the well-known small sample bias of the cointegration tests, however, arguably there is evidence that the restrictions are accepted. As for the bias in a small sample, see Pesaran and Shin (1999).

short sample period, the long-run relationships in accordance with our theoretical framework are identified.[10]

The three identified cointegration vectors enable us to determine the extent of excess demand, that is, deviations from long-run equilibrium in each sector. These excess demands will be potential sources of inflation, which will be analysed in the next section. On the basis of disequilibrium in each sector, it is worth describing inflationary pressure arising from each sector.

The first graph in Figure 1 shows inflationary pressure from the external sector. Note that we defined the deviations from steady states (*ecm(imp)*) as $p-(e+p^f)$ and thus positive excess demand in the external sector exists when the fitted values are lower than the actual values. The figure suggests that inflationary pressure began to substantially decrease from 1994, reflecting the strong real appreciation of the domestic currency. For example, while consumer price inflation increased by 52.6% during 1994(1)-1995(2), the nominal exchange rate rose by only 9.7%. This suggests that the external sector would have contributed to reducing inflation during 1994-1999 if the external sector had determined Polish inflation.

According to the second graph in Figure 1 that shows the extent of disequilibrium in the monetary sector, monetary policy appears to have been very tight in 1991 and subsequently relaxed from 1992 to 1995. The subsequent relaxation of restrictive monetary policy might have been prompted by a deeper output decline than expected in the years 1990 and 1991. Overall, apart from 1991, the figure shows that deviations from the steady states in the monetary sector are not so large. This implies that disturbances caused by monetary policy during this period were rather small: this can be interpreted in a way either that the supply of money has been generally in line with economic conditions or that monetary policy has been rather passive and subordinate to other policy objectives.

[10] In fact, Baffes et al (1999) argue that a relatively small sample may contain sufficient information for identifying long-run relationships if the impacts of shocks on variables are fairly

Excess demand in the labour sector, which seems much larger than that in the monetary sector, is presented in the last graph in Figure 1. Wages seem to have been substantially below steady-state levels from 1991 to 1993. This is likely to be associated with excess wage taxation in Poland during this period, which allowed a modest growth in wages with respect to price increases. Although excess wage taxation was officially abolished in 1995, it became less binding in practice over time (Enev and Koford, 2000). Following relatively small ups and downs during 1994-1996, excess demand in the labour sector began to increase rapidly from 1997. This implies that inflation in recent years in Poland is associated with the growth of wages above their equilibrium levels.

Having estimated the structural co-integrating VAR model, we now analyse the impacts of various shocks on our variable of interest, namely prices, in the system. We use the Generalised Impulse Response (GIR) functions, which describe the time profile of the effect of a unit shock on a particular equation on relevant endogenous variables, taking account of the contemporaneous interactions of all the endogenous variables of the system. Unlike other impulse responses, the GIR proves to be invariant to the ordering of the variables in the VAR (Pesaran and Shin, 1998). We assume that the shock is sufficiently small so that it does not change the parameters of the underlying VAR model.

In Figures 2-5, we present the results of shocks to different variables on prices, where the size of the shocks is scaled as one standard error. The figures show that various shocks die out within about 20-25 quarters. As Figure 2 suggests, the full impact of a shock to real money appears to be reflected in prices very quickly. It takes only a quarter for the shock to exert a maximum influence on prices, that is, a 1% decrease in prices. Note that we use real, not nominal, money in our analysis of the impact of money on prices. Figure 3 shows that the response of prices to real wage shocks shows a cyclical pattern over a protracted period of time; it initially increases prices by about 1% for the first and the sec-

quick and further claim that developing country data often have substantial variation in a short

ond years, then declining to –0.5% around the 15th quarter, and finally gradually tending towards zero.

In terms of the magnitude of effects, shocks to exchange rates and real output have relatively larger impacts on prices. According to Figure 4, a real output shock decreases prices by 1% within one year following the shock and gradually stabilises at a level of around -3%. The maximum possible impact of shocks to exchange rates on prices takes place later than that of shocks to real output. As Figure 5 shows, the impact response of prices, given a shock to exchange rates, is 1% in the first quarter after the shock, then reaches 3.5% at its peak before it stabilises at a level of around 3%.

The above findings suggest that a seemingly small disequilibrium in the external sector, as the first graph in Figure 1 shows, can influence inflation to a large extent. In more detail, exerting influence on inflation by the external sector, if any, is mainly a result of large impact responses of prices over a protracted period. In contrast, the third graph in Figure 1 shows a relatively large gap between equilibrium real wages and actual real wages, while price responses due to a shock in the wage equation are comparatively small, as displayed in Figure 3. This implies that, if excess wages affect prices, the effect is realised mainly through the magnitude of disequilibrium in the labour sector rather than its unit impact on prices. As for the monetary sector, small unit responses of prices to a shock in the money equation, combined as well with small sizes of disequilibrium in the sector, indicate that the effect of excessive money on prices should not be substantial or even negligible.

period, given the shocks.

V An Error Correction Model of Polish Inflation

We conducted weak exogeneity tests to determine which variables need to be endogenous in the short-run dynamics. We found that real output (y-p) and the exchange rate ($e+p^f$) are weakly exogenous to prices, suggesting that there is no need to model these variables for the short-run dynamics of inflation: the χ^2 statistics for real output and relative exchange rates are 12.05 (0.10) and 11.09 (0.13)[11]. Table 3 presents the estimation results of the short-run dynamics of inflation, which are obtained from using vector error correction methods. The equation appears to fit fairly well. There is little evidence of diagnostic problems. All the short-run related variables that are statistically significant are interpretable. Current inflation rises with increases in real wages with two lags but decreases with those in real output, again with two lags. The feedback from short-run exchange rate movements into inflation is relatively rapid: depreciation begins to feed into inflation within a quarter of a year.

As for excess demand from each sector of the economy, one of the key determinants of Polish inflation is the external transmission effect. A small open economy, in which the exchange rate will be reflected in prices of imported commodities, is prone to imported inflation when the economy experiences the depreciation of the domestic currency. In contrast, the appreciation of the domestic currency may result in disinflation. Since 1994, Poland has experienced the real appreciation of exchange rates. For example, annual inflation amounted to 28% in 1995 and 20% in 1996, while nominal exchange rates against the dollar increased by 4% and 13%. The significant and negative coefficient on the variable of imported inflation, $ecm(imp)_{-1}$, implies that the real appreciation (depreciation) of the Polish zloty in the transition period has contributed to reducing (increasing) inflation. The size of the coefficient implies that a 10% increase in

excess demand in the external sector induces a 3.1% increase in inflation in the long run. The positive short-run effect of depreciation on inflation, reflected in one of the other exchange rate-related variables, $\Delta(e + p^f)$ can be viewed as evidence that the full depreciation of the zloty reflecting the differences between domestic and world market prices would have resulted in much higher inflation.

Another main effect on inflation comes from the labour sector. The model suggests that there are two channels in the impact of wages on inflation. First, increases in real wages by themselves raise inflation within two quarters. This short-run effect is borne out by the significant coefficient of the difference in wages ($\Delta(w - p)_{-2}$). Second, if excess wages are created by wage increases, this has a long-run effect on inflation. The significant coefficient on $ecm(wage)_{-1}$ indicates that the deviations of real wages from the steady-state relation between wages and output have a positive impact on inflation but its unit impact is about 40% of that of exchange rates.

Last but not least, the model suggests that there is no effect of excess money on inflation. This is in line with a finding by Brada and Kutan (1999), who suggest that monetary policy in Poland has been used mainly to support the exchange rate. They claim that the underdevelopment of the mechanisms and institutions that transmit policy into economic outcomes tend to make monetary policy ineffective to a large extent. In this regard, Polish experience indicates that, in transition economies that are less likely to conduct sound monetary policy because of weak institutions, a fixed exchange rate or a managed floating exchange rate provides a better nominal anchor for stabilisation than monetary targets.

Given the volatility of economic variables in the transition period and thus the possibility of a regime shift, one would question the reliability of our estimates. Using recursive estimations, we tested whether our model suffers from

[11] The associated *p*-values are in parentheses. In contrast, the weak exogeneity of money and real wages in the price equation is rejected: the relevant χ^2 statistics are 26.26 (0.00) and 14.03

any structural breaks. Figure 6 shows that there is little evidence of regime shifts: variations in the inflation variable are within ±5% innovation errors. Furthermore, the narrowing band of innovation errors, which suggests that adding a period sharpens estimations, reinforces the belief that our estimation results are robust.

To conclude, disequilibria in the labour sector and the external sector dominate the determination of consumer price inflation in Poland. In particular, excess wages are found to be a main reason for inflation in Poland in recent years. In contrast, the real appreciation of the exchange rate has contributed to reducing inflation from 1994 onwards. The long-term effect of the appreciation of the domestic currency on the economy is, however, uncertain because it might undermine the export of domestic goods. Furthermore, taming inflation by the appreciation of the exchange rate will become a less attractive option when Poland seeks accession to the EU.[12] Joining the monetary union with a strong local currency implies that exportability to the EU will be negatively affected. However, allowing depreciation before joining can also be risky because it may spur inflationary pressures and thus fail to meet the Maastricht convergence criterion on inflation. A key policy implication is that inflation should be reduced by controlling wage pressure or more specifically imposing a hard-budget constraint on enterprises, which is expected to prevent wages from increasing beyond the level suggested by productivity and labour market conditions.

(0.50) for money and wages respectively.

[12] Of course the appreciation of the real exchange rate might reflect the so-called Balassa-Samuelson effect, that is, an increase in productivity. However, evidence suggests that real exchange rate movements in Poland are largely driven by nominal shocks rather than by real shocks such as productivity increases (Dibooglu and Kutan, 2001).

VI Conclusion

Using cointegration and error-correction models, this paper estimated the determinants of Polish inflation during 1990-1999. We identified possible sources of inflation in three different sectors, namely, the monetary sector, the labour sector, and the external sector. A structural co-integrating VAR was used to derive the deviations from the steady-state level, which were interpreted as excess demand pressure on inflation in a given sector. Together with other variables influencing inflation, these three derived disequilibria in the sectors of the Polish economy were incorporated to determine the short-run dynamics of Polish inflation. The reliability of the estimates of the short-run dynamic model was confirmed by various diagnostic tests including a test for parameter stability.

The main findings of this paper are as follows. First, the labour and the external sectors dominated the determination of Polish inflation during 1990-1999. Unlike in an earlier period from 1991 to 1994, increases in wages after 1994 resulted in higher inflation through the long-run effect of excess wages as well as through the short-run direct impact. In contrast, the appreciation of the real exchange rate has contributed to containing inflation in Poland from 1994. Second, excess money did not explain Polish inflation, implying that monetary policy has been used to support other policies, for example, exchange rate policy.

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Figure 1: Disequilibria in the External, Monetary and Labour Sectors in Poland

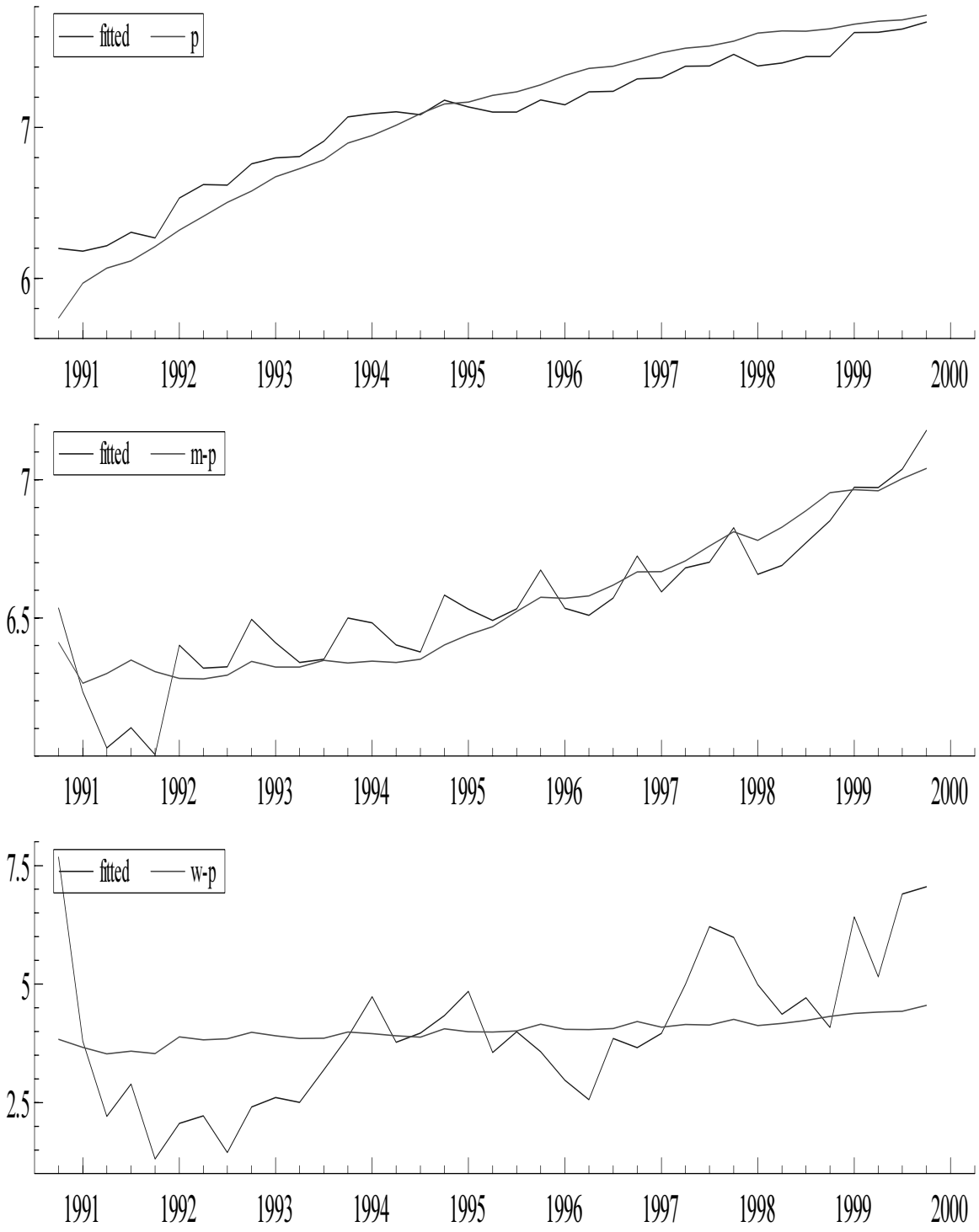


Figure 2: Generalised Impulse Responses of Prices to One Standard Error Shock in the Equation for Real Money

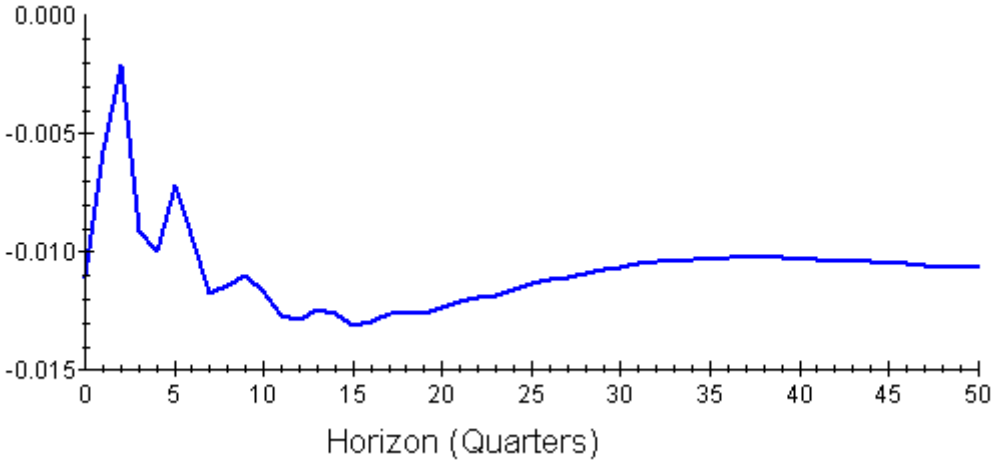


Figure 3: Generalised Impulse Responses of Prices to One Standard Error Shock in the Equation for Real Wages

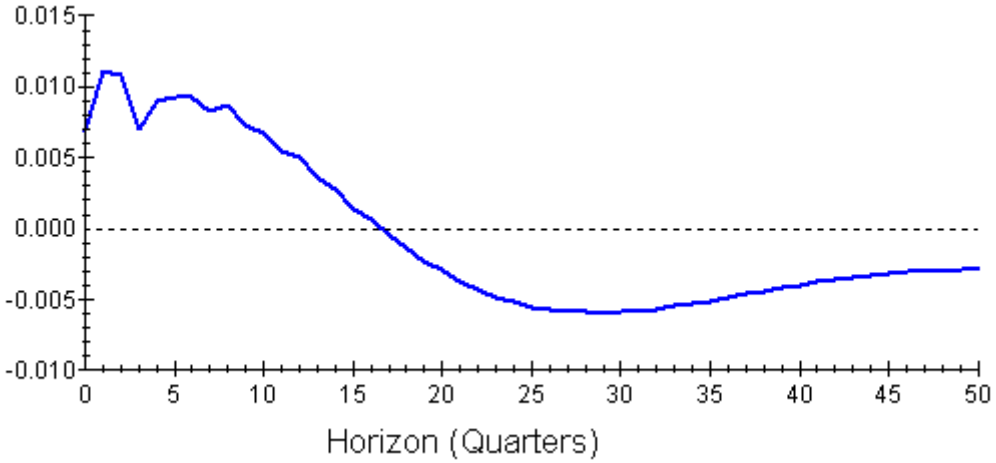


Figure 4: Generalised Impulse Responses of Prices to One Standard Error Shock in the Equation for Real Output

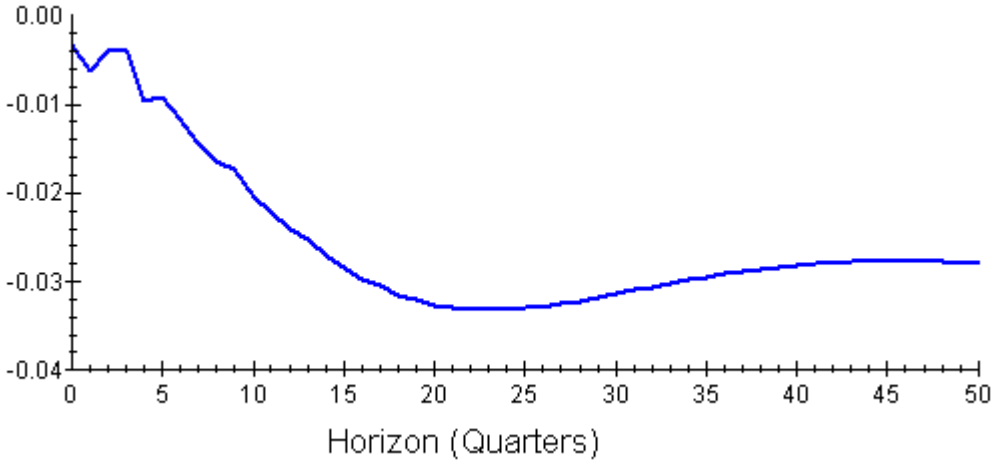


Figure 5: Generalised Impulse Responses of Prices to One Standard Error Shock in the Equation for Exchange Rates

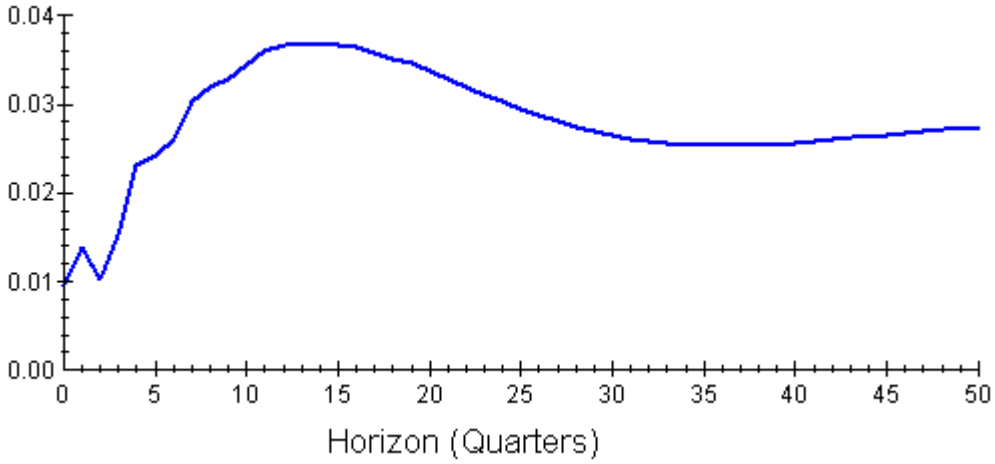


Figure 6: Parameter Constancy Test for Inflation

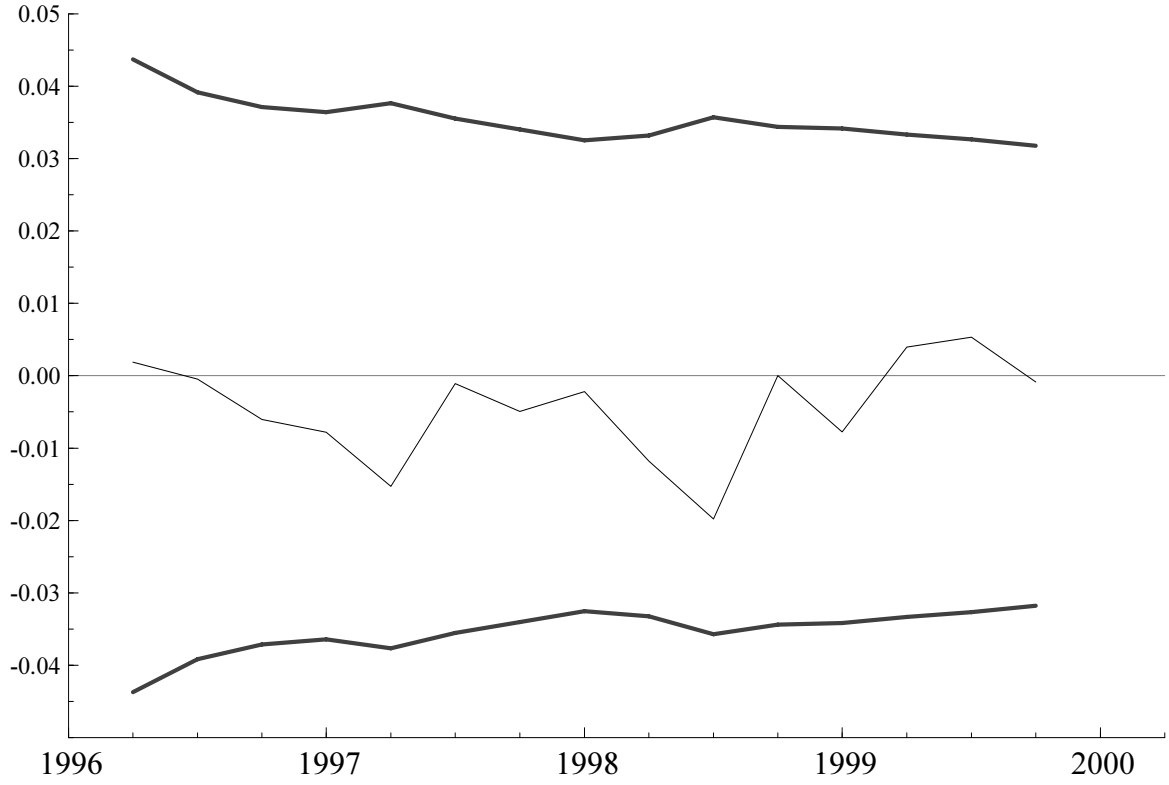


Table 1. List of Variables and their Descriptions

p:	natural logarithm of the Polish consumer price index.
e:	natural logarithm exchange rates between Poland and the USA (in zlotys divided by the US dollars).
p^f:	natural logarithm of the average of the consumer price indices in the member countries of the European Union.
y:	natural logarithm of Polish industrial production.
w:	natural logarithm of average monthly nominal wages.
m:	natural logarithm of the nominal money stock (M2) in the domestic currency (zlotys) and foreign currencies converted into zlotys in accordance with exchange rates (period average) of the National Bank of Poland.

Data sources: *Central Statistical Office Bulletin*-Monthly, Warsaw, various issues; *Short-term Economic Indicators*, OECD, various issues; *International Financial Statistics*, IMF, various issues; *Eurostatistics*, Eurostat, various issues.

Table 2. Cointegration tests (with unrestricted intercepts without trend)

Null (rank = p)	Alternater.	Eigenvalue[a].	95% CV	Trace[b]	95% CV
p = 0	p = 1	58.43**	33.5	115.96**	68.5
p ≤ 1	p = 2	26.77*	27.1	57.52**	47.2
p ≤ 2	p = 3	18.58	21.0	30.75**	29.7
p ≤ 3	p = 4	8.84	14.1	12.17	15.4
p ≤ 4	p = 5	3.33	3.8	3.33	3.8

[a] Eigenvalue statistics; [b] Trace statistics

**: significant at 95% critical values; *: significant at 90% critical values

Table 3: Error Correction Models: Short-run Dynamics of Inflation (Δp)

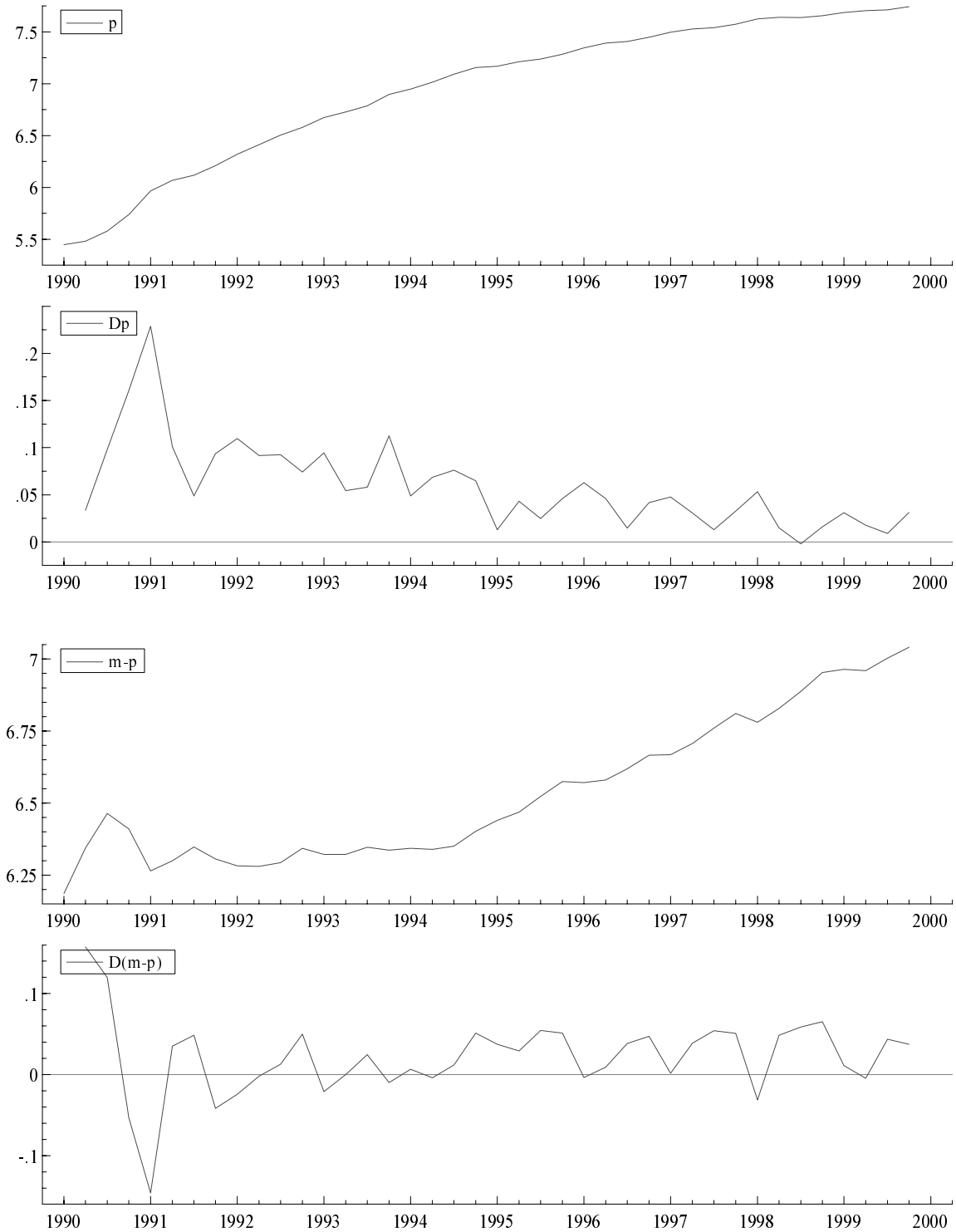
	Coefficients	Absolute t-values
Δp_{-1}	-0.408	1.712
Δp_{-2}	-0.560	2.592
$\Delta(w-p)_{-1}$	-0.010	0.215
$\Delta(w-p)_{-2}$	0.091	2.020
$\Delta(m-p)_{-1}$	0.113	0.678
$\Delta(m-p)_{-2}$	0.069	0.475
$\Delta(y-p)$	-0.031	0.434
$\Delta(y-p)_{-1}$	-0.076	1.033
$\Delta(y-p)_{-2}$	-0.154	1.791
$\Delta(e+p^f)$	0.203	2.430
$\Delta(e+p^f)_{-1}$	-0.123	1.136
$\Delta(e+p^f)_{-2}$	-0.165	1.625
$ecm(imp)_{-1}$	-0.313	6.443
$ecm(wage)_{-1}$	0.129	2.171
$ecm(money)_{-1}$	-0.040	0.752
Constant	0.930	5.254
d1990	-0.118	3.209
d1991	0.185	4.494
d1998(4)-1999(4)	-0.050	2.703
AR – F(3,15)	1.437	
Normality $\chi^2(2)$	0.138	
ARCH – F(3,12)	1.462	

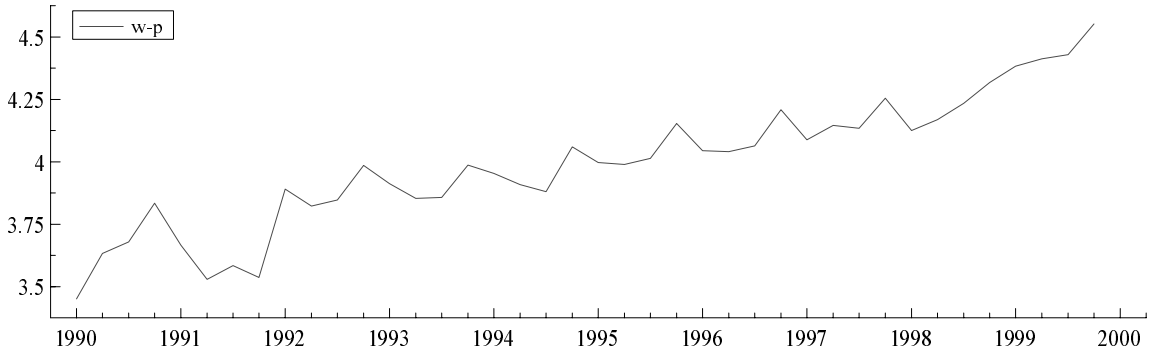
*AR is a LM type test for residual autocorrelation. ARCH is a test for autoregressive conditional heteroscedasticity. The normality test is based on the Jarque and Bera statistic.

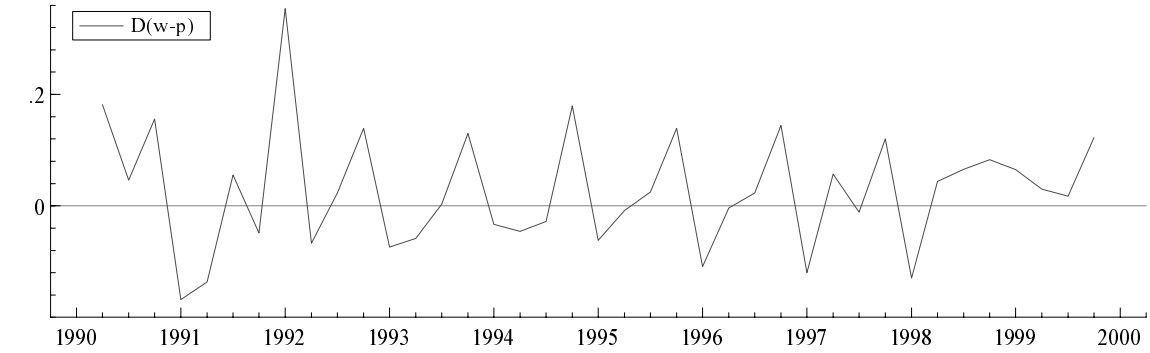
$$ecm(imp)_{-1} = p_{-1} - (e + p^f)_{-1}$$
$$ecm(wage)_{-1} = (w-p)_{-1} - (y-p)_{-1}$$
$$ecm(money)_{-1} = (m-p)_{-1} - (y-p)_{-1}$$

Notes: This is part of the estimation results of vector error correction models. Estimates for other variables are available but not reported for the sake of space.

Appendix: Data in Levels and First Differences




w-p
4.5
4.25
4
3.75
3.5
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000


D(w-p)
.2
0
1990
1991
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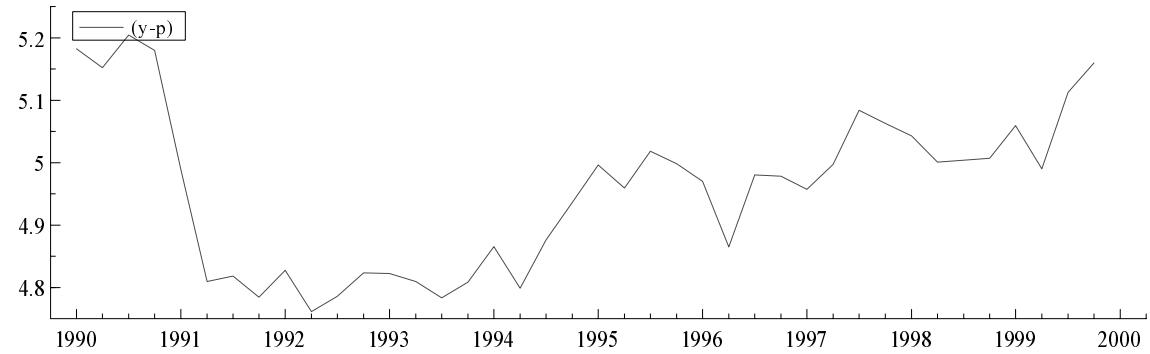
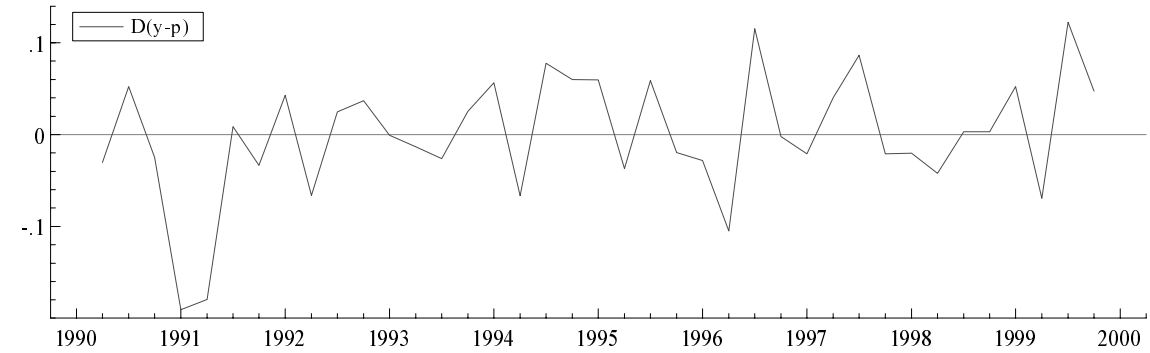
1994
1995
1996
1997
1998
1999
2000


(y-p)
5.2
5.1
5
4.9
4.8
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000


D(y-p)
.1
0
-.1
1990
1991
1992
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1995
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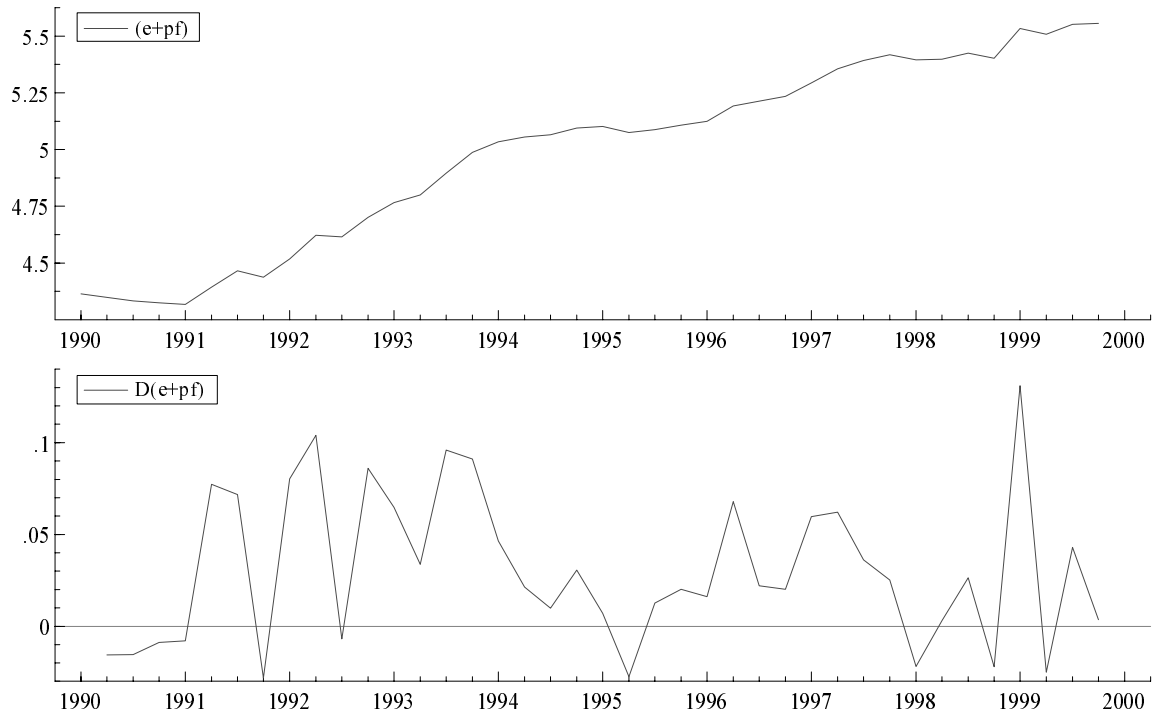
1999
2000



A. Table 1: Results of Non-stationarity Tests

	Augmented Dickey-Fuller Tests		Phillips-Perron Tests	
	Constant and trend included	Constant included	Constant and trend included	Constant included
p	-2.49	-5.15**	-6.269	-3.059
Δp	-5.13**	-2.61	-27.643**	-13.538*
m-p	-2.77	1.47	-3.341	0.603
Δ(m-p)	-4.19*	-3.07*	-21.854*	-24.298**
w-p	-2.26	-0.09	-28.693**	-2.137
Δ(w-p)	-5.35**	-5.44**	-41.054**	-41.496**
y-p	-2.97	-0.43	-6.423	-6.669
Δ(y-p)	-4.92**	-4.99**	-35.355**	-34.574**
$e+p^f$	-2.10	-2.08	-6.365	-0.459
$\Delta(e+p^f)$	-2.83	-2.32	-39.733**	-40.689**

*: the null hypothesis of non-stationarity is rejected at the 5% significance level
**: the null hypothesis of non-stationarity is rejected at the 1% significance level

Note: all the variables are in log forms.

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BOFIT
Discussion Papers
ISBN 951-686-814-2 (print)
ISSN 1456-4564 (print)

ISBN 951-686-815-0 (online)
ISSN 1456-5889 (online)

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