EXCHANGE RATE PASS-THROUGH INTO ROMANIAN PRICE INDICES A VAR APPROACH[1]

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Abstract

This paper investigates the exchange rate pass-through (ERPT) into import prices, producer prices and several different measures of consumer prices indices for Romanian economy. In order to determine the size, describe the dynamics and identify the asymmetries in ERPT the paper employs an array of econometric methods belonging to the VAR family. The methods range from RVARS (on different price indices and/or on a rolling window), Sign-restriction VARs (also using different consumer inflation measures), MS-VAR, TAR and SETAR, the last three methods being naturally equipped to capture various types of asymmetries. The results point to an almost complete pass-through into import prices and incomplete pass-through into producer and consumer prices. In all cases except import prices the ERPT displays a decline in magnitude over the analysed time interval. The paper also finds important asymmetries with respect to sign and size of the exchange rate, size of inflation and time period.

Keywords: exchange rate, pass-through, import prices, producer prices, consumer prices, vector autoregression, sign-restriction.

JEL Classification: C32, E31, E52, F31, O52.

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I. Introduction

In the context of the current financial crisis, the convergence of the Romanian economy towards that of the euro zone and the euro adoption process should foster renewed effort of understanding the causes of inflation - as this is currently the most important obstacle to the fulfilment of the Maastricht criteria. In an inflation targeting country like Romania, understanding the inflation causes is critical, as a *sine qua non* condition for sound economic decisions is the existence of a well performing forecasting model. The misunderstanding or erroneous measurement of the inflation's causes could jeopardize the economic prospects and endanger the desired objectives.

The exchange rate is bound to be an important determinant of the inflation rate in a small open economy like Romania. Thus, investigating the exchange rate pass-through (ERPT) is a necessary, even if not sufficient, condition for sound economic policies. The paper aims at investigating the subject using various econometric techniques. Its findings could be employed in enhancing the understanding of the inflation's determinants, in calibrating macroeconomic models – especially for modeling variable pass-through, in designing various policies aiming to make some sectors of the economy more flexible and competitive and also in designing sound, flexible and robust policies.

The paper is organized as follows. The second section of the paper is a review of the ERPT literature, presenting the seminal work of Dornbush (1987) and Krugman (1987) and the further rapid development of the subject, along with a brief presentation of the econometric methods employed.

The third section is devoted to an analysis of the exchange rate pass through employing the modeling strategy of McCarthy (2000) and the RVAR econometric approach. The method is subsequently used for different price measures and for different time spans, in order to illustrate the ERPT magnitude for different base inflation measures and also its evolution in time.

The fourth section investigates the phenomenon from a different angle, using a newer econometric technique developed by Uhlig (2005). Different variants of the method are employed; robustness checks and estimation using diverse base inflation measures are performed.

The fifth section is dedicated to asymmetries in the exchange rate pass-through. The method of choice is Markov Switching VAR in different specifications as various facets of the phenomenon are probed. The most important sources of asymmetries investigated regard time dynamics, sign and size of movements in the exchange rate and the size of the monthly inflation rate. The last section of the paper concludes and identifies some research areas worthy of further study.

II. Literature Review

Exchange rate pass-through is frequently defined as the responsiveness of domestic prices - including consumer prices, producer prices, import prices and sometimes the prices set by domestic exporters - to exchange rate movements. This topic has been the focus of interest in the international economics literature for a long time. In the context of the increase of most developed economies' openness and of the large fluctuations in nominal exchange rates, the understanding of the determinants of the transmission of exchange rate changes into traded goods prices had become very important.

Over the past two decades a large economic literature on exchange rate pass-through (ERPT) has developed. The early literature on exchange rate pass-through had its origins in the industrial organisation literature, analysing the relationship between the exchange rate pass-through and industry characteristics such as market structure and the nature of competition. The models analysed the response of prices to an exogenous movement in the nominal exchange rate. An important contribution to this early literature was that of Dornbusch (1987), which explains the degree of pass-through to destination currency import prices through the degree of market integration or segmentation, the degree of product differentiation, the degree of strategic relations between suppliers, the functional form of the demand curve and market organisation.

Krugman (1987) named the phenomenon of exchange rate induced price discrimination in international markets "pricing-to-market". Thus, in monopolistically competitive markets the firms apply different mark-ups over marginal costs depending on the elasticity of demand on each market, these elasticities being related to the firm's market share - which is affected by the exchange rate. Krugman (1987) signalled the need of a dynamic model of imperfect competition in order to understand the pricing to market. Froot and Klemperer (1988) examine pricing to market in the context of exchange rate changes in a model in which future demand of firms depends on their current market shares. The authors demonstrate that the magnitude and sign of the exchange rate pass-through will be influenced by whether exchange rate changes are seen as being temporary or permanent.

The key concepts in this literature are those of local currency pricing and producer currency pricing (LCP and PCP, respectively), representing the situation in which exporters set their prices in the currency of the importing country or in their own currency, respectively.

Simultaneously with the theoretical literature a large literature estimating the exchange rate pass-through appeared. Empirical literature on pass-through has principally adopted three approaches, namely standard single-equation regression techniques, stationary VAR and cointegration.

The most popular approach of empirical ERPT is the "pass-through regression" (Wolden Bache (2006)). The pass-through regression is a regression of a price index (an import or an export price index) on the nominal exchange rate and other determinants of prices, the ERPT being usually defined as the (partial) elasticity of prices with respect to the exchange rate while maintaining other determinants of prices fixed. Thus, estimates of ERPT from a single-equation model stand on a *ceteris paribus* interpretation of coefficients.

Most of the literature examining the effects of exchange rates on prices concentrates on import prices at an aggregate, sectoral or industry level. Campa and Goldberg (2005) presented cross-country, time-series, and industry-specific confirmation on the pass-through of exchange rates into import prices across twenty-three OECD countries. It resulted that the unweighted average of pass-through elasticities is about 46% over one quarter, and about 65% over the longer term. The authors also found that the in the longer run, pass-through elasticities are closer to one, although complete pass-through or producer currency pricing is still rejected for many countries. Campa, Goldberg and González-Mínguez (2005) analyze the exchange rate pass-through into import prices across countries and product categories, in the euro area over a period of fifteen years. It resulted that ERPT in the short run is high although incomplete, (the unweighted average rates by country and by industry are, respectively, 0.66 and 0.56) and that it differs across industries and countries. However, in the long run, exchange rate pass-through is higher and close to 1.

Another strand of empirical literature analyzes the exchange rate pass-through into consumer prices. From a macroeconomic perspective, Mishkin (2008) argues that in the context of a stable and predictable monetary policy environment, nominal shocks play a significantly reduced role in determining fluctuations in consumer prices; thus a stable monetary policy eliminates an important potential source of exchange rate pass-through into consumer prices. Taylor (2000) argued that the establishment of a strong nominal anchor in many countries in recent years is responsible for a low pass-through of exchange rate depreciation to inflation. Gagnon and Ihrig (2004) estimated exchange pass-through to consumer prices for twenty industrial countries between 1971 and 2003. On one hand the authors show that countries with low and stable inflation rates have low exchange rate pass-through to consumer prices. On the other hand, by splitting the sample used in two sub-samples the authors show that the pass-through of exchange rate changes into domestic inflation declined in many economies since the 1980s.

Ihrig, Marazzi, and Rothenberg (2006) examine the exchange-rate pass-through to both import and consumer prices in the G-7 countries, estimating the extent to which they have declined since the late 1970s and 1980s. The results show an average decline of the pass-through of an exchange rate depreciation from 0.7 to 0.4 for import prices and from 0.15 to 0% for consumer prices.

Several studies have analyzed the role played by distribution costs as a component of the retail price of imported goods. Burstein, Neves and Rebelo (2001) emphasize the importance of distribution costs (transportation, wholesaling and retailing services), showing that introducing a distribution sector in a standard model of exchange rate based stabilizations improves its performance. Campa and Goldberg (2006a) analyse the importance of distribution margins, their sensitivity to exchange rates and the role of imported inputs in the production of tradable and nontradable goods, applying these concepts to data from twenty-one OECD countries. Thus, the authors examine the channels for transmission of exchange rates into different types of consumption goods and into the aggregate level of prices. They found that distribution costs represent on average 32 to 50% of the goods' price, these distribution margins coming mainly from wholesale and retail services. Regarding the role of the imported inputs, the authors found evidence that these represent between 10 and 48% of the final price of tradable goods.

Burstein, Eichenbaum and Rebelo (2005) study the depreciation of real exchange rate that took place after large devaluation in the case of five large devaluation episodes: Argentina (2002), Brazil (1997), Mexico (1994) and Thailand (1997) and conclude that the driver of this depreciation is the slow adjustment in the price of nontradable goods and services. A concept analysed here is that of "flight from quality" (defined as the substitution by households towards lower-quality goods in the aftermath of large contractionary devaluations) that can induce a downward bias in the CPI inflation rates through measurement errors.

Another strand of papers examines the exchange rate pass-through into export prices (denominated in exporters' currency). Vigfusson, Sheets and Gagnon (2007) were the first that realized such an analysis. Thus, by using an analytical model the paper show that the prices charged on exports to the United States are more responsive to the exchange rate than is the case for export prices to other countries, and by using rolling regressions it suggests that exchange rate pass-through to export prices have been influenced by country and region-specific factors, including the Asian financial crisis (for emerging Asia), deepening integration with the United States (for Canada), and the effects of the 1992 ERM crisis (for the United Kingdom). Bussière and Peltonen (2008) extends the analysis presented in Vigfusson et al. (2007) by considering a much broader range of economies (twenty-eight emerging market and thirteen advanced economies) and by relating the estimated export price elasticities to economic fundamentals of the exporting countries.

III. Recursive Vector Autoregression (RVAR)

1. Economic framework

An alternative to pass-through regressions is the structural vector autoregression (VAR) methodology. This modelling strategy was developed for advanced countries by McCarthy (2000). The analysis is carried out within a Vector Autoregression (VAR) model, which is well suited to capture both the size as well as the speed of the pass-through. In the baseline model identification is achieved by resorting to the Cholesky decomposition. Impulse response functions are constructed in order to provide information on the size and the speed of the pass-through, while variance decompositions are computed to point out the relative importance of external shocks in explaining fluctuations in the price indices.

This methodology permits the tracking of the pass-through from exchange fluctuations to each stage of the distribution chain in a simple integrated framework. Thus, it is examined the pass-through of exchange rate and import price fluctuations to domestic producer and consumer inflation.

According to Faruqee (2004) the use of a VAR approach to examine exchange rate pass-through has several advantages compared to single-equation-based methods. By investigating exchange rate pass-through into a set of prices along the pricing chain, the VAR investigation describes not only absolute but relative pass-through in upstream and downstream prices. Second, the VAR methodology potentially permits the identification of specific “structural” shocks influencing the system.

McCarthy (2000) proposed equations for inflation rates of country i in period t at each of the three stages – import, producer (PPI), and consumer (CPI), considering the following assumptions:

- *Supply* shocks are identified from the dynamics of oil price inflation denominated in the local currency.
- *Demand* shocks are identified from the dynamics of the output gap in the country after taking into account the contemporaneous effect of the supply shock.
- *External* shocks are identified from the dynamics of exchange rate appreciation after taking into account the contemporaneous effects of the supply and demand shocks.

$$\pi_{it}^{oil} = E_{t-1}\left(\pi_{it}^{oil}\right) + \varepsilon_{it}^{s} \quad (1)$$

$$\tilde{y}_{it} = E_{t-1}\left(\tilde{y}_{it}\right) + a_{1i}\,\varepsilon_{it}^{s} + \varepsilon_{it}^{d} \quad (2)$$

$$\Delta e_{it} = E_{t-1}\left(\Delta e_{it}\right) + b_{1i}\,\varepsilon_{it}^{s} + b_{2i}\,\varepsilon_{it}^{d} + \varepsilon_{it}^{e} \quad (3)$$

$$\pi_{it}^{m} = E_{t-1}\left(\pi_{it}^{m}\right) + \alpha_{1i}\,\varepsilon_{it}^{s} + \alpha_{2i}\,\varepsilon_{it}^{d} + \alpha_{3i}\,\varepsilon_{it}^{e} + \varepsilon_{it}^{m} \quad (4)$$

$$\pi_{it}^{w} = E_{t-1}\left(\pi_{it}^{w}\right) + \beta_{1i}\,\varepsilon_{it}^{s} + \beta_{2i}\,\varepsilon_{it}^{d} + \beta_{3i}\,\varepsilon_{it}^{e} + \beta_{4i}\,\varepsilon_{it}^{m} + \varepsilon_{it}^{w} \quad (5)$$

$$\pi_{it}^{c} = E_{t-1}\left(\pi_{it}^{c}\right) + \gamma_{1i}\,\varepsilon_{it}^{s} + \gamma_{2i}\,\varepsilon_{it}^{d} + \gamma_{3i}\,\varepsilon_{it}^{e} + \gamma_{4i}\,\varepsilon_{it}^{m} + \gamma_{5i}\,\varepsilon_{it}^{w} + \varepsilon_{it}^{c} \quad (6)$$

where

$\pi_{it}^{m}, \pi_{it}^{w}, \pi_{it}^{c}$ - import prices (IVU), producer price index (PPI) and consumer price index (CPI) respectively

$\varepsilon_{it}^{s}, \varepsilon_{it}^{d}, \varepsilon_{it}^{e}$ - supply, demand, and exchange rate shocks respectively

$\varepsilon_{it}^{m}, \varepsilon_{it}^{w}, \varepsilon_{it}^{c}$ - IVU, PPI and CPI shocks respectively

$E_{t-1}(.)$ - the expectation of a variable based on the information set at the end of period *t-1*

The shocks are assumed to be serially uncorrelated as well as uncorrelated with one another within a period. The conditional expectations in equations (1)–(6) can be replaced by linear projections of the lags of the six variables in the system. Under these assumptions, the model was estimated as a VAR using a Cholesky decomposition. The impulse responses of IVU, PPI and CPI inflation to the orthogonalized shocks of exchange rate change then provide estimates of the effect of this variable on domestic inflation indicators.

McCarthy (2000) estimated the model for nine industrialised economies using quarterly data (1976Q1:1998Q4). Six variables are used: local currency oil price index, output gap, nominal effective exchange rate, import price index (or an index of import unit values), producer price index and consumer price index. The impulse response functions and variance decompositions suggest that exchange rate and import price shocks have "modest effects" on CPI for most of the countries analysed, especially for larger economies. Thus, McCarthy draw the conclusion that ERPT is very small, being largest on the import prices, followed by the effect on PPI and trailing is the effect on CPI. On the other hand, ERPT is larger in countries with a larger import share and more persistent exchange rate shocks.

Following the framework introduced by McCarthy (2000), Hahn (2003) analyzes the ERPT for the euro area. The analysis is based on quarterly data covering the time period 1970Q2 to 2002Q2. Besides the variables used by McCarthy (2000), Hahn (2003) introduced the 3-month interest rate to model the monetary policy, deciding to order the variables in the following way - as it is indicated by the vector of endogenous variables:

$$x_t' = (\Delta oil_t\,, i_t\,, gap_t, \Delta e_t\,, \Delta impp_t\,, \Delta ppi_t\,, \Delta hicp_t\,)$$

Thus, the monetary policy represented by its instrument, the interest rate was placed after the oil price, being considered that due to the lagged availability of GDP data, it seemed more reasonable for the author to allow for a contemporaneous impact of monetary policy shocks on the output gap than vice versa. Moreover, it seemed highly plausible to admit a simultaneous effect of monetary policy shocks on the exchange rate. In this context, monetary policy does not react to realized inflation but to expected inflation and may thus affect prices at different stages contemporaneously. In order to investigate the robustness of the results, the order of the variable was modified. The analysis indicates that over an one year horizon the ERPT to import price index, PPI and CPI are 50%, 28% and 8%, respectively. The speed of ERPT slows along the distribution chain.

Gueorguiev (2003) analyse the ERPT in PPI and CPI for Romania, applying McCarthy methodology for monthly data during the period 1997:07 - 2003:01. The results indicate that ERPT has been large and relatively fast, ranging from 60-70% for the PPI and 30-40% for the CPI.

Faruqee (2004) examines euro area ERPT in a set of prices (monthly import and export unit value indices, PPI and CPI) during the period 1990 - 2002. The results indicate that the short-run pass-through is very low in the euro area for a wide range of prices, but pass-through tends to rise over time, the ERPT in producer and export prices being fairly higher (after eighteen months being 0.2 and 0.5, respectively), but the highest degree of pass-though (near unity) is in import prices.

Ca'Zorzi, Hahn and Sánchez (2007) examines the degree of ERPT to prices in twelve emerging markets in Asia, Latin America, and Central and Eastern Europe using quarterly data. Following McCarthy (2000) methodology, the analysis is based on three alternative vector autoregressive models. The results confirm that ERPT declines across the pricing chain, being lower on consumer prices than on import prices. Moreover, it partly overturns the conventional perception that ERPT into both import and consumer prices is always higher in emerging than in developed countries. The results indicate that for emerging economies with only one digit inflation (most notably the Asian countries), ERPT to import and consumer prices are low and not very different from the levels of developed economies. In line with Taylor (2000)'s hypothesis the paper also finds support for a positive relationship between the degree of the ERPT and inflation.

2. *Econometric methodology*

The VAR models were introduced by Christopher Sims (1972, 1980, 1986) and have passed through a continuous development, from explaining and correcting some of the discrepancies with economic theory (e.g. price puzzles) to the improvement of initial technique by applying new methods of identification of structural shocks.

A vector autoregression is a generalization of the AR(p) model to the multivariate case. We have considered a vector of variables y_t. The analysis of any VAR model starts off by estimating a *reduced form* VAR model of order p, where A is an $(n \times n)$ matrix of autoregressive coefficients for $j = 1,2,\ldots,p$, α denotes an $(n \times 1)$ vector of intercept terms allowing for the possibility of nonzero mean $E(y_t)$ and e_t is an $(n \times 1)$ dimension vector of white noise. Σ is an $(n \times n)$ symmetric positive definite matrix.

$$\begin{aligned} y_t &= \alpha + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + e_t \\ E(e_t) &= 0 \\ E[e_t e_t^{'}] &= \Sigma \end{aligned} \tag{7}$$

Considering:

$$Y_t = \left[y_t^{'}, y_{t-1}^{'}, \ldots, y_{t-p+1}^{'} \right] \tag{8}$$

we can write the VAR as an AR(1) process:

$$Y_t = \begin{bmatrix} \alpha \\ 0 \\ \vdots \\ 0 \end{bmatrix} + \begin{bmatrix} A_1 & A_2 & \cdots & A_{p-1} & A_p \\ I & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & I & 0 \end{bmatrix} Y_{t-1} + \begin{bmatrix} e_t \\ 0 \\ \vdots \\ 0 \end{bmatrix} \tag{9}$$

or as:

$$Y_t = \Gamma_0 + \Gamma_1 Y_{t-1} + e_t \tag{10}$$

Using lag operator notation, eq. (7) can be written in the form

$$(I_n - A_1 L - A_2 L^2 - \dots - A_p L^p) y_t = \alpha + e_t \tag{11}$$

or

$$A(L) y_t = \alpha + e_t \tag{12}$$

Here $A(L)$ indicates an $(n \times n)$ matrix polynomial in the lag operator L. The row i, column j element of $A(L)$ is a scalar polynomial in L:

$$A(L) = (\delta_{ij} - a_{ij}^{(1)} L^1 - a_{ij}^{(2)} L^2 - \dots - a_{ij}^{(p)} L^p) \tag{13}$$

where δ_{ij} is unity if $i = j$ and zero otherwise.

A vector y_t is said to be covariance-stationary if its first and second moments ($E(y_t)$ and $E(y_t y'_{t-j})$) are independent of the date t. If the process is covariance-stationary, the expectation operator is applied on both sides of eq. (7) to calculate the mean μ of the process:

$$\mu = \alpha + A_1 \mu + A_2 \mu + \dots + A_p \mu \tag{14}$$

or

$$\mu = (\mathrm{I_n} - A_1 - A_2 - \dots - A_p)^{-1} \alpha \tag{15}$$

Eq. (7) can be written in terms of deviations from the mean as:

$$(y_t - \mu) = A_1 (y_{t-1} - \mu) + A_2 (y_{t-2} - \mu) + \cdots + A_p (y_{t-p} - \mu) + e_t \tag{16}$$

It is useful to rewrite eq. (16) in terms of a VAR (1) process. Thus, there are defined:

$$\xi_t \stackrel{\text{def}}{=} \begin{bmatrix} y_t - \mu \\ y_{t-1} - \mu \\ \vdots \\ y_{t-p+1} - \mu \end{bmatrix}; \xi_t \ (np \times 1) \tag{17}$$

$$F \stackrel{\text{def}}{=} \begin{bmatrix} A_1 & A_2 & A_3 & \dots & A_{p-1} & A_p \\ I_n & 0 & 0 & \dots & 0 & 0 \\ 0 & I_n & 0 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \dots & I_n & 0 \end{bmatrix}; F(np \times np) \tag{18}$$

$$v_t \stackrel{\text{def}}{=} \begin{bmatrix} e_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}; v_t \ (np \times 1) \tag{19}$$

The VAR (p) in eq. (16) can then be rewritten as the following VAR(1). This form is also named the ***companion form***.

$$\xi_t = F\xi_{t-1} + v_t$$

$$E(v_t v_t') = Q$$

$$Q = \begin{bmatrix} \Sigma & 0 & \dots & 0 \\ 0 & 0 & \dots & 0 \\ \vdots & \vdots & \dots & \vdots \\ 0 & 0 & \dots & 0 \end{bmatrix}; Q\ (np\ \times np) \tag{20}$$

Eq. (20) implies that:

$$\xi_{t+s} = v_{t+s} + Fv_{t+s-1} + F^2 v_{t+s-2} + \dots + F^{s-1} v_{t+1} + F^s \xi_t \tag{21}$$

For the process to be covariance - stationary, the consequences of any e_t must die out in time. If the eigenvalues of F all lie inside the unit circle, the VAR is said to be covariance stationary. Thus, the eigenvalues of the matrix F in (18) satisfy:

$$\left|I_n \lambda^p - A_1 \lambda^{p-1} - A_2 \lambda^{p-2} - \dots - A_p\right| = 0 \tag{22}$$

Thus, a VAR(p) is covariance - stationary as long as $|\lambda| < 1$ for all values of λ that satisfy eq. (22). Equally, the VAR is covariance- stationary if all values of z are satisfying eq. (23) lie outside the unit circle.

$$\left|I_n - A_1 z - A_2 z^2 - \dots - A_p z^p\right| = 0 \tag{23}$$

The first n rows of the vector system represented in eq. (21) can be written in the following form:

$$y_{t+s} = \mu + e_{t+s} + \psi_1 e_{t+s-1} + \psi_2 e_{t+s-2} + \dots + + \psi_{s-1} e_{t+1} + F_{11}^{(s)}(y_t - \mu) + F_{12}^{(s)}(y_{t-1} - \mu) + \dots + F_{1p}^{(s)}(y_{t-p+1} - \mu) \tag{24}$$

In this equation $\psi_j = F_{11}^{(j)}$, which represents the upper-left block of $F^{(j)}$ - the matrix F raised to the jth power. Thus, the $(n \times n)$ matrix $F_{11}^{(j)}$ indicates rows 1 through n and columns 1 through n of the $(np \times np)$ matrix $F^{(j)}$. In the same way, $F_{12}^{(j)}$ indicates the block of $F^{(j)}$ consisting of rows 1 through n and columns $(n \times 1)$ through $2n$, while $F_{1p}^{(j)}$ indicates rows 1 through n and columns $(n(p-1)+1)$ through np of $F^{(j)}$.

If the eigenvalues of F all lie inside the unit circle, then $F^s \to 0, as\ s \to \infty$ and y_t can be expressed as a convergent sum of the past values of e_t:

$$y_t = \mu + e_t + \psi_1 e_{t-1} + \psi_2 e_{t-2} + \psi_3 e_{t-3} + \cdots = \mu + \psi(L) e_t \quad (25)$$

The y_t is a vector **MA(∞) representation**.

The matrix ψ_s has the interpretation

$$\frac{\partial y_{t+s}}{\partial e_t} = \psi_s \quad (26)$$

Thus, the row *i*, column *j* element of ψ_s identifies the consequences of one-unit increase in the *j*th variable's innovation at date *t* (e_{jt}) for the value of the *i*th variable at time t+s ($y_{i,t+s}$), maintaining all other innovations at all dates constant.

The combined effects of the change of e_{jt} innovation by δ_j on the value of the y_{t+s} vector will given by:

$$\Delta y_{t+s} = \frac{\partial y_{t+s}}{\partial e_{1t}} \delta_1 + \frac{\partial y_{t+s}}{\partial e_{2t}} \delta_2 + \cdots + \frac{\partial y_{t+s}}{\partial e_{nt}} \delta_n = \psi_s \delta \quad (27)$$

A plot of the row *i*, column *j* element of ψ_s as a function of *s* is called the **impulse-response function**. It presents the response of $y_{i,t+s}$ to a one-time impulse in y_{jt} with all other variables dated *t* or earlier held constant.

$$\frac{\partial y_{i,t+s}}{\partial e_{jt}} \quad (28)$$

As the variance-covariance matrix Σ is a symmetric positive definite matrix, there exists an unique lower triangular matrix M with unit diagonal and a unique diagonal matrix Ω with positive diagonal elements such that:

$$\Sigma = M \Omega M' \quad (29)$$

Using M we can construct an $(n \times 1)$ vector ε_t from:

$$\varepsilon_t = M^{-1} e_t \quad (30)$$

Since e_t is uncorrelated with its own lags or with lagged values of y, it results that ε_t is also uncorrelated with its own lags or with lagged values of y. The elements of ε_t are moreover uncorrelated with each other:

$$E(\varepsilon_t\varepsilon_t') = [M^{-1}]E(e_te_t')[M^{-1}]' = [M^{-1}]\Sigma[M^{-1}]' = [M^{-1}]M\Omega M'[M^{-1}]' = \Omega \qquad (31)$$

Pre-multiplying the eq. (30) by M, results:

$$M\varepsilon_t = e_t \qquad (32)$$

and

$$\begin{bmatrix} 1 & 0 & 0 & \dots & 0 \\ m_{21} & 1 & 0 & \dots & 0 \\ m_{31} & m_{32} & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ m_{n1} & m_{n2} & m_{n3} & \dots & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \vdots \\ \varepsilon_{nt} \end{bmatrix} = \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ \vdots \\ e_{nt} \end{bmatrix} \qquad (33)$$

Thus, it results that:

$$\varepsilon_{jt} = e_{jt} - m_{j1}\varepsilon_{1t} - m_{j2}\varepsilon_{2t} - \cdots - m_{jj-1}\varepsilon_{j-1,t}$$

Applying the conditional mean it results that:

$$\hat{E}(e_{jt}/\varepsilon_{1t}) = m_{j1}\varepsilon_{1t} \qquad (34)$$

As

$$\frac{\partial\hat{E}(e_{1t}/e_{1t})}{\partial e_{1t}} = \frac{\partial\hat{E}(e_{jt}/\varepsilon_{1t})}{\partial\varepsilon_{1t}} = m_{j1} \qquad (35)$$

it results that:

$$\frac{\partial\hat{E}(e_{jt}/y_{1t}, y_{t-1,} \dots y_{t-p,})}{\partial y_{1t}} = m_{j1} \qquad (36)$$

Merging these equations for $j = 1, 2, \dots n$ into a vector

$$\frac{\partial\hat{E}(e_t/y_{1t}, y_{t-1,} \dots y_{t-p,})}{\partial y_{1t}} = m_1 \qquad (37)$$

Substituting eq. (37) generalized for y_{jt} into eq. (27), the consequences for y_{t+s} of new information about y_{jt} are specified by:

$$\frac{\partial\hat{E}(y_{t+s}/y_{jt}, y_{jt-1,t} \dots y_{1t,} y_{1t}, y_{t-1,} \dots y_{t-p,})}{\partial y_{1t}} = \psi_s\, m_j \qquad (38)$$

The plot of the sample estimate of eq. (38) as a function of s is known as an *orthogonalized impulse-response function*.

It is considered that the structural relations between variables can be written under the following form:

$$BY_t = \Phi_o + \Phi_1 Y_{t-1} + \varepsilon_t \tag{39}$$

Premultiplication by B^{-1} allows us to obtain the VAR model in a *standard* form, similar to that in eq. (10):

$$Y_t = B^{-1}\Phi_0 + B^{-1}\Phi_1 Y_{t-1} + B^{-1}\varepsilon_t \tag{40}$$

Identifying the terms from eq. (10) it results:

$$\begin{gathered}\Gamma_0 = B^{-1}\Phi_0 \\ \Gamma_1 = B^{-1}\Phi_1 Y_{t-1} \\ e_t = B^{-1}\varepsilon_t \\ E\left(e_t e_t^{'}\right) = E(B^{-1}\varepsilon_t \varepsilon_t'(B^{-1})') = B^{-1}E(\varepsilon_t \varepsilon_t')(B^{-1})' = B^{-1}\Omega(B^{-1})' = \Sigma\end{gathered} \tag{41}$$

The problem is to take the observed values of e_t and to restrict the system so as to recover ε_t as $\varepsilon_t = Be_t$. Since Σ is symmetric, it contains only $n(n-1)/2$ distinct elements. Given that the diagonal elements of B are all unity, B contains n^2 -*n* unknown values. In addition, there are the *n* unknown values for $\text{var}(\varepsilon_{it})$ for a total of n^2 unknown values in the structural model. Thus, in order to identify the n^2 unknowns from the known $n(n-1)/2$ independent elements of Σ, that is to identify the structural model from an estimated VAR, it is necessary to impose $n(n-1)/2$ restrictions on the structural model.

Assuming that all structural shocks are mutually independent and normalized to be of variance 1, we can write that $\Omega = I_n$. In this context:

$$\Sigma = B^{-1}(B^{-1})' = CC' \tag{42}$$

A method of identification of the structural shocks of this model in the can be accomplished by applying a Cholesky decomposition. The Cholesky decomposition includes the decomposition of the variance covariance matrix Σ of the reduced form residuals in a lower triangular matrix $\tilde{C}$ and an upper triangular matrix $\widetilde{C'}$. Thus the $n(n-1)/2$ economic restrictions, necessary to identify the structural model, are imposed as zero restrictions on the matrix $\tilde{C}$, that links the reduced form and the structural residuals. Economically, these restrictions imply that some of the structural shocks do not have a simultaneous impact on some of the variables.

In this case, we can identify the magnitude of the effect of an structural shock in the jth variable on future values of each of the variables in the system. According to eq. (41), the VAR innovations e_t is a linear combination of the structural disturbances ε_t. The structural disturbances coincide with the orthogonalized innovations in eq. (30)

3. *Empirical analysis*

3.1. Data description

I estimated for Romania a seven-variable VAR model similar to that of McCarthy (2000). The analysis is based on monthly data covering the period between 2000M01 and 2008M12.

The variables used are:

- WPI - US dollar based all Commodities Index - The source of data is IMF's International Financial Statistics (henceforth IFS). This is converted into a local currency index. The variable was seasonally adjusted using EViews 6.0 Census X12. Then it was normalized (considering 2000=100) and transformed into logarithm. Thus, the variable was written as *l_wpi_u_sa_idx*.
- Output gap: The series was determined by applying Hodrick-Prescott Filter to monthly real GDP series. The monthly data were calculated by interpolating the quarterly seasonally adjusted[4] real GDP data (expressed in national currency) in logarithm through Chow-Lin method[5] using as indicator variable the industrial production. The Hodrick-Prescott Filter was applied on the series with additional twelve observations forecasted from a simple ARIMA model in order to avoid the end point problem. The resulting variable was labelled *l_y_sa_yindcl_hpgap* variable.
- Nominal effective exchange rate: The RON nominal effective exchange rate was determined as a basket of two exchange rates, one against the EUR (70%) and the other against the USD (30%). The weights are that of EUR and USD-denominated transactions of Romania's international trading. The series was normalized (considering 2000=100) and transformed into logarithm. The resulting variable was labelled *l_s_ef_sa_idx*.

[4] The seasonally adjustment was made using Tramo/Seats method in Demetra 5.1

[5] The program used for interpolation is using Matlab R2008a, the source being Spain National Institute of Statistics (Quilis (2004)).

- Import prices: The series used were unit value index (expressed in national currency), the source of the data being Eurostat. The series was normalized (considering 2000=100) and transformed into logarithm. The resulting variable was labelled *l_ivu_imp_t_sa_idx* variable.
- Producer Price Index: The industry PPI index was used. The series was normalized (considering 2000=100) and transformed into logarithm. The resulting variable was labelled *l_ppi_n_sa_idx* variable.
- Consumer Price Index: The CPI index published by Romanian National Institute of Statistics was used. The series was normalized (considering 2000=100) and transformed into logarithm. The resulting variable was labelled *l_cpi_u_sa_idx* variable. Besides the CPI index, several other measures of inflation were employed: CORE1 price index (total CPI excluding administered prices[6]), CORE2 price index (total CPI excluding vegetables, fruit, eggs, fuels and administered prices) and Adjusted CORE2 (or CORE3) price index (total CPI excluding vegetables, fruit, eggs, fuels, administered prices, alcoholic beverages and tobacco).
- Short-term Interest Rate: computed as an arithmetic average of overnight tenor ROBID and ROBOR interest rates, the series was labelled *ibon*.

The variables were ordered in the model as listed above. Employing a recursive identification scheme effectively means that the identified shocks contemporaneously affect their corresponding variables and those variables that are ordered at a later stage, but have no impact on those that are ordered before. Therefore, it is reasonable to order the most exogenous variable, in our case the commodity prices, first, as their associated shock influences all other variables in the system contemporaneously, but they are not themselves influenced contemporaneously by any of the other shocks. The next variables in the model are the output gap and the nominal effective exchange rate. Thus, a contemporaneous impact of the demand shocks on the exchange rate is assumed while also imposing a certain time lag on the impact of exchange rate shocks on output. Next price variables follow, being contemporaneously influenced by all of the above mentioned shocks. Following the pricing chain, import prices precede producer and consumer prices. The last variable is interest rate,

[6] The administered prices are: medicines, electric energy, gas, heat energy, rent established by local government, water, sewerage, sanitation, urban transport, railway, transport by inland waterway, post services, fix telephone services, radio-TV subscription, services for the issuance of identity cards, driving licences and passports.

permitting for the money market, and in particular monetary policy, to react simultaneously to all variables in the model.

In order to assess the time series properties of the data unit root tests were completed. The results of the Augmented Dickey Fuller (ADF) and the Phillips Perron (PP) tests are summarized in Table 6 (Appendix 1). The tests indicate that commodities prices (*l_wpi_u_sa_idx*), nominal effective exchange rate (*l_s_ef_sa_idx*), import prices (*l_ivu_imp_t_sa_idx*), producer (*l_ppi_n_d_idx*) and consumer prices (*l_cpi_u_sa_idx, l_core1_u_idx*, *l_core2_u_sa_idx* and *l_core3_u_sa_idx*) are integrated of order one, I(1), while (by construction) the output gap (*l_y_sa_yindcl_hpgap*) is a stationary series. On the other hand, tests suggest that the short-term interest rate (*ibon*) is stationary, I(0).

Given these data properties, a VAR in the first differences of the non-stationary variables was estimated. To determine the lag order of the VAR model several order selection criteria were examined. While the Akaike Information Criterion (AIC), the Hannan-Quinn (HQ) and the Schwarz Criterion (SC) indicated one lag, the likelihood ratio (LR) test suggested two lags (see Table 7 Appendix 2). I decided to rely on the LR test results and estimate the VAR with a constant and two lags.

3.2. Estimation results

In this section the impulse responses of the different price indices to exchange rate shocks are reported and analyzed along the distribution chain. Figures 1 and 2 display the impulse responses (non-accumulated and accumulated) of the import price index, the PPI, and the CPI to an exchange rate shock over a time horizon of sixty months. In this model, the exchange rate shock is estimated given past values of all the variables plus the current values of commodities prices and the output gap.

As the figures show, the initial impact of an exchange rate appreciation on import prices, producer prices and consumer prices is positive as expected and remains so by the end of the 60 months.

Figure 1 - Impulse responses of exchange rate, import, producer and consumer prices to 1% increase in exchange rate

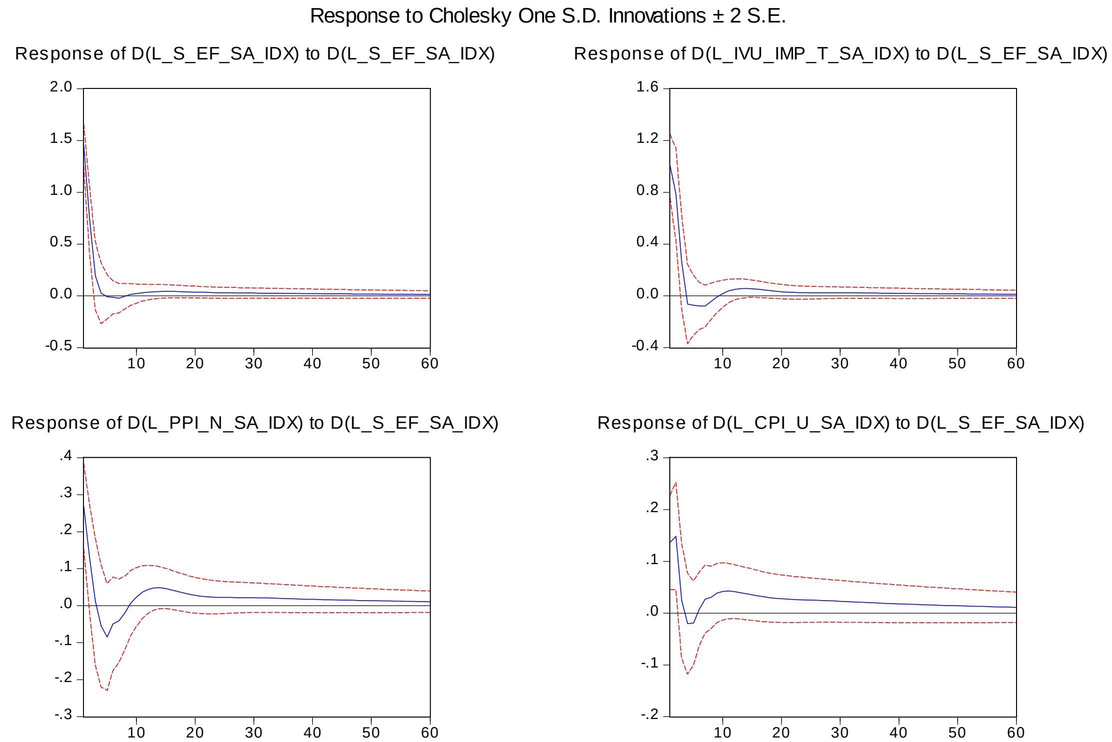
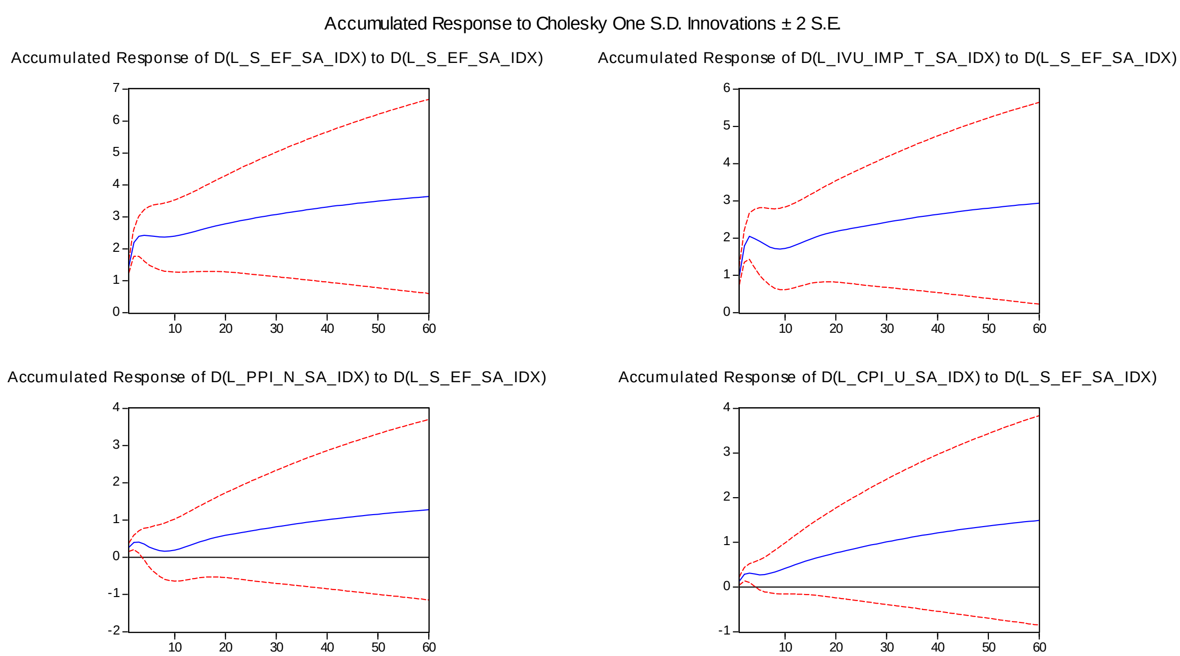


Figure 2 - Accumulated impulse responses of exchange rate, import, producer and consumer prices to 1% increase in exchange rate



The size of the pass-through was determined as the ratio of the accumulated response of the price index to a 1% shock of exchange rate and the accumulated response of the exchange rate to a 1% shock in the exchange rate. The results are presented in the following table:

Table 1 - Exchange rate pass-through into price indices

Price Index	Time frame				
	3M	6M	12M	24 M	60M
ERPT into Import Prices	0.86	0.77	0.74	0.78	0.81
ERPT into Producer Prices	0.17	0.09	0.11	0.23	0.35
ERPT into Consumer Prices	0.13	0.12	0.20	0.30	0.41

Thus, it resulted that the exchange rate pass-through to import prices after three months (the short-term pass-through) is 86%, declines to 74% after one year and increases to 81% after five years. On the other hand, the pass-through into producer prices after three months is very low (17%), declines to 11% after one years and increases to 35% after five years. The ERPT into consumer prices after three months is 13% and rise to 20% after one years and 41% after five years. Thus, as it was expected the ERPT into import prices is very high, but not complete. On the other hand, although the ERPT to import prices is significant higher than to producer and consumer prices, ERPT declines along the pricing chain only on short-term as after six months it becomes higher for the consumer than to producer prices.

Additional insights into the impact of external shocks on the different price indices to those obtained from the impulse responses functions may be received from variance decompositions. Although impulse response functions provide information on the size and speed of the pass-through, they give no information on the importance of the respective shocks for the variance of the price indices. The variance decompositions specify the percentage contribution of the different shocks to the variance of the k-step ahead forecast errors of the variables.

I begin by investigating the importance of exchange rate pass-through for import price fluctuations (Table 2). Exchange rate shocks are particularly significant in explaining import price variance, their share ranging from over 38 to 46%. The percentage declines as the forecast horizon increases. For producer prices, the percentage of variance explained by exchange rates is quite low, ranging from 9 to 14%. The results for consumer price index are similar to the ones for producer price index, exchange rate shocks accounting for 8-14% of the variations in CPI.

Figure 3 - Variance Decomposition

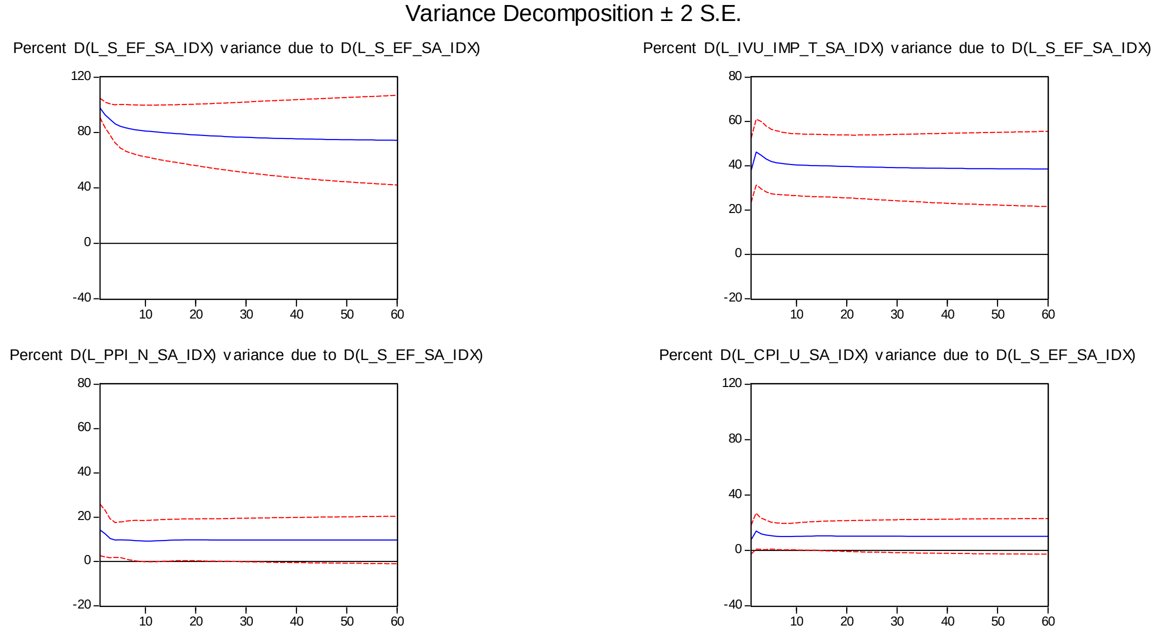


Table 2 - Percentage of Price index forecast variance attributed to exchange rate

Price Index	Time frame				
	3M	6M	12M	24 M	60M
Import Prices	44.7	41.4	40.2	39.4	38.6
Producer Prices	10.4	9.6	9.3	9.7	9.7
Consumer Prices	11.8	10.2	10.3	10.2	10.1

3.3. RVAR rolling window estimation

I performed a rolling window estimation using the same specification as in previous estimated VAR, shortening the sample with two years. Thus, it yielded twenty-four VARs on successive time periods, spanning the entire sample used in the previous estimation (2000M0-2008M12).

The time dynamics in the successive rolling window estimations of exchange rate pass-through into import, producer and consumer price indices are presented at different exchange rate shock propagation time periods. It resulted that the exchange rate pass-through in producer and consumer price indices has declined in time while for import prices the case is less clear cut.

Figure 4 - Rolling window estimation of ERPT into import prices

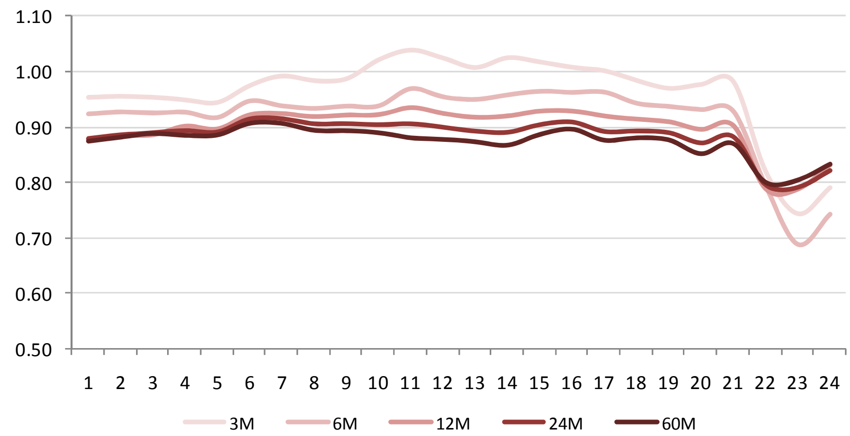


Figure 5 - Rolling window estimation of ERPT into producer prices

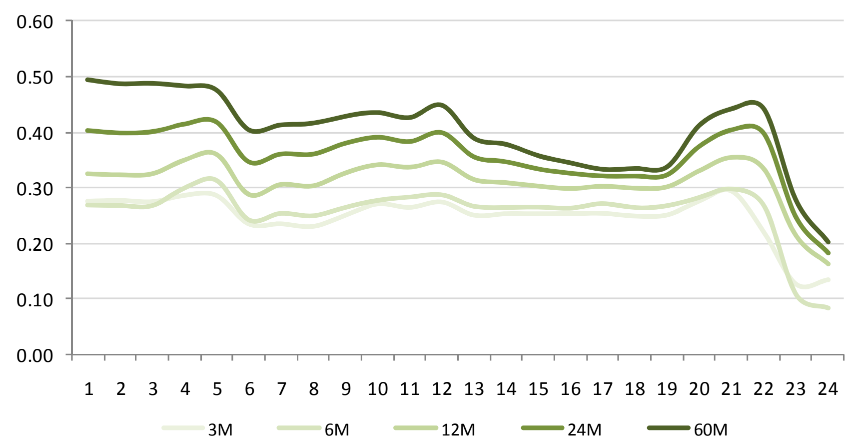
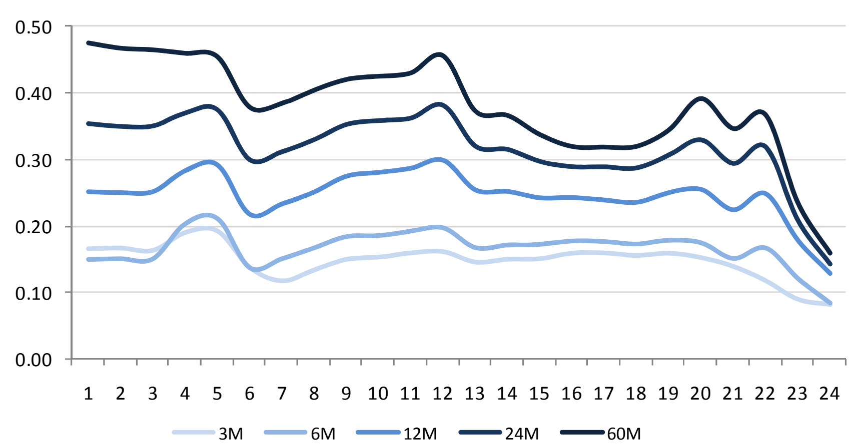


Figure 6 - Rolling window estimation of ERPT into consumer prices



3.4. *Estimation results for different consumer price measures*

I estimated other three VARs by replacing the *l_cpi_u_sa_idx* variable with other measures of inflation: CORE1 price index (*l_core1_u_idx*), CORE2 price index (*l_core2_u_sa_idx*) and Adjusted CORE2 (or CORE3) price index (*l_core3_u_sa_idx*). The pass-troughs into these price indices are presented in the following figure and table.

Figure 7 - Exchange rate pass-through into consumer price indices

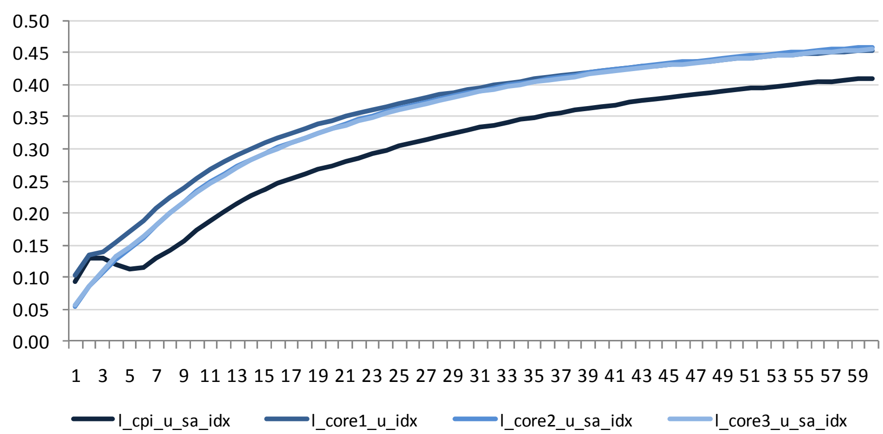


Table 3 - Exchange rate pass-through into consumer price indices

Price Index	Time frame				
	3M	6M	12M	24 M	60M
l_cpi_u_sa_idx	0.13	0.12	0.20	0.30	0.41
l_core1_u_idx	0.14	0.19	0.28	0.37	0.45
l_core2_u_sa_idx	0.11	0.16	0.26	0.36	0.46
l_core3_u_sa_idx	0.11	0.16	0.26	0.36	0.45

The results suggest that the exchange rate pass-through is higher in the case of core measures than in the case of for total CPI. This could be explained by the consumer price index components that are not present in the core measures, some of which being legally linked to a fixed exchange rate from a particular moment of the previous year[7].

As in the previous section I performed rolling window estimates for these VARs. The results suggest that the exchange rate pass-through into consumer prices' core measures corroborate the previous finding of a declining time path.

[7] For example the excises in the fuel prices (which represents roughly 50%) is linked to the exchange rate announced by the central bank on October 1st of the previous year.

Figure 8 - Rolling window estimation of ERPT into consumer price index CORE1

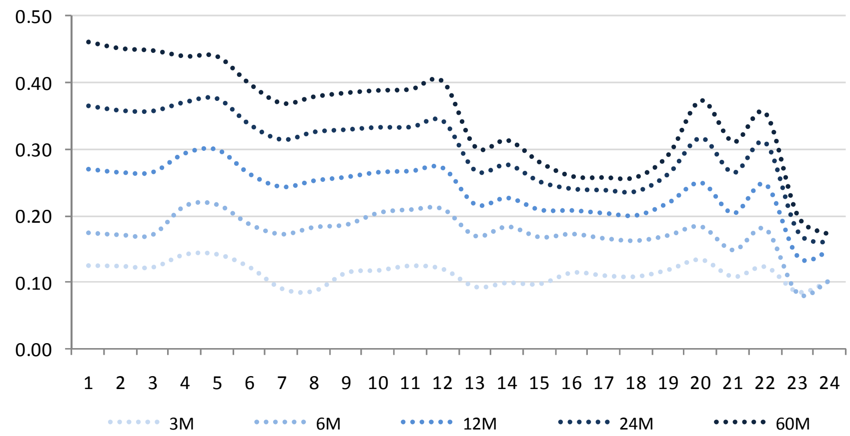


Figure 9 - Rolling window estimation of ERPT into consumer price index CORE2

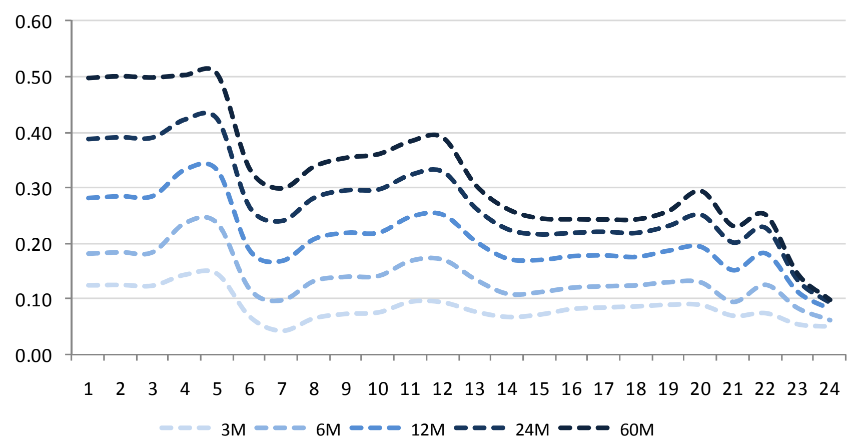
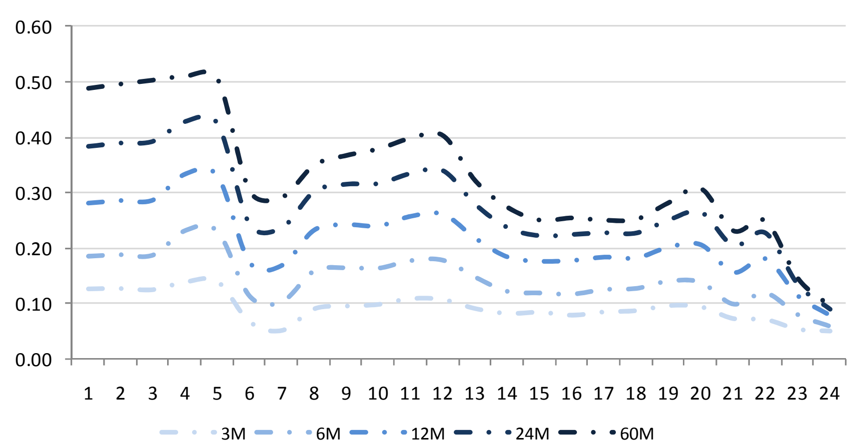


Figure 10 - Rolling window estimation of ERPT into consumer price index CORE3



IV. Sign restriction VAR

1. Economic and econometric methodology

The literature regarding the VARs with restrictions on the impulse response functions developed much lately, applications of this method being found in all areas where the Structural VAR can be applied. Harald Uhlig (2006) presents the applications of this methodology in different areas of research. For the determination of the impact of a shock on a certain variable, the main problem that arises is that of identification, different methods of identification conducting to different results. The wrong answers of variables at different shocks were named in the literature "puzzles", these "puzzles" being solved by modifying the set of endogenous or exogenous variables used, by changing the set of restrictions or by changing the sample of data used.

In the case of VAR models the criteria on which the performance is judged are the amplitude, the shape and especially the sign of the impulse response function. Recent developments study the shock identification by imposing explicit restrictions and recovering the duration and amplitude, also analyzing the relevance of responses for the economic phenomenon studied. The literature presents different methods for the creation and for the implementation of the restrictions. Uhlig (1999) proposes sign restrictions on the impulse response functions. This method could be seen as minimalistic as it identify only one shock with minimum of restrictions imposed.

In contrast to other types of identification methods that attempt to identify n fundamental innovations (as it was presented earlier in the paper), Uhlig[8] (2005) proceeded differently, being interested only in one fundamental innovation, the other $n \times 1$ fundamental innovations not being identified. Thus, by finding only one fundamental innovation, only a single column $c \in \mathbb{R}^n$ of the matrix C (eq. (42)) has to be identified. The author proves that multiplying the Cholesky factor $\tilde{C}$ with a rotation matrix (a matrix which rotates a column and a row of the initial matrix) is equivalent with multiplying an impulse vector with a vector for which its components are drawn from a normal standard distribution. The vector $\mathrm{c} \in \mathbb{R}^{\mathrm{n}}$ is defined as an *impulse vector* if there is some matrix C, so that $\Sigma = CC'$ and so that c is a

[8] The theoretical framework described here is taken from Uhlig (2005).

column of C. Considering $\tilde{C}\tilde{C}' = \Sigma$ be the Cholesky decomposition Σ, c will be an *impulse vector* if there exists a n-dimension vector α of unit length so that:

$$c = \tilde{C}\alpha \tag{43}$$

To determine the impulse response, it is considered $r_i(k)\epsilon\mathbb{R}^n$ be a vector response at horizon k to the ith shock in a Cholesky decomposition of Σ. The impulse response $r_c(k)$ for c is then given by:

$$r_c(k) = \sum_{i=1}^{n} \alpha_i \, r_i(k) \tag{44}$$

Further, a vector $\tilde{b} \neq 0$ is find with r $(\Sigma - cc')\tilde{b} = 0$ is normalised so that $b'c = 1$. Then, the real number $\varepsilon_t^{(c)} = b'e_t$ is the scale of the shock at date t in the direction of the impulse vector c and $\varepsilon_t^{(c)}$is the part of e_t which is attributable to that impulse vector. Basically, b is the appropriate row of C^{-1}.

The fraction of the variance of this forecast error for variable *j* explained by shock at horizon k is given by:

$$\phi_{c,j,k} = \frac{(r_{c,j}(k))^2}{\sum_{i=1}^{n}(r_{i,j}(k))^2} \tag{45}$$

Considering the coefficient matrices of a VAR (as in eq. (7)): $A = [A_1', \ldots, A_p',]$, an error variance–covariance matrix Σ and some horizon K, a set $\mathcal{A}(A, \Sigma, K)$ of all impulse vectors is considered.

As a first step, Uhlig (2005) simply use the OLS estimate of the VAR, $A = \tilde{A}$ and $\Sigma = \tilde{\Sigma}$, fix K or try out a few choices for K and creates the entire range of impulse responses. The set $\mathcal{A}(\tilde{A}, \tilde{\Sigma}, K)$ results in an interval for the impulse responses. Numerically, this is performed by generating many impulse vectors, by calculating their implied impulse response functions, and checking whether or not the sign restrictions are satisfied. The impulse vectors are generated randomly: draw $\tilde{c}$ from a standard normal in $\mathbb{R}^n$, flip signs of entries which violate sign restrictions, multiply with $\tilde{C}^{-1}$ to calculate the corresponding $\tilde{\alpha}$ and divide by its length to obtain a candidate draw for c. It is verified if $c \in \mathcal{A}(\tilde{A}, \tilde{\Sigma}, K)$ by verifying the sign restrictions on the impulse responses for all relevant horizons $k = 0, \ldots, K$. After the candidate draws for *c* were generated, the maximum and the minimum of the impulse responses for those *c* were plotted.

Based on a Bayesian approach, chosen by Uhlig (2005) as it is considered "computationally simple and since it allows for a conceptually clean way of drawing error bands for statistics of interest such as impulse responses", the author proposes two related, but different approaches: the "pure-sign-restriction approach" and the "penalty-function approach". In the first one, all impulse vectors satisfying the impulse response sign restrictions are considered equally likely, while in the second approach an additional criterion to select the best of all impulse vectors is used.

For the "pure-sign-restriction approach" it is considered a lower triangular Cholesky factor of Σ: $\tilde{C}(\Sigma)$, a space of positive definite $n \times n$ matrices: $\mathcal{P}_n$ and $\mathcal{S}_n$ as the unit sphere in $\mathbb{R}^n$, with $\mathcal{S}_n = \{\alpha \in \mathbb{R}^n : \|\alpha\| = 1\}$. Numerically, the pure-sign restriction approach is implemented in the subsequent manner. The posterior is given by the usual Normal–Wishart posterior for (A, Σ), given the assumed Normal–Wishart prior for (A, Σ). To draw from this posterior, it is performed a joint draw from both the posterior for the unrestricted Normal–Wishart posterior for the VAR parameters (A, Σ) and from an uniform distribution over the unit sphere $\alpha\mathcal{S}_n$. A draw a from the n-dimensional unit sphere was obtained by drawing $\tilde{\alpha}$ from the n-dimensional standard normal distribution and after that normalizing its length to unity: $\alpha = \tilde{\alpha} / \|\tilde{\alpha}\|$. Then the impulse vector c is constructed and from eq. (44) are calculated the impulse responses $r_{k,j}$ at horizon $k = 0, \dots, K$ for the variables j and it was verified if the sign restrictions are satisfied. If they were satisfied, the draw was kept; otherwise, the next draw was initiated. Error bands were calculated using all the draws which have been kept.

An (2006) apply the VAR with sign restriction procedure in estimating exchange rate pass-through at different stages of distribution for eight major industrial countries: United States, Japan, Canada, Italy, Finland, Sweden and Spain. The results indicate that the exchange rate pass-through is incomplete in many horizons, though complete pass-through is observed occasionally.

2. *Empirical analysis*

The methodology applied is based on a SVAR with sign restrictions on impulse responses of the variables, similar to that of Uhlig (2005). The programs used are the ones of the author, customised to the set of variables used and in accordance with the restrictions considered relevant. Routines for the variance decomposition of the variables and for the simulation of confidence intervals - corresponding to one standard deviation - were also implemented. All the programs are performed in WinRats 7.2.

The analysis is made for the Romanian economy and it is based on monthly data covering the period between 2000M01 and 2008M12. The variables are the ones used in the previous section: WPI - an all commodities index (*l_wpi_u_sa_*idx), real GDP (*l_y_sa_yind_u_cl_idx*), nominal effective exchange rate (*l_s_ef_sa_idx*), import prices (*l_ivu_imp_t_sa_idx*), producer price index (*l_ppi_n_sa_idx*), consumer price index (*l_cpi_u_sa_idx*) and short-term interest rate (*ibon*). A VAR with two lags in levels was used.

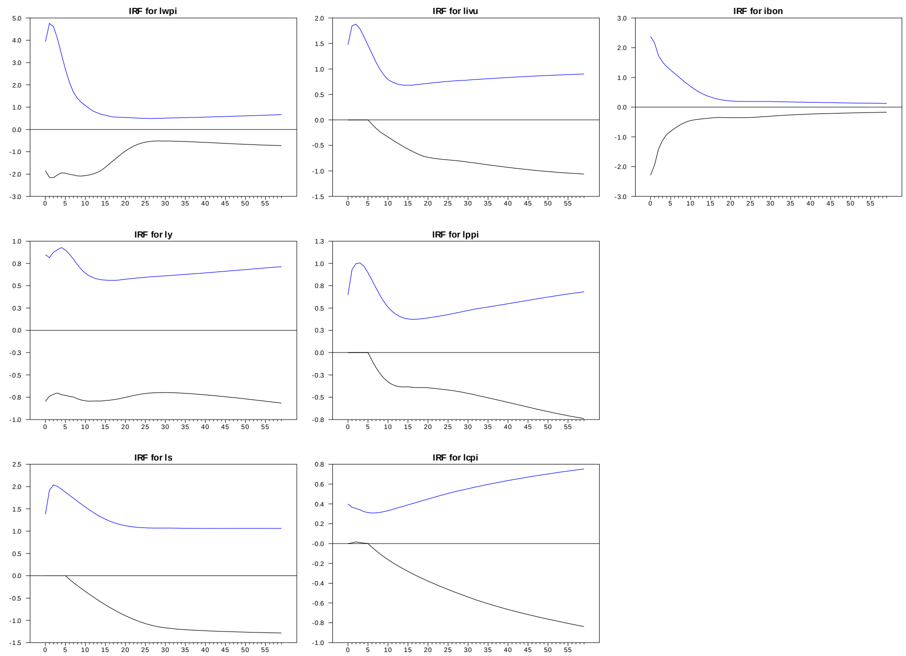
The sign restrictions imposed on impulse responses assure that the exchange rate will not decline in response to its own positive shock and that the import, producer and consumer prices will not decrease in the context of exchange rate depreciation. I did not impose additional restrictions on the GDP response as in the case of the Romanian economy the effect of the exchange rate on net exports may be compensated (or possibly overcompensated at times) by wealth and balance sheet effects. Also the monetary policy's response to an exchange rate shock in the context of an inflation targeting regime is not clear cut, the direct effect of the exchange rate in import prices could be overturned by an inverse response induced by an opposite reaction of the output gap.

For robustness confirmation the horizon K for the sign restrictions will vary to 2 (3-month), 5 (6-month), 8 (9-month), 11 (one year) and 23 (two years).

First of all I applied the sign restriction approach that imply the simply use the OLS estimate of the VAR. Thus, I generated 1,000,000 candidate draws for c in order to plot the maximum and the minimum of the impulse responses for those c that satisfy the restrictions.

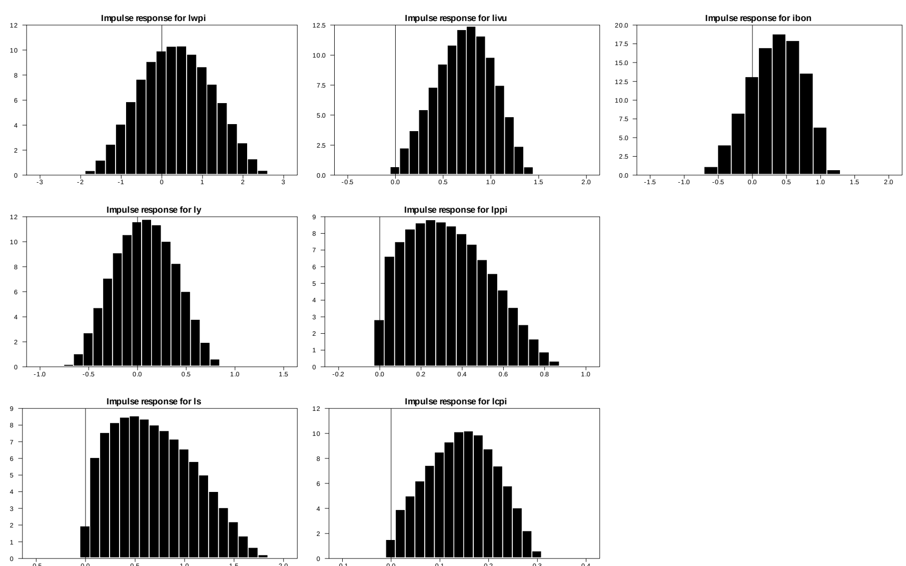
Thus Figure 11 shows the range of impulse response functions, which satisfies the sign restrictions for $k = 0, ..., K$ months after the shock, where K=5.

Figure 11 - The maximum and the minimum of the IRF (10^6 extractions) when imposing the sign restrictions for K-5 at the OLSE point estimate for the VAR



min & max for IRF K=5

Figure 12 - Histogram for initial impulse responses (at horizon 0) when imposing the sign restrictions for K=5 at the OLSE point estimate for the VAR

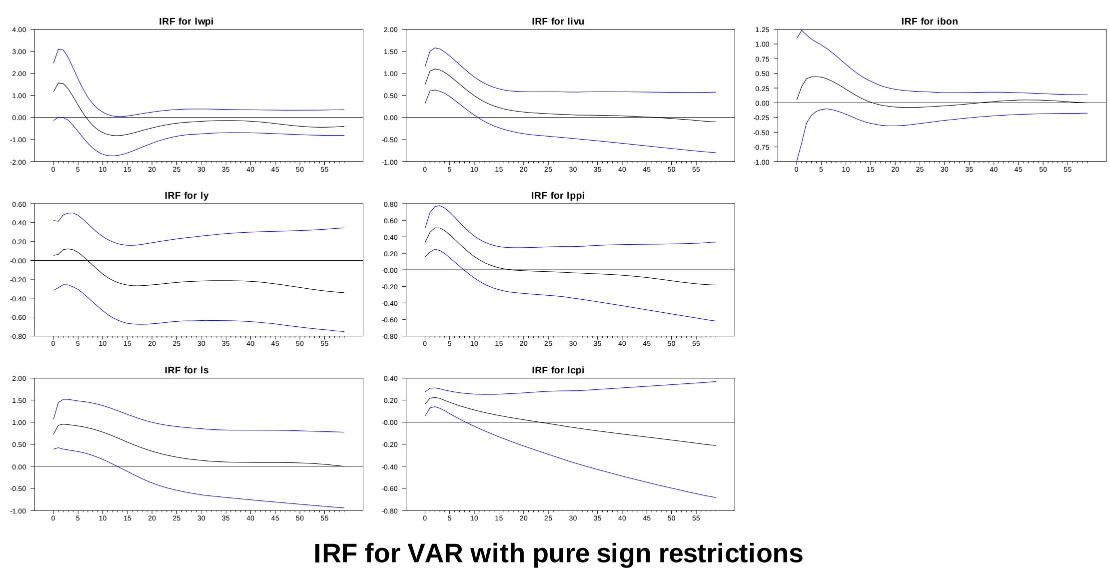


Histogram for initial IRF

Figure 12 shows the histograms of the initial responses of all variables (at horizon 0), when drawing the orthogonalized impulse vectors uniformly from the unit sphere, as described for the pure-sign-restriction approach. It can be seen that for the initial response of the exchange rate and price indices the sign restrictions seem to cut off a relatively small part of the distributions. The figure also suggests that the extractions of the orthogonalized impulse vectors and the restrictions of the signs of the impulse responses lead to shaped distributions for the initial impulse responses.

For the pure sign restriction approach the number of draws from the posterior of the VAR (n_1) was chosen to be equal to the number of draws α from the unit sphere (n_2) and it was set to 750. Impulse responses to an exchange rate shock were constructed, considering K equal to 5. Thus, the responses of the exchange rate and of the import, producer and consumer price indices have been restricted to be positive for the next six months (k = 0, ..., 5) after the shock.

Figure 13 - Impulse responses to an exchange rate shock, using the pure sign restriction approach with K = 5



The Figure 13 presents the median as well as the 16% and the 84% quantiles for the sample of impulse responses: if the distribution was normal, these quantiles would correspond to a one standard deviation band. Thus, the nominal effective exchange rate increase right away and considerably in response to their own shocks and they remain significant for one year. The import price indices react strongly and positively instantly after the shock. It remains statistically significant for ten months. On the other hand, the producer and consumer price indices responded in the same way as import price indices, but at a smaller scale.

The size of the pass-through was determined as the ratio of the accumulated response of the price index to an exchange rate shock and the accumulated impulse response of the exchange rate to its own shock.

Table 4 and Figures 14 to 16 present the exchange rate pass-through to import, producer and consumer price indices. Thus, the exchange rate pass-through to import prices is higher than 1 in the short run, but after one-year horizon it declines towards 67% after five years. Even though the median of the exchange rate pass-through distribution seems higher than one, the confidence intervals are relatively broad and encompass the full pass-through pointed by the previous econometric method applied (RVAR).

The pass-through ratios are largest for import price index, followed by the producer price index and then by the consumer price index over a two-years horizon. Thus, up to two years period, the pass-through declines along the distribution chain; after that the pass-through to CPI exceeds that to PPI.

Table 4 - Exchange rate pass-through into price indices, using the pure sign restriction approach with K = 5

Price Index	Time frame				
	3M	6M	12M	24 M	60M
ERPT into Import Prices	1.11	1.10	0.94	0.72	0.67
ERPT into Producer Prices	0.50	0.50	0.40	0.19	0.15
ERPT into Consumer Prices	0.24	0.23	0.20	0.16	0.30

Figure 14 - Exchange rate pass-through into import price index, using the pure sign restriction approach with K = 5

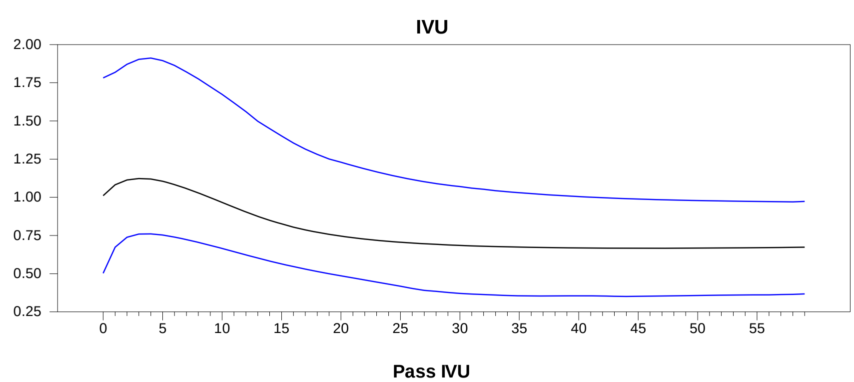


Figure 15 - Exchange rate pass-through into import price index, using the pure sign restriction approach with K = 5

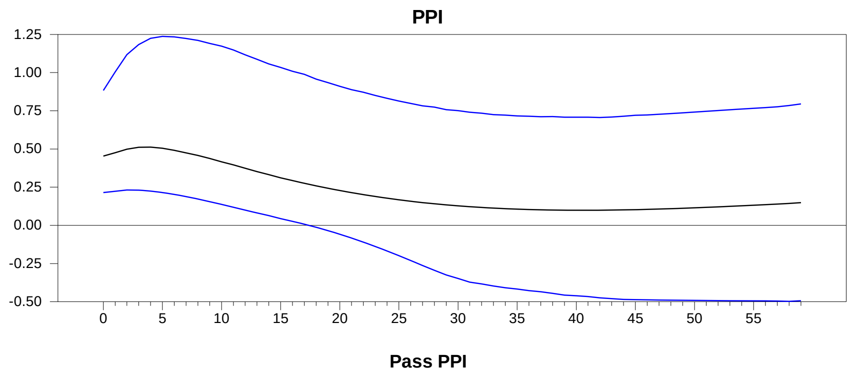
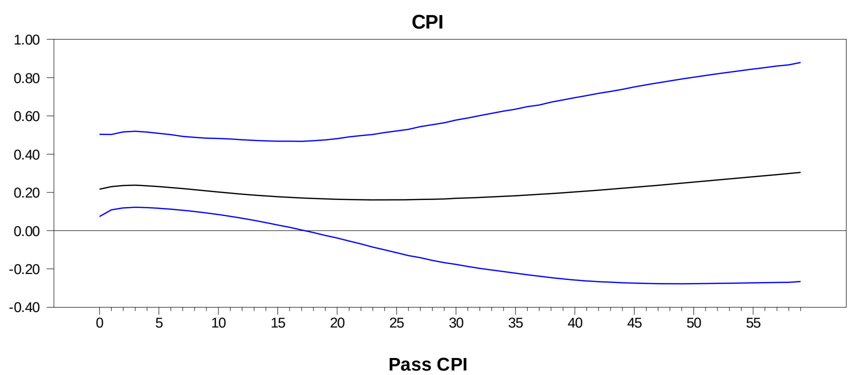


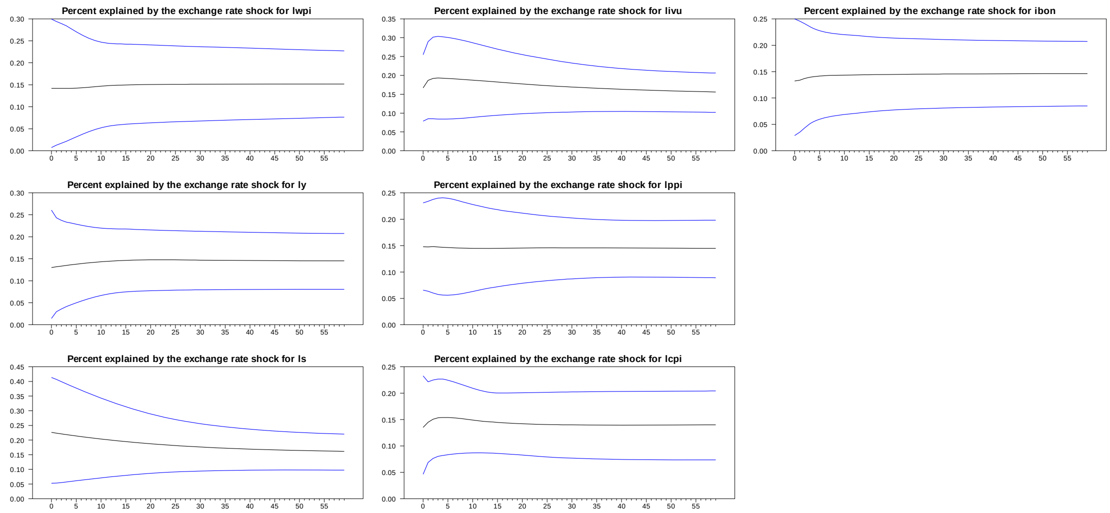
Figure 16 - Exchange rate pass-through into import price index, using the pure sign restriction approach with K = 5



It is important to find out how much of the variation is explained by the shocks. Using the pure sign restriction approach with a six months restriction (K = 5), the Figure 17 presents the variance decomposition. Thus, the plots show the fraction of the variance of the variables explained by the exchange rate shock. The three lines are the 16% quantile, the median and the 84% quantile.

According to the median estimates, exchange rate shocks account for 15 - 20% of the variance in the import price index at all horizons and for 15% of the long-horizon variance in the producer and consumer prices. Thus, the variance decomposition indicates that the exchange rate shock explains a significant proportion of the forecast error variance of the price indices.

Figure 17 - Variance decomposition using the pure sign restriction approach with K = 5



VD for VAR with pure sign restrictions

3. Robustness check

In order to establish how sensitive are the results to the variation in horizon K for the sign restrictions, I present the results for 3-months (K =2), 12-months (K =11) and 24-months (K =23) horizon restriction. Figure 39 (Appendix 4) presents the impulse response functions to an exchange rate shock for different K specifications. The results are fairly similar to that of the baseline setup, especially for K =2. But as horizon K increases, it seems that the bands move up.

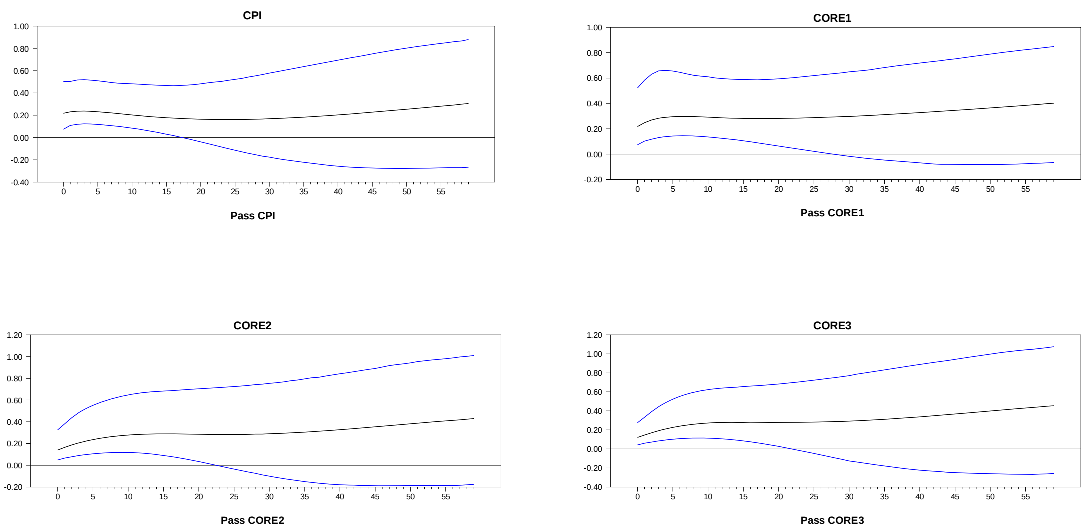
Figures 40 to 42 (Appendix 4) present the exchange rate pass-through into the price indices for different K. Up to six-months the exchange rate pass-trough for the four K specifications are almost equal in the case of import and producer price indices. After six-months the four estimations of the exchange rate pass-through begin to distance a little from each other; the size of the pass-through increasing in proportion to K horizon. On the other hand, in the case of consumer price index, the four specifications of exchange rate pass-through slightly differentiate since the beginning.

Figure 43 presents the forecast error variance decompositions of the variables for different K specifications, suggesting that these results are similar to those from the baseline setup - only for the consumer price index the percentage of variance increases a little in line with K horizon. In general, the results seem to be quite robust to different horizons.

4. Estimation results for different consumer price measures

An examination of the exchange rate pass-through into several consumer price index core measures was performed. It resulted that the exchange rate pass-through is higher in the core measures than in total consumer price index. This evidence further substantiates the case previously exposed by the RVAR analysis.

Figure 18 - Exchange rate pass-through consumer price indices, using the pure sign restriction approach with K = 5



V. Markov Switching VARs - Investigating the asymmetry of the pass-through

1. Economic framework

Although many articles consider that the degree of pass-through is not affected by the direction of the change in the exchange rate, there could be cases in which pass-through may vary depending on whether the importer's currency is appreciating or depreciating. Also bigger movements in the exchange rate could alter the behaviour of the economic agents evident in different pass-throughs.

Pollard & Coughlin (2004) presents the pricing decisions taken by exporters in the context of exchange rate changes. Thus, when production is realized only with domestic inputs, in the context of the depreciation of home's currency (the importer's currency), a foreign firm will have to take to main decisions: on one hand to reduce its mark-up on order to keep the home currency price of its product (no pass-through) and on the other hand, to maintain its mark-up by rising the home currency price to cover the entire depreciation (in this case will probably lose some market share) (complete pass-through). Another decision will be a combination of these two (partial pass-through). In the first case of no pass-through, the sales of the foreign firm abroad will be maintained, but its revenues will decline implying a decline in its profits. In the case of complete pass-through the prices will remain unchanged, but sales in the home country will decline, which will result in a drop in revenue and consequently in profit. The size of the decline in profit is determined by the elasticity of demand for that certain good in the home country. In the case of partial pass-through both the received price and the sales will drop. In the case of the depreciation of the home currency, the negative consequences on the profits could be diminished by using both foreign and local inputs in production.

On the other hand, the appreciation of the home currency has a positive impact for the foreign firm: the firm may increase its mark-up by keeping the prices constant (no pass-through) or may chose to increase market share by cutting the prices in accordance with the appreciation (complete pass-through) or some combination of both. While in the case of no pass-through, the prices rise and the quantity remains unchanged, in the case of complete pass-through opposite occurs. In the case of partial pass-through both elements increase. In all these cases the profit will raise, but this will depend on the elasticity of demand for that certain good in the home country.

Pollard & Coughlin (2004) presents the main explanations for asymmetric pass-through.

A first explanation could reside in the firms purpose to maintain the *market share*. One possibility is that the firms to maintain their prices constant in the face of exchange rate fluctuations, that imply profits decline during periods of exchange rate appreciation and profits increase during periods of depreciation. In this case, pricing to market implies symmetric pass-through. Another possibility is that the firm will adjust their mark-ups. Thus, an appreciation of the importing country's currency will give the foreign firms the opportunity to lower the import prices and thus to rise their market share, while keeping their mark-ups constant. On the contrary, in order to reserve their market share in the case of the depreciation, the firms will have to absorb a part of the inflationary impact that will determine a decline in their mark-ups. Given the fact that the foreign firms' actions are restricted by the size of their mark-ups, the pass-through will be higher for appreciation than for depreciation. Thus, the pass-through will be asymmetric.

Another explanation for asymmetries in pass-through focuses on *production switching*, namely on the fact that foreign firms will tend to switch towards inputs produced in their own countries when the exchange rate appreciates and inversely when the exchange rate depreciates. Thus, in the case of depreciation, foreign firms will use imported inputs, implying no pass-through.

The *binding quantity constraints* refers to the incapacity of exporting firms to rise the production in the importing country due to capacity constrains in their distribution network or due to trade restrictions. When the importer's currency depreciates the revenues expressed in foreign currency decline. In this context the foreign firm could increase sales up to the capacity constraints limit, as an alternative to increase prices. In the case of appreciation, the revenues expressed in foreign currency will increase. In this context, the exporter will maintain the price level intact. Thus, the exchange rate pass-through is higher in the case of depreciation than in the case of appreciation of the exchange rate.

Menu costs together with the type of price invoicing which is followed determine the asymmetry with respect to the size of exchange rate change. The cost of changing prices enlarges the probability that firms will adjust the invoice price only if the modify in the exchange rate is above some threshold. The direction of the asymmetry in pass-through will depend on the currency of invoice. Thus, when imports are invoiced in the importer's currency, a small change in the exchange rate will not determine the adjustment of local prices and the foreign firm will absorb the modification in the exchange rate through the price it receives (expressed in its currency) - in this case pass-through is zero. But if the change in the exchange rate is significant, the foreign firm will adjust local prices. While in the case of partial pass-through both local currency prices and foreign currency prices will change, in the case of complete pass-through foreign currency prices will not change. Therefore, with invoicing in the importer's currency, pass-through will be larger when exchange rate changes are large than when they are small.

When imports are invoiced in the exporter's currency the pass-through will be complete (will fully determine the local prices) at a small change in the exchange rate. The exporters adjust the foreign currency prices when the exchange rate change is large, thus dropping the amount of pass-through. Thus, in the case of exporter's currency invoicing the pass-through is greater when exchange rate changes are small.

2. Markov Switching Vector Autoregression (MS-VAR)

2.1. Econometric methodology

A popular method for determining asymmetries is by using Markov Switching models. This class of models have been proposed by Goldfeld and Quandt (1973) in the form of switching regressions. Another step in Markov Switching models analysis is due to Hamilton (1989), which extended the methodology to the case of dependent data, specifically on autoregressions. Important contributions to the use of Markov Switching models combined with vector autoregression are due to Hamilton (1989) and Krolzig (1998).

As data for emerging economies could present structural breaks or shifts, this class of models (Markov Switching Vector Autoregression - MS-VAR) is naturally equipped to capture the properties of the data used.

As presented in Hamilton (1994)[9] the changing behaviour of variables could be explained by the fact that the process could be influenced by an unobservable random variable s_t^*, named *state* or *regime* that the process was in at the time *t*. As s_t^* takes only discrete values, the simplest time series model for a discrete-valued random variable is Markov chain.

Considering s_t a random variable that can only take integer values $\{1,2,\dots,M\}$, the probability that s_t will be equal to some particular value *j* depends only on the most recent value s_{t-1}, thus the process will follow an M-state Markov chain with transition probabilities $\{p_{ij}\}_{i,j=1,2,\dots M}$. The transition probabilities p_{ij} give the probability that state *i* will be followed by state *j*.

$$P\{s_t = j \mid s_{t-1} = i, s_{t-2} = k, \dots\} = P\{s_t = j \mid s_{t-1} = i\} = p_{ij} \tag{46}$$

and

$$p_{i1} + p_{i2} + \dots + p_{iM} = 1 \tag{47}$$

The transition matrix P $(M \times M)$ is:

$$P = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{M1} \\ p_{12} & p_{22} & \cdots & p_{M2} \\ \vdots & \vdots & \vdots & \vdots \\ p_{1M} & p_{2M} & \cdots & p_{MM} \end{bmatrix} \tag{48}$$

Considering the a random vector ξ_t $(M \times 1)$ for which its jth element is equal to 1 when $s_t = j$ and it is equal to 0, otherwise, it results the following Markov chain representation:

$$\xi_t = \begin{cases} (1, & 0, & 0, & \dots & 0)' & when\ s_t = 1 \\ (0, & 1, & 0, & \dots & 0)' & when\ s_t = 2 \\ & & \vdots & & & \vdots \\ (0, & 0, & 0, & \dots & 1)' & when\ s_t = M \end{cases} \tag{49}$$

Thus, the conditional expectation of ξ_{t+1} is given by the *i*th column of the matrix P and in addition, when $s_t = i$ the vector ξ_t corresponds to the ith column of $I_M(M \times M)$identity matrix, the conditional expectation could be expressed as $P\xi_t$. And from the Markov property in eq. (46) it results:

$$E(\xi_{t+1} \mid s_t = i) = \begin{bmatrix} p_{i1} \\ p_{i2} \\ \vdots \\ p_{iN} \end{bmatrix} \tag{50}$$

[9] The theoretical framework presented is that of Hamilton (1994)

$$E(\xi_{t+1} | \xi_t) = P\xi_t$$

$$E(\xi_{t+1} | \xi_t, \xi_{t-1}, \dots) = P\xi_t$$

The eq. (50) can be expressed as a first-order vector autoregression for ξ_t, where the innovation v_t is a martingale difference sequence, with average zero.

$$\begin{gathered} \xi_{t+1} = P\xi_t + v_{t+1} \\ v_{t+1} \equiv \xi_{t+1} - E(\xi_{t+1} | \xi_t, \xi_{t-1}, \dots) \end{gathered} \tag{51}$$

Essential properties of theoretical MS-VAR models are that of ergodicity and irreducibility. Thus, according to Hamilton (1994), an M-state Markov chain is said to be reducible if there exists a method to mark the states (a method to decide which cell to be state 1, state 2 and so on) such that the transition matrix to be written in the following form:

$$P = \begin{bmatrix} B & C \\ 0 & D \end{bmatrix} \tag{52}$$

where B is a $(K \times K)$ matrix for some $1 \leq K < M$. Thus, P is upper block-triangular. Therefore, once the process enters a state j, such that $j \leq K$, there is no possibility of ever returning to one of the states $K+1, K+2, \dots M$. In such a case it is said that the state j is an *absorbing state* and the Markov chain is *reducible*. Otherwise, it is name *irreducible*.

For an M-state irreducible Markov chain with transition matrix P, if the one of the eigenvalues of P is unity and all that all other eigenvalues of P are inside the unit circle, the Markov chain is *ergodic*.

Krolzig (1998) considers a generalization of the basic finite order VAR model of order p as in eq. (7) and the same transformations as in eq. (11) - (16). In generalization of the mean-adjusted VAR(p) model in eq. (16), Krolzig (1998) considers Markov-Switching vector autoregressions of order p and M regimes:

$$(y_t - \mu(s_t)) = A_1(s_t)(y_{t-1} - \mu(s_{t-1})) + \dots + A_p(s_t)(y_{t-p} - \mu(s_{t-p})) + e_t \tag{53}$$

where $e_t \sim NID(0, \Sigma(s_t))$ and $\mu(s_t), A_1(s_t), \dots, A_p(s_t), \Sigma(s_t)$ are parameter shift functions describing the dependence of the parameters $\mu, A_1, \dots, A_p, \Sigma$ on the realized regime s_t.

Model (53) presents an immediate one-time jump in the process mean after a change in the regime. There could be the case in which the mean smoothly approaches to a new level after the transition from one state to another. In this case, the regime-dependent intercept term $\alpha(s_t)$ could be used. From eq. (53), considering expression $\mu = (\mathrm{I_n} - A_1 - A_2 - \dots - A_p)^{-1}\,\alpha$ from eq. (15), it results:

$$y_t = \alpha\,(s_t) + A_1(s_t)\,y_{t-1} + \dots + A_p(s_t)\,y_{t-p} + e_t \qquad (54)$$

The following table presents the types of Markov-Switching vector autoregressive models.

Table 5- Markov -Switching Vector Autoregressive Models

		MSM	MSI Specification		
		μ varying	μ invariant	α varying	α invariant
A_j invariant	Σ invariant	MSM - VAR	linear MVAR	MSI - VAR	linear VAR
	Σ varying	MSMH - VAR	MSM-MVAR	MSIH - VAR	MSH-VAR
A_j varying	Σ invariant	MSMA - VAR	MSA-MVAR	MSIA - VAR	MSA-VAR
	Σ varying	MSMAH - VAR	MSAH-MVAR	MSIAH - VAR	MSAH-VAR

Source: Krolzig (1998)

According to Krolzig (1998), the mean-adjusted form (53) and the intercept form (54) of the MS(M)-VAR model are not equal as while a permanent regime shift in the mean $\mu(s_t)$ causes an instant jump of the observed time series vector onto its new level, the dynamic response to a once-and-for-all regime shift in the intercept term $\alpha\,(s_t)$ is the same to an equivalent shock in the white noise e_t.

The MS-VAR models differ in their assumptions concerning the stochastic process generating the regime. A special case is that in which *the mixture of normal distributions model* is characterized by serially independently distributed regimes (Hamilton(1994)). In this case the density of y_t conditional on the random variable s_t which takes the value *j* is:

$$f(\,y_t|\,s_t = j;\,\theta) = \frac{1}{\sqrt{2\pi\sigma_j}}\exp\left\{\frac{-(\,y_t - \mu)^2}{2\sigma_j^2}\right\} \qquad (55)$$

for j = 1,2,3, … , M. θ is a vector of population parameters that include $\mu_1, \dots, \mu_M$ and σ_1^2,… , σ_M^2. The unobserved regime $\{s_t\}$ is generated by a probability distribution, for which the unconditional probability that s_t takes on the value *j* is denoted π_j, these probabilities also being included in θ.

$$P\{s_t = j;\ \theta\} = \pi_j$$
$$\theta \equiv \left(\mu_1, \dots, \mu_M, \sigma_1^2, \dots, \sigma_M^2, \pi_1, \dots, \pi_M\right)' \tag{56}$$

Considering the conditional probability of an event A given an event B, we can write *the joint density-distribution function of* y_t *and* s_t .

$$P\{A|B\} = \frac{P\{A\ and\ B\}}{P\{B\}}$$
$$P\{A\ and\ B\} = P\{A|B\} \cdot P\{B\} \tag{57}$$
$$p(y_t, s_t = j;\ \theta) = f(y_t|\ s_t = j;\ \theta) \cdot P\{s_t = j;\ \theta\}$$

Replacing in this expression eq. (55) and (56), it results:

$$p(y_t, s_t = j;\ \theta) = \frac{\pi_j}{\sqrt{2\pi\sigma_j}} \exp\left\{\frac{-(y_t - \mu)^2}{2\sigma_j^2}\right\} \tag{58}$$

The *unconditional density of* y_t will be given by the following sum:

$$f(y_t;\ \theta) = \sum_{j=1}^{M} p(y_t, s_t = j;\ \theta) \tag{59}$$

In the context of s_t being distributed iid across different data y_t, the *log likelihood* for the observed data can be calculated as:

$$\mathcal{L}(\theta) = \sum_{t=1}^{T} log f(y_t;\ \theta) \tag{60}$$

From the definition of the conditional probability it also results that:

$$P\{s_t = j|\ y_t;\ \theta\} = \frac{p(y_t, s_t = j;\ \theta)}{f(y_t;\ \theta)} = \frac{\pi_j \cdot f(y_t|\ s_t = j;\ \theta)}{f(y_t;\ \theta)} \tag{61}$$

Maximum likelihood (ML) estimation of the model is based on the implementation of the *Expectation Maximization (EM)* algorithm proposed by Hamilton as a special case of the EM principle developed by Dempster, Laird and Rubin (1977). Thus, Hamilton (1994) demonstrates that the maximum likelihood estimate $\hat{\theta}$ represents a solution to the following system of nonlinear equations, obtained from computing the FOC (First Order Conditions) for the Lagrangean of the log likelihood eq. (60).

$$\hat{\mu}_j = \frac{\sum_{t=1}^{T} y_t \cdot P\{ s_t = j | y_t; \hat{\theta}\}}{\sum_{t=1}^{T} P\{ s_t = j | y_t; \hat{\theta}\}} \quad for\, j = 1, 2, \dots, M \tag{62}$$

$$\hat{\sigma}_j^2 = \frac{\sum_{t=1}^{T} (y_t - \hat{\mu}_j)^2 \cdot P\{ s_t = j | y_t; \hat{\theta}\}}{\sum_{t=1}^{T} P\{ s_t = j | y_t; \hat{\theta}\}} \quad for\, j = 1, 2, \dots, M \tag{63}$$

$$\hat{\pi}_j = T^{-1} \sum_{t=1}^{T} P\{ s_t = j | y_t; \hat{\theta}\} \quad for\, j = 1, 2, \dots, M \tag{64}$$

Due to the fact that eq. (62) - (64) are nonlinear, it is not possible to solve them analytically for $\hat{\theta}$ as a function of $\{ y_1, y_2, \dots, y_T\}$. In this context the EM algorithm is employed. Thus, starting with an arbitrary initial value of θ, labelled $\theta^{(0)}$, the probability $P\{ s_t = j | y_t; \theta^{(0)}\}$ is calculated from eq. (61). Then, with replacing the level of probability level in eq. (62) - (64), it results the values for $\hat{\mu}, \hat{\sigma}^2, \hat{\pi}$ from which a new estimate results $\theta^{(1)}$. This estimate is then replaced in eq. (61) and a new value for probability is obtained that will be replaced in eq. (62) - (64) in order to produce other values for $\hat{\mu}, \hat{\sigma}^2, \hat{\pi}$, that will generate a new θ. The iteration continues until the change between $\theta^{(m+1)}$ and $\theta^{(m)}$ is smaller than some specified convergence criterion.

2.2. *Empirical results*

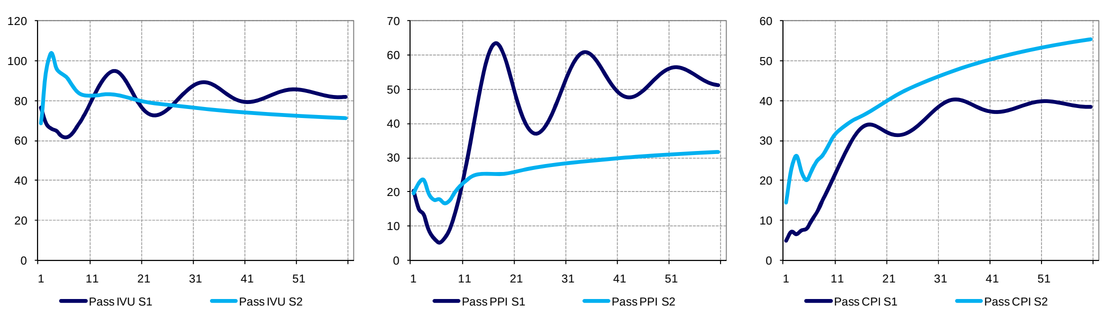
Using the same data as in previous sections of the paper, I estimated a MS-VAR belonging to the MSIAH type of model as introduced by Krolzig (1998). The program used for estimation is the Ox version 3.30 combined with the MSVAR module version 1.31k (from 2004) written by Hans Martin Krolzig.

As the MS-VAR results cannot be easily interpreted, I have retrieved from the estimation program the coefficient and variance-covariance matrices for each regime (each being a VAR). These were used to compute the impulse response functions derived from the companion form VAR representation (eq. 20) combined with Cholesky identification of the shocks:

$$\xi_t = F^t \cdot C \cdot v_t \qquad (65)$$

The IRFs were computed using matrix operations in Microsoft Excel (for ease of use) - the matrices from the Ox program were exported in Excel form and thus they were easily linked with an IRF generating spreadsheet. The IRFs were accumulated and used to compute the pass-through coefficients for the price variables for each regime. It would have been very suggestive to be able to compute the confidence intervals for the ERPT albeit this was not possible due to the computational burden of bootstrapping each regime (as detailed in Ehrmann, Ellison and Valla (2001)), on one hand, and because the confidence intervals should have been reconstructed by dividing the confidence intervals of the accumulated IRFs for two variables (a price index and the exchange rate), on the other hand.

Figure 19 - MSIAH MS -VAR model - ERPT into price indices for each of the two regimes s_t



The previous figure indicates similar pass-through for IVU prices in the two regimes and some marked differences regarding pass-through in the PPI and to a smaller extend into CPI. The first regime shows a pass-through higher for PPI and lower for CPI than the second regime. As the bulk of the observations in the second regime are concentrated at the beginning of the sample we can infer that the competition in the producer sector was relatively strong but its effects were overcompensated by an almost oligopolistic competition in the retail sector. The first regime (mostly concentrated in second part of the sample) points to a reversal compared to the second, the producer sector being more oligopolistic and the retail sector becoming more monopolistic.

The next figures and Appendix 5 detail the MS-VAR estimation results and diagnostics tests. Figure 20 presents the variables used and the resulting regime probabilities.

Figures 21 and 22 present the smooth and predicted errors in the model and the standard errors, on one hand and correlation and normality tests for the residuals, on the other hand. The figures indicate that the standard errors are not autocorrected and are normally distributed.

Figure 23 suggests that the model seems to capture well the data properties. The Figure 24 presents the model probabilities - the predicted h-step probabilities of each regime (almost 50%), the probability of duration and the cumulated probability of duration.

Figure 20 - MSIAH MS -VAR model - Probabilities of the two regimes s_t

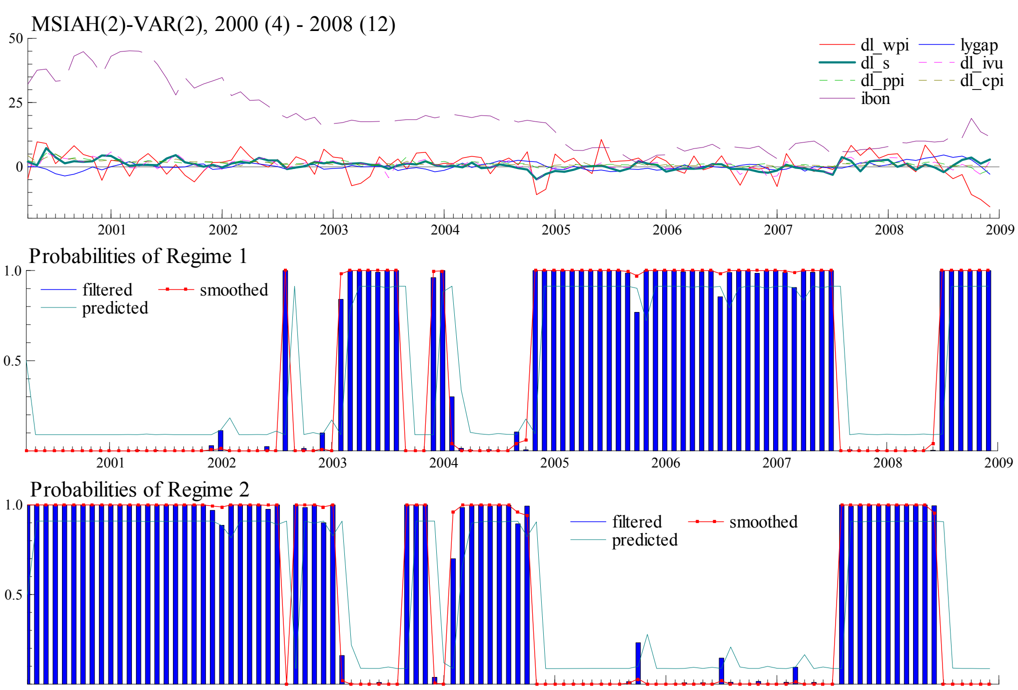


Figure 21- MSIAH MS -VAR model - Prediction error and Standard resids

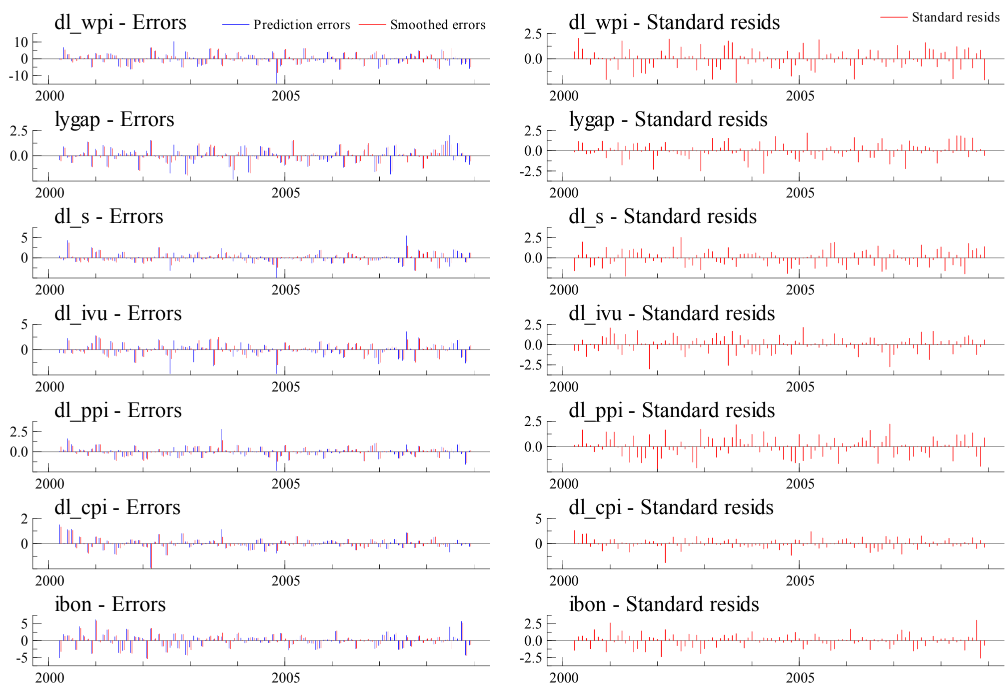


Figure 22 - MSIAH MS -VAR model - Correlogram, Spectral density, Density and QQ Plot of standard resids

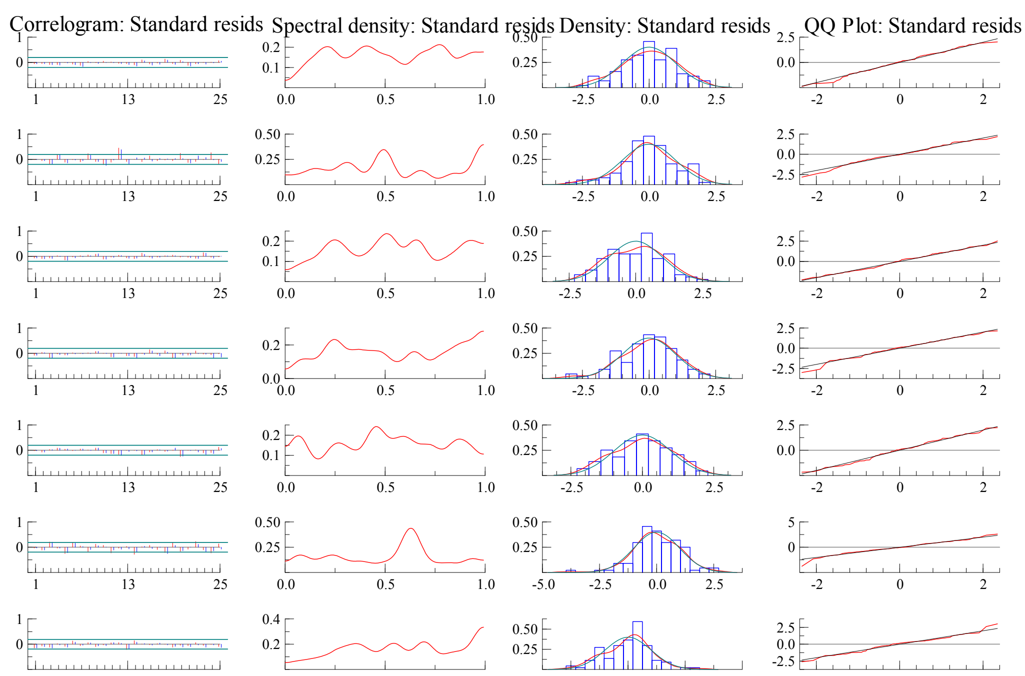


Figure 23 - MSIAH MS -VAR model - Actual and fitted values

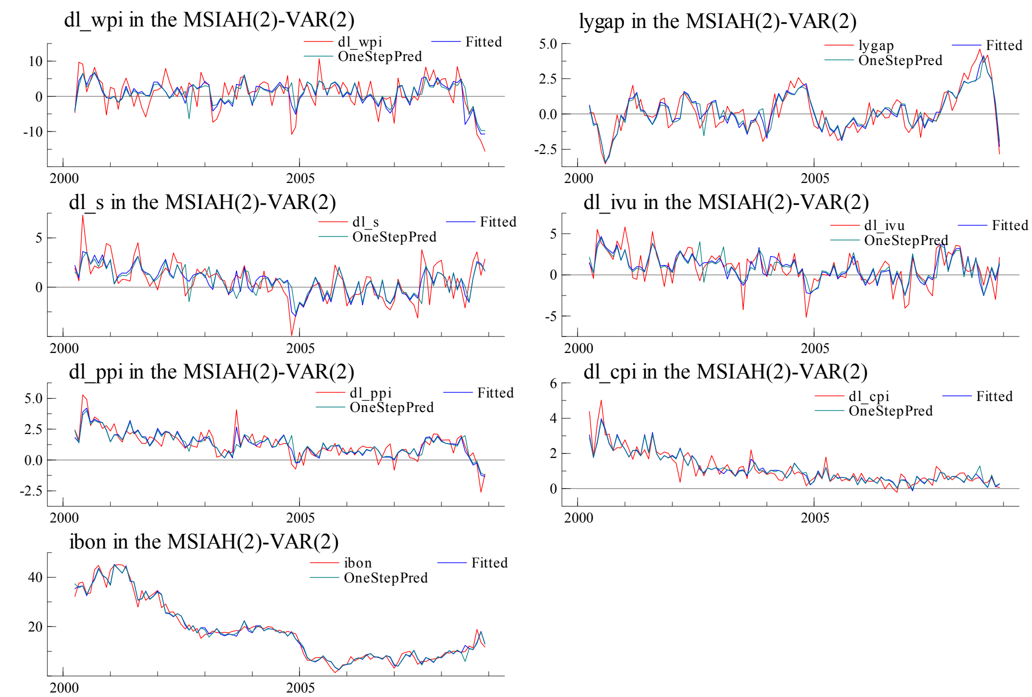
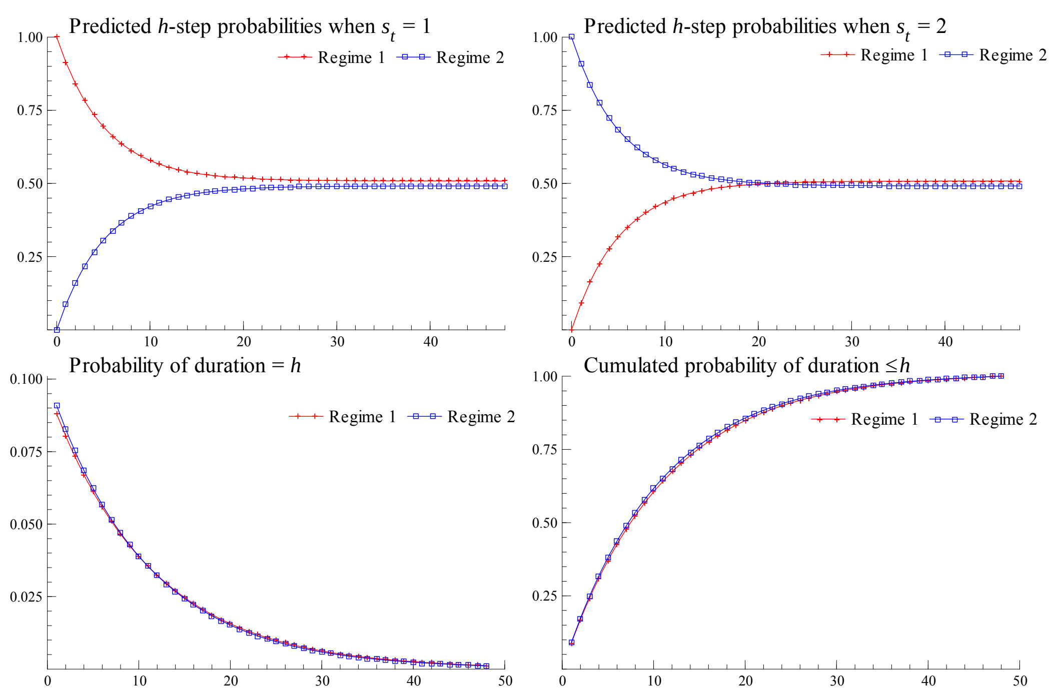


Figure 24 - MSIAH MS -VAR model - Model probabilities



3. Threshold vector autoregressive (TAR or TVAR)

The threshold autoregressive (TAR) models were first presented by Tong & Lim (1980), being one class of non-linear autoregressive models. In contrast to Markov Switching models, in the case of TAR models the state variable is supposed to be known and observable. A general TAR model, that permits the existence of more than two regimes and more than one lag, may be written as:

$$y_t = \sum_{j=1}^{J} I_t^{(j)} (\phi_0^{(j)} + \sum_{i=1}^{p1} \phi_1^{(j)} y_{t-1} + u_t^{(j)}, r_{j-1} \leq z_{t-d} \leq r_j \qquad (66)$$

where $I_t^{(j)}$ is an indicator function for the *jth* regime taking the value one if the underlying variable is in state j and zero otherwise. z_{t-d} is an observed variable that determines the switching point and $u_t^{(j)}$ is zero-mean independently and identically distributed error process.

The TAR approach considers the y variable in one regime or another, given the value of z and there are discrete transitions between the regimes, in contrast with the Markov Switching approach, where the variable y is in both regimes with some probability at each point in time.

Thus, for a given threshold r, the "probability" of the unobservable regime $s_t = 1$ is given by:

$$P\left\{s_t = 1 | \left\{s_{t-j}\right\}_{j=1}^{\infty}, \left\{y_{t-j}\right\}_{j=1}^{\infty}\right\} = I\left\{z_{t-d} \leq r\right\} = \begin{cases} 1 & if \ z_{t-d} \leq r \\ 0 & if \ z_{t-d} > r \end{cases} \qquad (67)$$

Using the corresponding VAR version of TAR (TVAR), I will discuss the nature and extent of exchange rate pass-through to price indices. I considered four different threshold variables that identify two different regimes. As in the previous section, the program used for estimation is the Ox version 3.30 combined with the MSVAR module version 1.31k from 2004 written by Krolzig (1998). I will present the evolution of the exchange rate pass-through into the three price indices. The Ox outputs, including: prediction error and standard residuals, the correlogram, spectral density, density and QQ Plot of standard residuals and actual and fitted values are presented in Appendixes 6 to 9.

3.1. Time asymmetry

The first threshold variable considered is a *time variable* for which the indicator function takes value one for the period 2000M02 - 2003M12 (regime 2) and value zero for the period 2004M01-2008M12 (regime 1).

According to Figure 26, the exchange rate pass-through into all price indices (import, producer and consumer price index) is lower for the second than for the first regime. However, the difference between the two regimes ERPT increases along the distribution chain. Thus, after 24 months the exchange rate pass-through into import prices was 95% during the first part of the data sample (regime 2) and 78% in the second part of the data sample, the difference being of 17 percentage points. On the other hand, the difference of ERPT between the two regimes increases for producer and consumer prices. Thus, after two years the difference of ERPT between the two regimes is 26 percentage points (40% versus 14%) for producer price index and 35 percentage points (46% versus 11%) for consumer price index.

Figure 25 - TVAR model (Time asymmetry) - Probabilities of the two regimes s_t

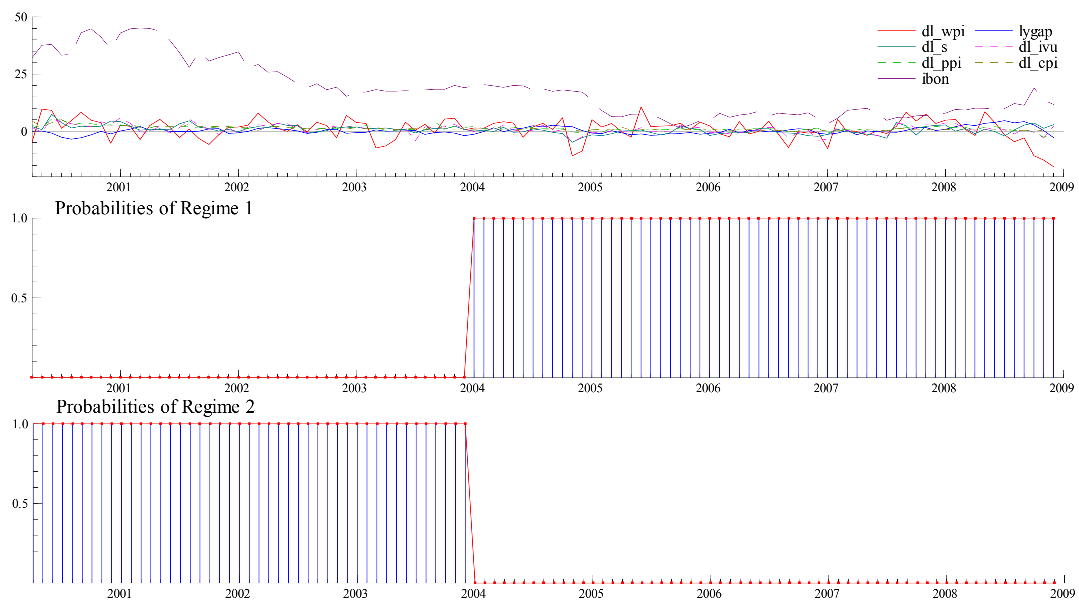
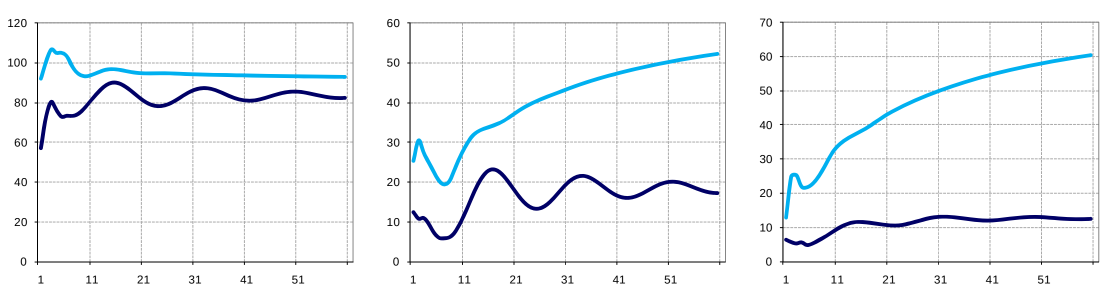


Figure 26 - TVAR model (Time asymmetry) - ERPT into price indices for each of the two regimes s_t



3.2. Sign of the exchange rate change asymmetry

The second threshold variable accounts the *difference between exchange rate appreciation and depreciation*. Thus, the indicator function takes value one in the case of a monthly increase (depreciation) of exchange rate and value zero in the case of a monthly decline of the exchange rate (appreciation). Thus, the first regime groups the appreciation episodes, while the second regime the ones of depreciation.

An analysis of Figure 28 indicates a significant difference regarding the behaviour of importers comparing to that of producers and retailers. Therefore, the behaviour of local importers seems to be opportunistic, the figure suggesting a higher pass-through for an exchange rate depreciation than that of an appreciation. This could indicate a widely used pricing strategy of local importers which regards depreciation as a reason for price increases. Thus, after 24 months, the ERPT in the first regime (of appreciation) is 60%, while in the second regime (of depreciation) is 78%.

On the other hand, the pass-through of exchange rate appreciation is higher than that of depreciation in the case of producer and consumer price indices. An explanation of this behaviour may be the fact that domestic producers and retailers are trying to maintain their *market share*. Consequently, the appreciation regime will represent a good opportunity to increase market share, while keeping their mark-ups, while in the case of depreciation regime, the firms absorb a part of the inflationary impact, this implying the decline of their mark-ups. Another explanation would be that in periods of exchange rate depreciation, the firms will increase the weight of local products (inputs for producers and goods for the retailers) in the detriment of the foreign ones that become more expensive. The opposite occurs in the context of exchange rate appreciation when the foreign products become cheaper.

Thus, after 24 months, while in the first regime the ERPT into produce prices was 61% and into consumer prices was 59%, during the second regime the ERPT was 11%, respectively 32%. Moreover, during both regimes the ERPT increases along the time horizon.

Figure 27 - TVAR model (Exchange rate appreciation - depreciation) - Probabilities of the two regimes s_t

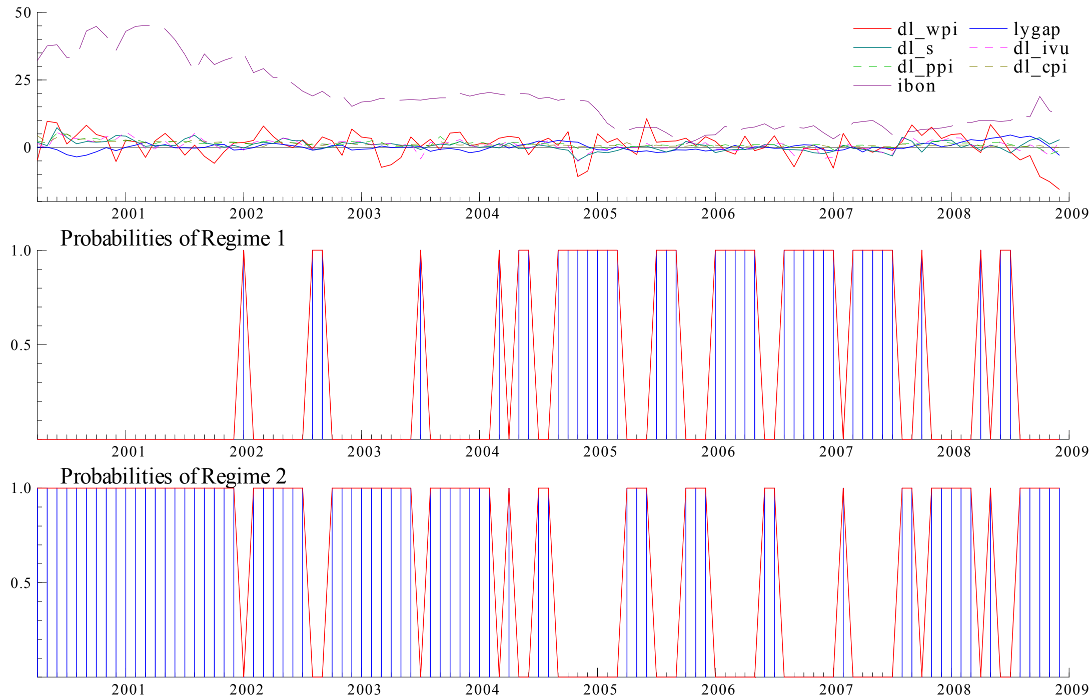
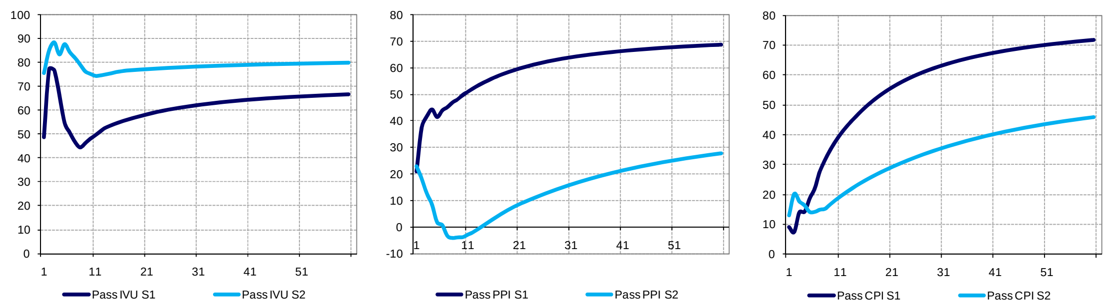


Figure 28 - TVAR model (Exchange rate appreciation - depreciation) - ERPT into price indices for each of the two regimes s_t



3.3. Size of the exchange rate change asymmetry

Another threshold variable used refers to the *magnitude of monthly change in exchange rate* (depreciation or appreciation) in order to examine whether the effects of exchange rates on price indices differ during periods of *big* versus *small* changes in exchange rates. Hence, in the first regime I considered a monthly change (depreciation or appreciation) lower than 1.3%, while the second regime I considered a monthly depreciation/appreciation higher than 1.3%. Thus, the threshold chosen was ∓1.3%, so that the sample data of the two regimes to be equilibrated.

Figure 29 presents the periods in which each of the two regimes occurs. Thus, the first regime includes periods of *small* changes in exchange rate, while the second one includes periods of *large* changes.

Analyzing Figure 30 it results a significant difference regarding the behaviour of importers comparing to that of local producers and retailers. Thus, the pass-through into import price index is greater when exchange rate changes are small, a possible explanation being that the *imports are invoiced in the exporter's currency*. In this context a small change in the exchange rate has no effect on price received by the exporters (the invoice price), but completely affects the local import prices – the pass-through is complete. When the exchange rate change is large the exporter adjusts the foreign prices, dropping the amount of pass-through.

On the other hand, during the first thirteen months for producers and during the first ten months for retailers, the pass-through is greater when the changes of exchange rate are small, as it is easier to pass a smaller change in the exchange rate into prices so that the sales will not be very much affected. But after this time span, pass-through becomes greater when exchange rate changes are large than when they are small, probably due to the fact that both producers and retailers pass the large exchange rate shock gradually. Thus the ERPT into producer and consumer prices increases during the second regime and remains almost constant during the first regime.

Figure 29 - TVAR model (magnitude of monthly change in exchange rate) - Probabilities of the two regimes s_t

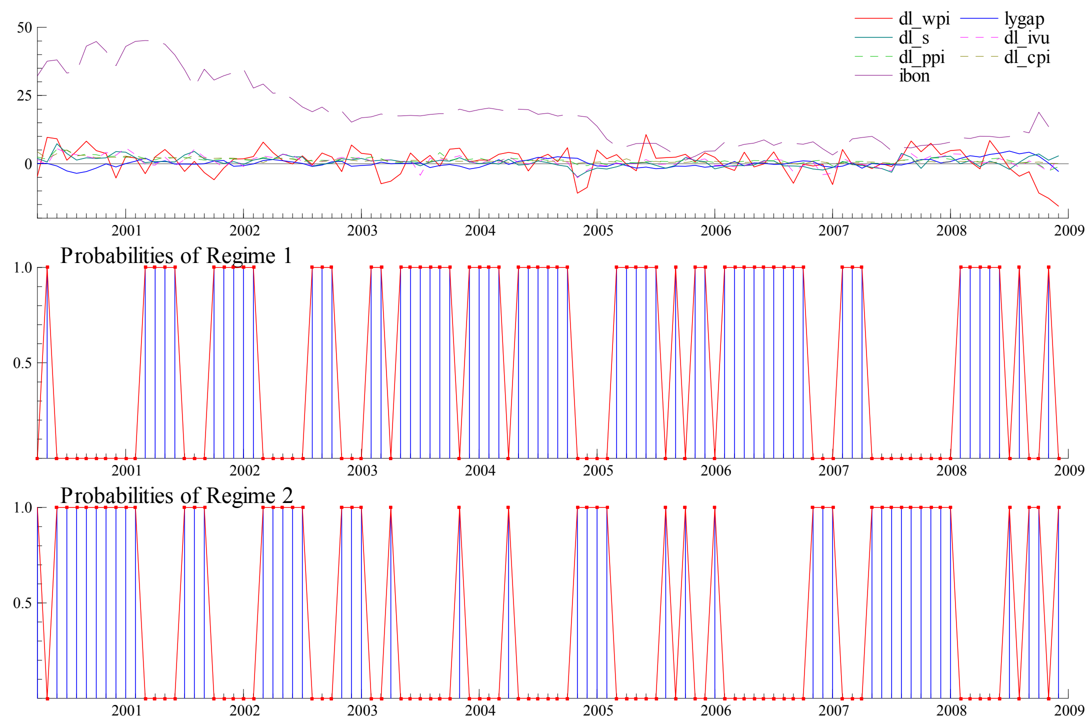
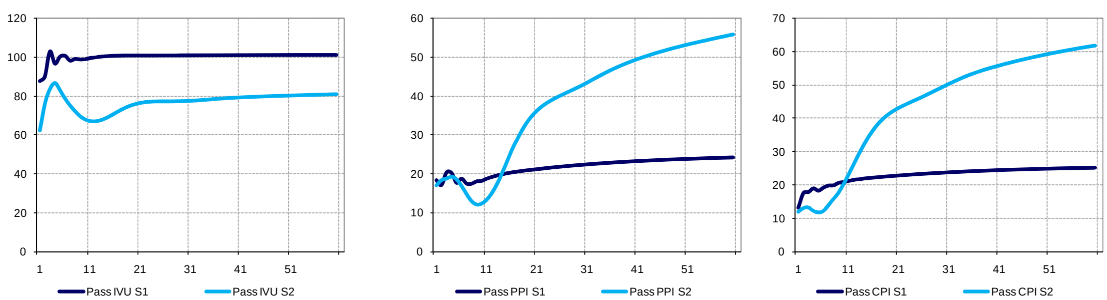


Figure 30 - TVAR model (magnitude of monthly change in exchange rate) - ERPT into price indices for each of the two regimes



3.4. *Size of the monthly inflation asymmetry*

Another variable considered is the *magnitude of the monthly increase of the inflation*. The threshold chosen was 1%. Thus, when the monthly inflation rate is higher than 1%, the indicator function will take value 1, otherwise will take value zero. The Figure 31 suggests that the first regime is that of *low inflation* (below 1%), while the second one is occurring when the *inflation is high* (above 1%). Analyzing the Figure 32, it can be seen that the exchange rate pass-throughs into all price indices are lower in the low inflation regime, this being in line with the hypothesis put forward in Taylor (2000) regarding the asymmetric effects of exchange rates during periods of high and low inflation.

Figure 31 - TVAR model (magnitude of monthly inflation) - Probabilities of the two regimes s_t

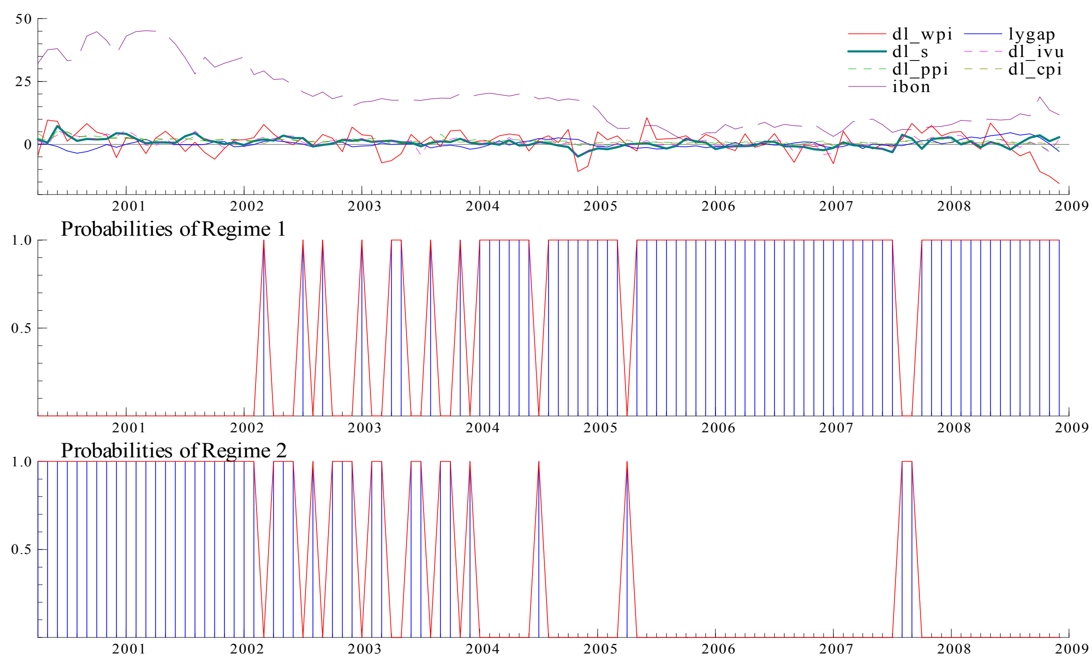
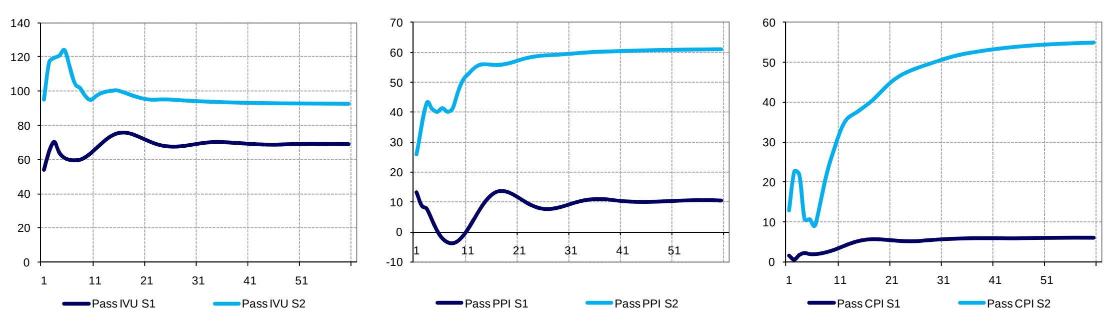


Figure 32 - TVAR model (magnitude of monthly inflation) - ERPT into price indices for each of the two regimes



4. *Self-exciting threshold autoregressive (SETAR)*

In the self-exciting threshold autoregressive SETAR model, the regime-generating process is not assumed to be exogenous, but linked to the lagged endogenous variable y_{t-d}. Thus, in eq. (66) the variable z_{t-d} is replaced by y_{t-d}. Thus, for a given threshold r, the probability of the unobservable regime $s_t = 1$ is given by

$$P\left\{s_t = 1 | \left\{s_{t-j}\right\}_{j=1}^{\infty}, \left\{y_{t-j}\right\}_{j=1}^{\infty}\right\} = I\left\{ y_{t-d} \le r\right\} = \begin{cases} 1 & if\ y_{t-d} \le r \\ 0 & if\ y_{t-d} > r \end{cases}$$

Using the same program as in previous sessions I estimated a SETAR model. Based on this I determined the exchange rate pass-through to price indices. I considered two different threshold variables that identify two different regimes. The Ox outputs, including: prediction error and standard residuals, correlogram, spectral density, density and QQ Plot of standard residuals and actual and fitted values are presented in Appendixes 10 and 11.

4.1. *Threshold variable: Exchange rate*

The first threshold variable considered is the *monthly change in exchange rate*. The value of the threshold was estimated to be 0.88957 percent. As a result, the high regime (the second one) was identified as the one in which the exchange rate increases are higher than 0.88957%. The Figure 34 presents the periods in which the each of the two regimes take place, while the Figure 35 presents the threshold variable shifting from one regime to another. The Figure 33 suggest that the exchange rate pass-throughs into all price indices are higher in the second regime than in the first one, suggesting that a depreciation higher than 0.88957% will be more likely to be passed into prices.

Figure 33 - SETAR (exchange rate threshold variable) - ERPT into price indices for each of the two regimes

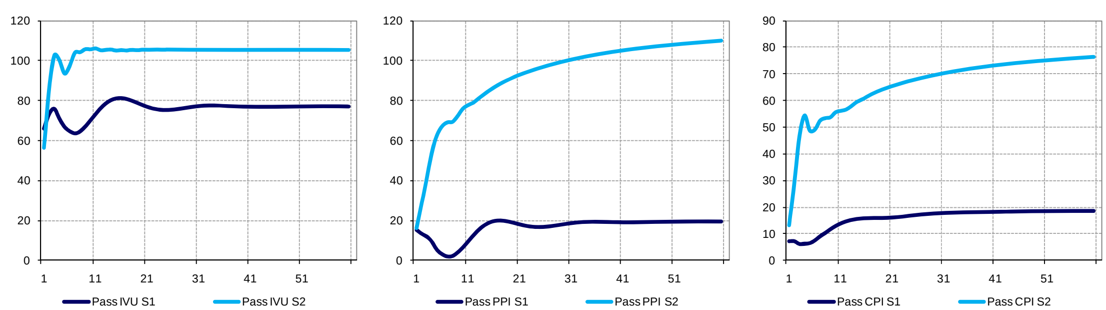


Figure 34 - SETAR (exchange rate threshold variable) - Probabilities of the two regimes s_t

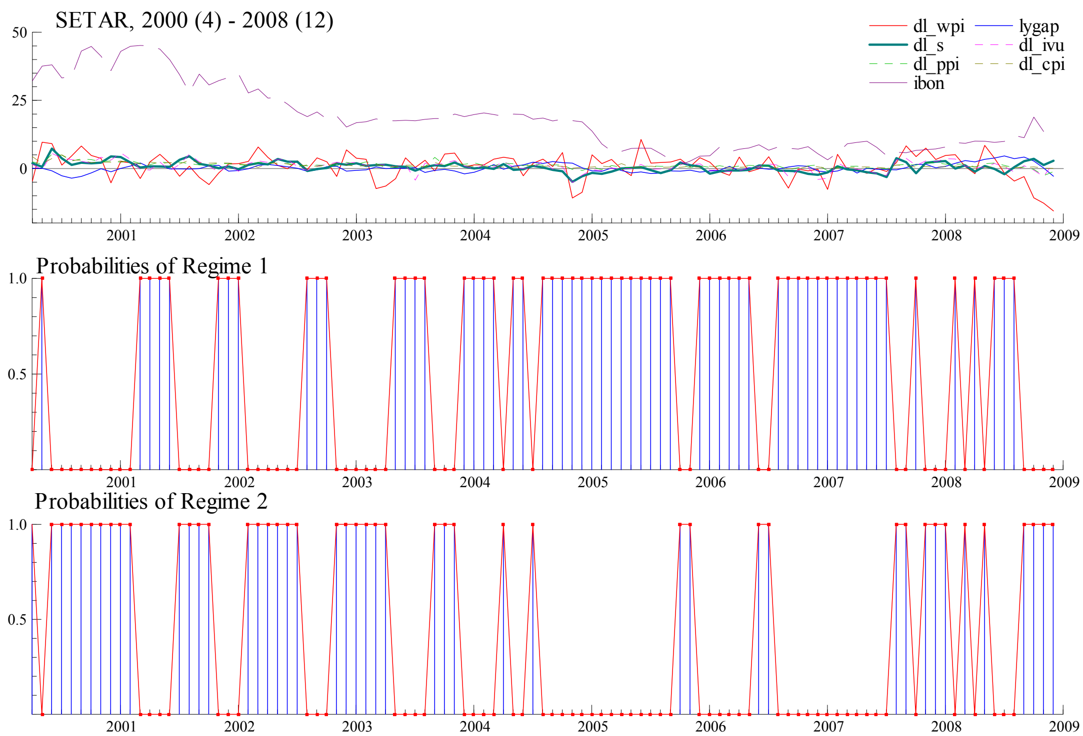
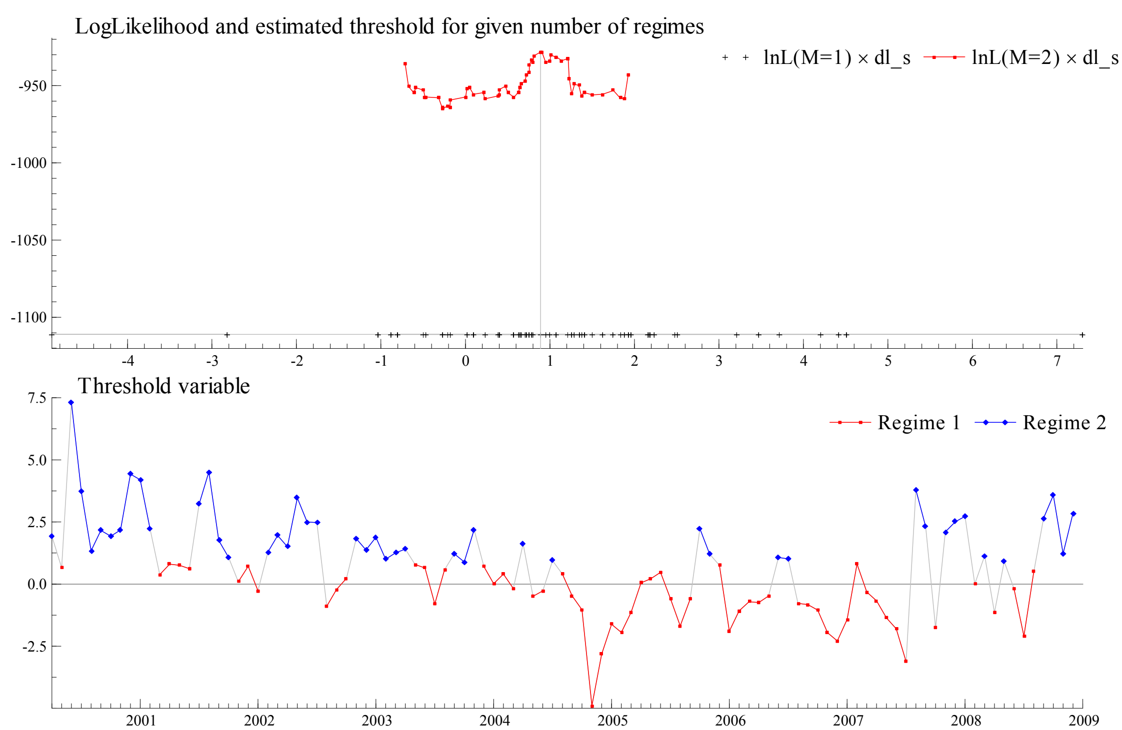


Figure 35 - SETAR (exchange rate threshold variable) - Estimated threshold



4.2. *Threshold variable: Monthly inflation*

The second threshold variable considered is *monthly inflation*, respectively the monthly change of consumer price index. The threshold level estimated by the model is 1.6904 percent.

The high inflation regime in this case is observed when the monthly inflation rate is higher than 1.6904 percent. Thus, when the inflation exceeds the threshold of 1.6904 percent, the system enters into the second regime. This regime includes 24% of total observations and occurs mainly in the first part of the data sample.

Figure 37 presents the threshold variable shifting from one regime to another. The Figure 38 suggest that in the high inflation regime the ERPT into all price indices are higher than in the low inflation regime, once again the Taylor's (2000) hypothesis of asymmetric effects of exchange rates during periods of high and low inflation being verified.

Figure 36 - SETAR (CPI threshold variable) - ERPT into price indices for each of the two regimes

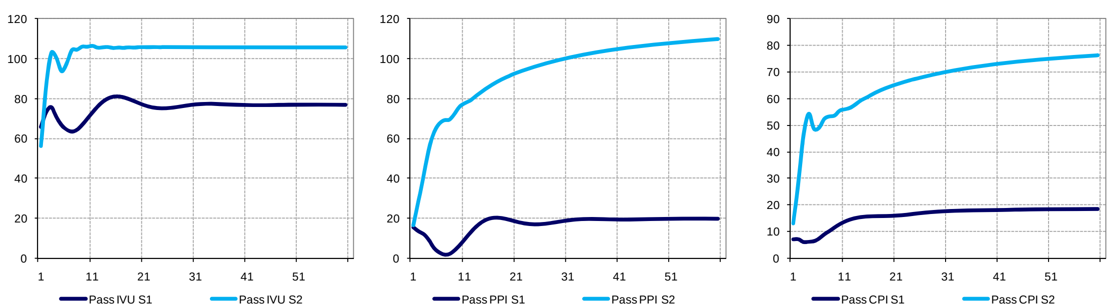


Figure 37 - SETAR (CPI threshold variable) - Probabilities of the two regimes s_t

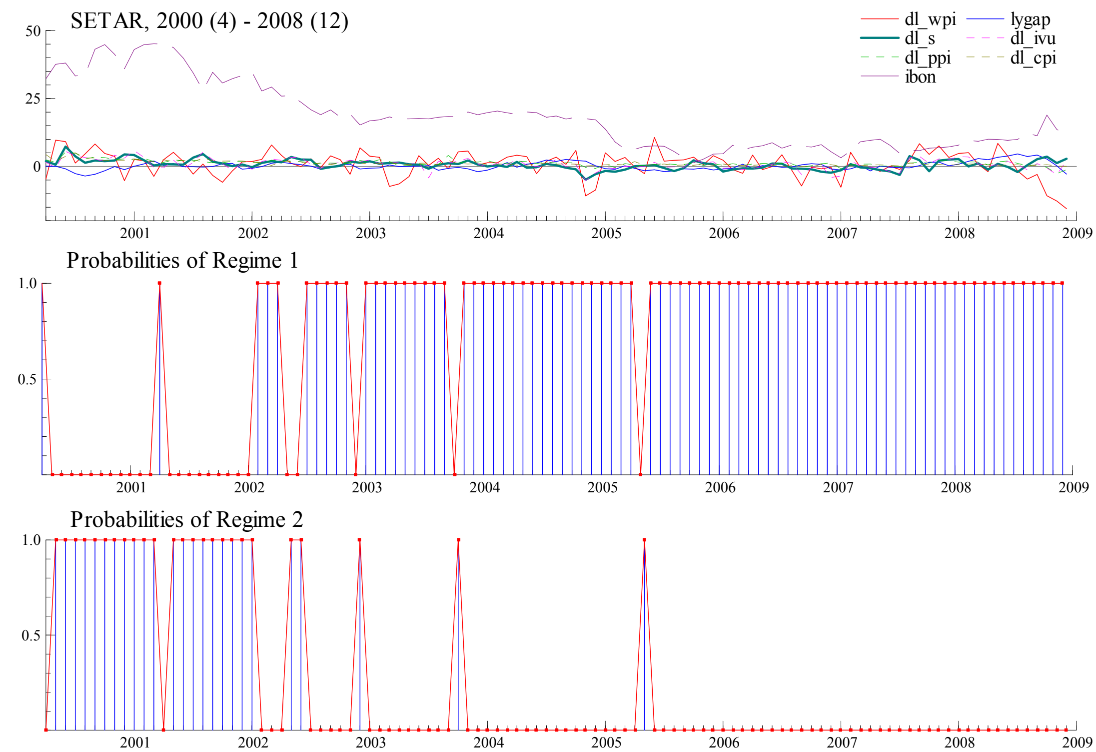
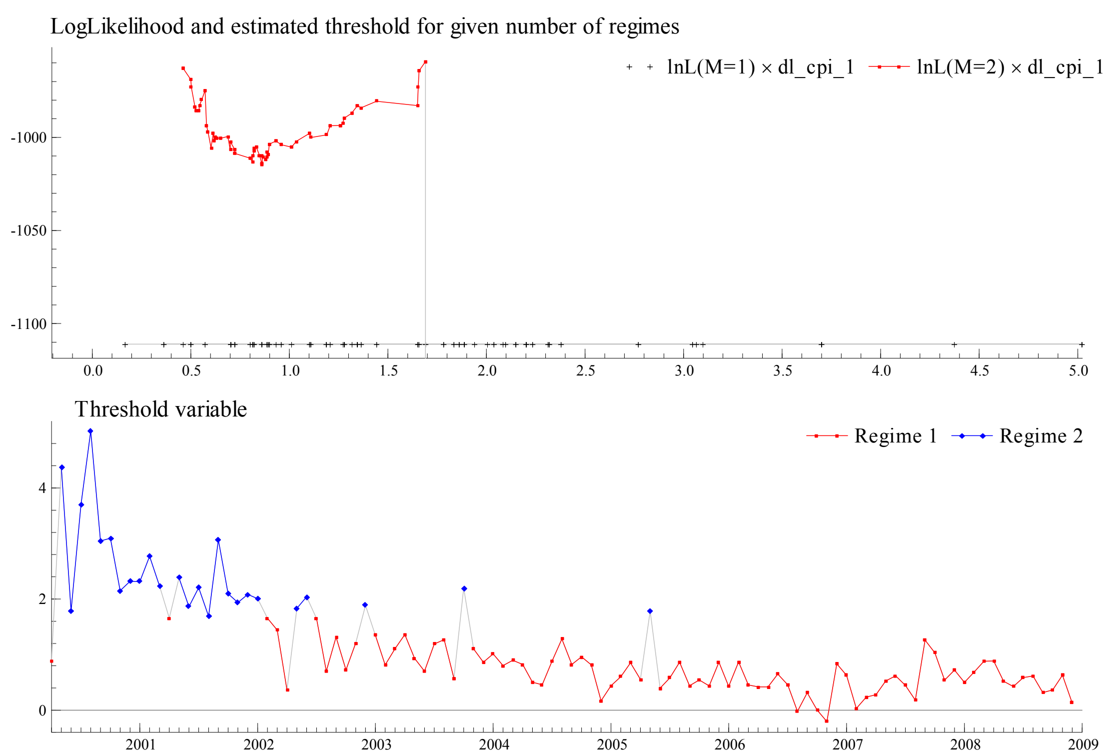


Figure 38 - SETAR (CPI threshold variable) - Estimated threshold



VI. Conclusions

The paper investigates, with various VAR models, the pass-through of an exchange rate shock into prices in the Romanian economy. The main findings of the paper are as follows.

Firstly, the *average pass-through throughout the entire sample* seems to be almost complete for import prices, around 35% for producer prices and around 30% for consumer prices as indicated by RVAR and the Sign-restriction VAR.

Secondly, the *pass-through in consumer prices is affected by the inflation measure used* (cpi, core1, core2, core3), the core measures being more responsive to an exchange rate shock, as the regulated prices are legally linked to a fixed exchange rate from a particular moment of the previous year.

Thirdly, the *rolling windows estimation* points on one hand, to a markedly decrease in the size of the pass-through for producer and consumer prices (irrespectively of the price measure used - cpi, core1, core2, core3) and on the other hand, to an almost constancy in import prices pass-through.

Fourthly, there are *important asymmetries* in the exchange rate pass-through pertaining to different time periods, the sign and the size of the exchange rate change and the size of the monthly inflation.

Testing for *two different time periods* further supports the rolling window estimates in indicating a decrease of the pass-through during time.

As for the *sign of the exchange rate movements*, the behaviour of local importers seems to be opportunistic, as a higher pass-through is apparent for exchange rate depreciation than in the case of an appreciation. This is in contrast with the behaviour of the local producers and retailers which are trying to maintain their *market share*; another explanation could be that during periods of exchange rate depreciation, the firms will increase the weight of local products (inputs for producers and goods for the retailers) to the detriment of foreign ones that are becoming more expensive.

Investigating the threshold for the exchange rate shock at which there is a change in the behaviour of the agents, it is clear that a relatively larger depreciation has a more pronounced effect on prices.

Regarding the *size of the exchange rate shock*, there seems also to exist a behavioural shift at the level of the importers, on one hand, and at the level of producers and retailers, on the other hand. Thus, the pass-through into import price index seems to be greater when exchange rate changes are small, a possible explanation being that the *imports are invoiced in the exporter's currency*. In this context a small change in the exchange rate has no effect on price received by the exporters (the invoice price), but completely affects the local import prices – the pass-through is complete. On the other hand, during the first thirteen months for producers and during the first ten months for retailers, the pass-through is greater when the changes of exchange rate are small, being easier to pass a lower modification of exchange rate into prices so that the sales will not be very much affected. But after this time span, pass-through becomes greater when exchange rate changes are large than when they are small, probably due to the fact that both producers and retailers pass the large exchange rate shock gradually.

If the *magnitude of the monthly increase of the inflation* is considered as a source of asymmetry, it appears that the exchange rate pass-throughs into all price indices are lower for the low inflation regime, this being in line with the hypothesis put forward in Taylor (2000) regarding the asymmetric effects of exchange rates during periods of high and low inflation. This conclusion is further supported by the threshold value identified for the change in regime.

The paper tries to contribute to the growing field of empirical investigation of the exchange rate pass-through by supporting existing conclusions and pointing to new ones. Further developments in the research could steam from employing single equation estimates for subsector of the importers, producers and consumers. Also, the conclusions drawn could be compared with the research results from other emerging economies.

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VIII. Appendixes

Appendix 1 - Unit root tests results

Table 6 - Augmented Dickey Fuller (ADF) and the Phillips Perron (PP) tests results

Test	**ADF**				**PP**			
Null Hypothesis	I(1)	I(2)		I(3)	I(1)	I(2)		I(3)
Variable	Prob.	Prob.		Prob.	Prob.	Prob.		Prob.
l_wpi_u_sa_idx	0.9657	0.0000	c,t	0.0000	0.9808	0.0000	c,t	0.0000
l_y_sa_yindcl_hpgap	0.0004	0.0000		0.0000	0.0000	0.0000		0.0000
l_s_ef_sa_idx	0.9913	0.0000		0.0000	0.9940	0.0000		0.0000
l_ivu_imp_t_sa_idx	0.9986	0.0000		0.0000	0.9993	0.0000		0.0000
l_ppi_n_sa_idx	0.9998	0.0000	c,t	0.0000	1.0000	0.0000	c,t	0.0000
l_cpi_u_sa_idx	0.8715	0.0000	c,t	0.0000	0.9191	0.0000	c,t	0.0001
l_core1_u_idx	0.9988	0.0000	c,t	0.0000	0.9999	0.0000	c	0.0000
l_core2_u_sa_idx	0.9991	0.0000	c,t	0.0000	0.9998	0.0000	c,t	0.0000
l_core3_u_sa_idx	0.9986	0.0000	c,t	0.0000	0.9997	0.0000	c,t	0.0000
ibon	0.0000	0.0000		0.0000	0.0000	0.0000		0.0000

* MacKinnon (1996) one sided p-values.

* c: constant, t: trend

Appendix 2 - VAR Lag Order Selection Criteria

Table 7 - VAR (CPI) Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: D(L_WPI_U_SA_IDX) L_Y_SA_YINDCL_HPGAP D(L_S_EF_SA_IDX) D(L_IVU_IMP_T_SA_IDX) D(L_PPI_N_SA_IDX) D(L_CPI_U_SA_IDX) IBON
Exogenous variables: C
Sample: 1980M01 2020M12
Included observations: 102

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1380.004	NA	1526.949	27.19616	27.37631	27.26911
1	-1099.176	517.6059	16.24233*	22.65050*	24.09166*	23.23408*
2	-1057.422	71.22712*	18.96282	22.79258	25.49476	23.88679
3	-1015.668	65.49529	22.59464	22.93468	26.89787	24.53951
4	-977.5311	54.58872	29.82368	23.14767	28.37188	25.26313
5	-931.4863	59.58746	35.25086	23.20561	29.69084	25.83170

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 8 - VAR (CORE1) Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: D(L_WPI_U_SA_IDX) L_Y_SA_YINDCL_HPGAP D(L_S_EF_SA_IDX) D(L_IVU_IMP_T_SA_IDX) D(L_PPI_N_SA_IDX) D(L_CORE1_U_IDX) IBON
Exogenous variables: C
Sample: 1980M01 2020M12
Included observations: 102

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1381.858	NA	1583.484	27.23252	27.41266	27.30546
1	-1101.242	517.2147	16.91394*	22.69102*	24.13218*	23.27459*
2	-1056.929	75.59188*	18.78066	22.78293	25.48511	23.87713
3	-1019.315	59.00286	24.26939	23.00618	26.96937	24.61101
4	-975.5419	62.65575	28.68282	23.10866	28.33288	25.22413
5	-927.6147	62.02350	32.67388	23.12970	29.61493	25.75579

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 9 - VAR (CORE2) Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: D(L_WPI_U_SA_IDX) L_Y_SA_YINDCL_HPGAP D(L_S_EF_SA_IDX) D(L_IVU_IMP_T_SA_IDX) D(L_PPI_N_SA_IDX) D(L_CORE2_U_SA_IDX) IBON
Exogenous variables: C
Sample: 1980M01 2020M12
Included observations: 102

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1350.764	NA	860.6534	26.62283	26.80297	26.69577
1	-1049.238	555.7549	6.100956*	21.67133*	23.11249*	22.25490*
2	-1003.396	78.20095*	6.574152	21.73325	24.43543	22.82745
3	-961.7157	65.38035	7.844519	21.87678	25.83997	23.48161
4	-918.4377	61.94688	9.361526	21.98897	27.21319	24.10444
5	-874.2872	57.13596	11.48382	22.08406	28.56929	24.71015

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 10 - VAR (CORE3) Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: D(L_WPI_U_SA_IDX) L_Y_SA_YINDCL_HPGAP D(L_S_EF_SA_IDX) D(L_IVU_IMP_T_SA_IDX) D(L_PPI_N_SA_IDX) D(L_CORE3_U_SA_IDX) IBON
Exogenous variables: C
Date: 06/20/09 Time: 23:24
Sample: 1980M01 2020M12
Included observations: 102

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1343.860	NA	751.6803	26.48745	26.66759	26.56039
1	-1029.016	580.3009	4.103899*	21.27482*	22.71598*	21.85839*
2	-980.6897	82.43837*	4.211975	21.28803	23.99021	22.38224
3	-942.8316	59.38535	5.416981	21.50650	25.46970	23.11133
4	-904.0933	55.44885	7.066364	21.70771	26.93192	23.82317
5	-863.1102	53.03703	9.223755	21.86491	28.35013	24.49100

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Appendix 3 - Vector Autoregression Estimates - Eviews Output

Table 11 - Vector Autoregression Estimates (CPI)

Vector Autoregression Estimates
Sample (adjusted): 2000M04 2008M12
Included observations: 105 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(L_WPI_U_SA_IDX)	L_Y_SA_YINDCL_HPGAP	D(L_S_EF_SA_IDX)	D(L_IVU_IMP_T_SA_IDX)	D(L_PPI_N_SA_IDX)	D(L_CPI_U_SA_IDX)	IBON
D(L_WPI_U_SA_IDX(-1))	0.274629	-0.002640	0.009434	0.067180	0.080449	0.000708	-0.009772
	(0.13968)	(0.02969)	(0.04799)	(0.05283)	(0.02333)	(0.01587)	(0.08200)
	[1.96607]	[-0.08893]	[0.19658]	[1.27153]	[3.44850]	[0.04465]	[-0.11917]
D(L_WPI_U_SA_IDX(-2))	-0.037364	-0.026496	0.063697	0.056800	0.044669	0.029720	-0.228463
	(0.14643)	(0.03112)	(0.05031)	(0.05538)	(0.02445)	(0.01663)	(0.08595)
	[-0.25517]	[-0.85128]	[1.26616]	[1.02557]	[1.82660]	[1.78668]	[-2.65795]
L_Y_SA_YINDCL_HPGAP(-1)	0.027974	0.624480	0.309901	0.317278	0.053808	0.092318	0.099730
	(0.53812)	(0.11438)	(0.18488)	(0.20354)	(0.08987)	(0.06113)	(0.31588)
	[0.05199]	[5.45962]	[1.67624]	[1.55883]	[0.59872]	[1.51017]	[0.31572]
L_Y_SA_YINDCL_HPGAP(-2)	-0.534632	0.095118	-0.219155	-0.430737	-0.062401	-0.088675	-0.069157
	(0.50770)	(0.10792)	(0.17443)	(0.19203)	(0.08479)	(0.05768)	(0.29802)
	[-1.05305]	[0.88141]	[-1.25643]	[-2.24308]	[-0.73594]	[-1.53749]	[-0.23205]
D(L_S_EF_SA_IDX(-1))	-0.003428	-0.205971	0.734889	0.807701	0.024181	0.053172	-0.105860
	(0.43374)	(0.09220)	(0.14902)	(0.16406)	(0.07244)	(0.04927)	(0.25461)
	[-0.00790]	[-2.23408]	[4.93155]	[4.92331]	[0.33381]	[1.07912]	[-0.41577]
D(L_S_EF_SA_IDX(-2))	-1.036867	-0.142193	-0.098374	-0.030581	-0.034296	0.056084	0.132505
	(0.48199)	(0.10245)	(0.16559)	(0.18230)	(0.08050)	(0.05475)	(0.28293)
	[-2.15124]	[-1.38793]	[-0.59407]	[-0.16775]	[-0.42606]	[1.02429]	[0.46833]
D(L_IVU_IMP_T_SA_IDX(-1))	0.165030	0.287085	-0.228415	-0.314721	0.071685	0.006283	0.153674
	(0.43325)	(0.09209)	(0.14885)	(0.16387)	(0.07236)	(0.04922)	(0.25432)
	[0.38091]	[3.11744]	[-1.53455]	[-1.92056]	[0.99072]	[0.12765]	[0.60425]
D(L_IVU_IMP_T_SA_IDX(-2))	0.210951	0.106268	-0.134036	-0.206436	-0.137492	-0.145447	0.023846
	(0.44177)	(0.09390)	(0.15178)	(0.16709)	(0.07378)	(0.05019)	(0.25933)
	[0.47751]	[1.13168]	[-0.88311]	[-1.23545]	[-1.86352]	[-2.89815]	[0.09195]
D(L_PPI_N_SA_IDX(-1))	-0.463923	0.128668	-0.321731	-0.142879	0.012889	0.208961	0.093547
	(0.86162)	(0.18315)	(0.29602)	(0.32590)	(0.14390)	(0.09788)	(0.50578)
	[-0.53843]	[0.70254]	[-1.08684]	[-0.43842]	[0.08957]	[2.13483]	[0.18495]
D(L_PPI_N_SA_IDX(-2))	0.594497	0.242135	0.222612	0.416613	0.094766	-0.193708	1.064090
	(0.80827)	(0.17180)	(0.27769)	(0.30572)	(0.13499)	(0.09182)	(0.47447)
	[0.73552]	[1.40936]	[0.80165]	[1.36274]	[0.70202]	[-2.10963]	[2.24272]
D(L_CPI_U_SA_IDX(-1))	1.747827	-0.397445	-0.077637	-0.125913	0.116761	0.087304	1.178145
	(0.92553)	(0.19673)	(0.31798)	(0.35007)	(0.15457)	(0.10514)	(0.54330)
	[1.88845]	[-2.02026]	[-0.24416]	[-0.35968]	[0.75537]	[0.83034]	[2.16850]
D(L_CPI_U_SA_IDX(-2))	1.475536	-0.206287	0.838223	0.759947	0.412890	0.425027	0.033463
	(0.98123)	(0.20857)	(0.33712)	(0.37114)	(0.16388)	(0.11147)	(0.57599)
	[1.50376]	[-0.98906]	[2.48646]	[2.04762]	[2.51953]	[3.81296]	[0.05810]
IBON(-1)	-0.118454	0.053036	-0.047214	-0.116024	0.014031	-0.023714	0.851497
	(0.15528)	(0.03301)	(0.05335)	(0.05873)	(0.02593)	(0.01764)	(0.09115)
	[-0.76285]	[1.60686]	[-0.88502]	[-1.97549]	[0.54105]	[-1.34435]	[9.34167]
IBON(-2)	-0.010984	-0.040331	0.049462	0.087023	0.001848	0.050741	-0.024213
	(0.13568)	(0.02884)	(0.04661)	(0.05132)	(0.02266)	(0.01541)	(0.07964)
	[-0.08096]	[-1.39845]	[1.06110]	[1.69575]	[0.08157]	[3.29205]	[-0.30402]
C	-0.441323	-0.124003	-0.345501	0.141783	0.184776	0.031007	0.059045
	(0.90748)	(0.19289)	(0.31178)	(0.34324)	(0.15156)	(0.10309)	(0.53270)
	[-0.48632]	[-0.64286]	[-1.10817]	[0.41307]	[1.21917]	[0.30077]	[0.11084]
R-squared	0.287857	0.677503	0.441499	0.432686	0.642076	0.761151	0.961860
Adj. R-squared	0.177079	0.627337	0.354622	0.344438	0.586399	0.723997	0.955927
Sum sq. resids	1660.841	75.03857	196.0402	237.6041	46.32505	21.43367	572.2999
S.E. equation	4.295788	0.913106	1.475881	1.624822	0.717442	0.488008	2.521684
F-statistic	2.598507	13.50519	5.081841	4.903032	11.53216	20.48623	162.1221
Log likelihood	-293.9473	-131.3507	-181.7674	-191.8624	-106.0290	-65.56620	-238.0129
Akaike AIC	5.884711	2.787633	3.747951	3.940237	2.305314	1.534594	4.819294
Schwarz SC	6.263848	3.166770	4.127088	4.319374	2.684451	1.913731	5.198431
Mean dependent	0.889933	0.159972	0.638665	0.885001	1.296000	1.119663	18.03449
S.D. dependent	4.735477	1.495764	1.837148	2.006775	1.115568	0.928902	12.01167

Determinant resid covariance (dof adj.)	10.76906
Determinant resid covariance	3.660585
Log likelihood	-1111.045
Akaike information criterion	23.16276
Schwarz criterion	25.81672

Table 12 - Vector Autoregression Estimates (CORE1)

Vector Autoregression Estimates
Sample (adjusted): 2000M04 2008M12
Included observations: 105 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(L_WPI_U_SA_IDX)	L_Y_SA_YINDCL_HPGAP	D(L_S_EF_SA_IDX)	D(L_IVU_IMP_T_SA_IDX)	D(L_PPI_N_SA_IDX)	D(L_CORE1_U_IDX)	IBON
D(L_WPI_U_SA_IDX(-1))	0.232182	0.010779	0.021324	0.080020	0.077572	-0.001433	-0.053487
	(0.13496)	(0.02855)	(0.04699)	(0.05124)	(0.02243)	(0.01467)	(0.08095)
	[1.72038]	[0.37763]	[0.45381]	[1.56171]	[3.45828]	[-0.09768]	[-0.66076]
D(L_WPI_U_SA_IDX(-2))	-0.090760	-0.019605	0.038863	0.037162	0.033171	-0.010778	-0.242568
	(0.14083)	(0.02979)	(0.04903)	(0.05347)	(0.02341)	(0.01531)	(0.08447)
	[-0.64449]	[-0.65819]	[0.79264]	[0.69507]	[1.41721]	[-0.70409]	[-2.87181]
L_Y_SA_YINDCL_HPGAP(-1)	-0.181239	0.660375	0.278929	0.321369	0.029350	0.058247	-0.087395
	(0.51269)	(0.10844)	(0.17850)	(0.19465)	(0.08521)	(0.05573)	(0.30751)
	[-0.35350]	[6.08979]	[1.56262]	[1.65102]	[0.34443]	[1.04515]	[-0.28420]
L_Y_SA_YINDCL_HPGAP(-2)	-0.497215	0.084978	-0.246759	-0.471230	-0.069538	-0.099580	0.026423
	(0.50377)	(0.10655)	(0.17539)	(0.19126)	(0.08373)	(0.05476)	(0.30216)
	[-0.98698]	[0.79752]	[-1.40688]	[-2.46381]	[-0.83051]	[-1.81847]	[0.08745]
D(L_S_EF_SA_IDX(-1))	-0.034991	-0.199082	0.748285	0.809613	0.031507	0.010947	-0.094368
	(0.43941)	(0.09294)	(0.15299)	(0.16683)	(0.07303)	(0.04776)	(0.26355)
	[-0.07963]	[-2.14207]	[4.89122]	[4.85307]	[0.43142]	[0.22918]	[-0.35806]
D(L_S_EF_SA_IDX(-2))	-1.018170	-0.142445	-0.107955	-0.035378	-0.044867	-0.077832	0.128326
	(0.48865)	(0.10335)	(0.17013)	(0.18552)	(0.08122)	(0.05312)	(0.29309)
	[-2.08364]	[-1.37822]	[-0.63455]	[-0.19070]	[-0.55245]	[-1.46530]	[0.43785]
D(L_IVU_IMP_T_SA_IDX(-1))	0.164952	0.281305	-0.269479	-0.354936	0.057451	0.051266	0.200236
	(0.42995)	(0.09094)	(0.14969)	(0.16324)	(0.07146)	(0.04674)	(0.25788)
	[0.38365]	[3.09332]	[-1.80020]	[-2.17438]	[0.80396]	[1.09691]	[0.77647]
D(L_IVU_IMP_T_SA_IDX(-2))	0.216892	0.109284	-0.102949	-0.189384	-0.123604	0.040063	0.039527
	(0.44363)	(0.09383)	(0.15446)	(0.16843)	(0.07373)	(0.04822)	(0.26608)
	[0.48890]	[1.16468]	[-0.66653]	[-1.12442]	[-1.67636]	[0.83079]	[0.14855]
D(L_PPI_N_SA_IDX(-1))	0.034093	0.011375	-0.325481	-0.179084	0.065942	0.060860	0.484453
	(0.80792)	(0.17088)	(0.28129)	(0.30673)	(0.13428)	(0.08782)	(0.48458)
	[0.04220]	[0.06657]	[-1.15712]	[-0.58384]	[0.49108]	[0.69299]	[0.99974]
D(L_PPI_N_SA_IDX(-2))	0.998105	0.194876	0.439278	0.582008	0.192800	-0.027988	1.177310
	(0.72893)	(0.15418)	(0.25379)	(0.27675)	(0.12115)	(0.07924)	(0.43721)
	[1.36927]	[1.26398]	[1.73089]	[2.10304]	[1.59139]	[-0.35323]	[2.69281]
D(L_CORE1_U_IDX(-1))	1.361765	-0.289692	-0.123719	0.016548	-0.007925	0.372789	0.313270
	(1.02952)	(0.21775)	(0.35844)	(0.39087)	(0.17111)	(0.11191)	(0.61749)
	[1.32272]	[-1.33037]	[-0.34516]	[0.04234]	[-0.04631]	[3.33116]	[0.50732]
D(L_CORE1_U_IDX(-2))	1.537242	-0.327090	0.656906	0.663852	0.460720	0.067475	0.112542
	(1.05034)	(0.22216)	(0.36569)	(0.39877)	(0.17457)	(0.11417)	(0.62998)
	[1.46356]	[-1.47234]	[1.79635]	[1.66475]	[2.63915]	[0.59099]	[0.17864]
IBON(-1)	-0.111125	0.056702	-0.015030	-0.094331	0.026526	0.020573	0.852642
	(0.15243)	(0.03224)	(0.05307)	(0.05787)	(0.02533)	(0.01657)	(0.09143)
	[-0.72901]	[1.75869]	[-0.28320]	[-1.62999]	[1.04700]	[1.24159]	[9.32596]
IBON(-2)	-0.042262	-0.035797	0.020651	0.058894	-0.013063	0.006754	-0.010868
	(0.13617)	(0.02880)	(0.04741)	(0.05170)	(0.02263)	(0.01480)	(0.08167)
	[-0.31036]	[-1.24290]	[0.43560]	[1.13921]	[-0.57718]	[0.45627]	[-0.13307]
C	-0.396509	-0.131564	-0.340654	0.149199	0.186900	-0.006246	0.064726
	(0.90972)	(0.19241)	(0.31673)	(0.34538)	(0.15120)	(0.09889)	(0.54564)
	[-0.43586]	[-0.68376]	[-1.07553]	[0.43198]	[1.23612]	[-0.06316]	[0.11862]
R-squared	0.285063	0.679426	0.424203	0.426170	0.644133	0.732389	0.960026
Adj. R-squared	0.173851	0.629559	0.334634	0.336908	0.588776	0.690760	0.953807
Sum sq. resids	1667.357	74.59115	202.1115	240.3331	46.05886	19.70126	599.8225
S.E. equation	4.304206	0.910379	1.498560	1.634126	0.715378	0.467871	2.581607
F-statistic	2.563233	13.62476	4.736076	4.774357	11.63596	17.59348	154.3883
Log likelihood	-294.1529	-131.0368	-183.3687	-192.4620	-105.7264	-61.14145	-240.4789
Akaike AIC	5.888626	2.781653	3.778451	3.951657	2.299551	1.450313	4.866265
Schwarz SC	6.267763	3.160790	4.157588	4.330794	2.678688	1.829451	5.245402
Mean dependent	0.889933	0.159972	0.638665	0.885001	1.296000	1.009124	18.03449
S.D. dependent	4.735477	1.495764	1.837148	2.006775	1.115568	0.841353	12.01167

Determinant resid covariance (dof adj.)	11.22152
Determinant resid covariance	3.814383
Log likelihood	-1113.206
Akaike information criterion	23.20392
Schwarz criterion	25.85788

Table 13 - Vector Autoregression Estimates (CORE2)

Vector Autoregression Estimates
Sample (adjusted): 2000M04 2008M12
Included observations: 105 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(L_WPI_U_SA_IDX)	L_Y_SA_YINDCL_HPGAP	D(L_S_EF_SA_IDX)	D(L_IVU_IMP_T_SA_IDX)	D(L_PPI_N_SA_IDX)	D(L_CORE2_U_SA_IDX)	IBON
D(L_WPI_U_SA_IDX(-1))	0.250649	-0.006772	0.019060	0.079142	0.097000	-0.000258	-0.025792
	(0.13827)	(0.02941)	(0.04697)	(0.05168)	(0.02319)	(0.00962)	(0.07904)
	[1.81270]	[-0.23023]	[0.40582]	[1.53128]	[4.18368]	[-0.02681]	[-0.32634]
D(L_WPI_U_SA_IDX(-2))	-0.045597	-0.019045	0.054006	0.050094	0.036497	0.003217	-0.186318
	(0.14707)	(0.03129)	(0.04995)	(0.05497)	(0.02466)	(0.01023)	(0.08407)
	[-0.31003]	[-0.60872]	[1.08110]	[0.91125]	[1.47997]	[0.31438]	[-2.21635]
L_Y_SA_YINDCL_HPGAP(-1)	-0.249400	0.682618	0.267234	0.295181	0.029545	0.059464	0.100159
	(0.52235)	(0.11112)	(0.17742)	(0.19524)	(0.08759)	(0.03634)	(0.29857)
	[-0.47745]	[6.14309]	[1.50621]	[1.51187]	[0.33732]	[1.63613]	[0.33546]
L_Y_SA_YINDCL_HPGAP(-2)	-0.324088	0.073443	-0.183213	-0.404976	-0.058368	-0.058315	0.022043
	(0.50945)	(0.10837)	(0.17304)	(0.19042)	(0.08542)	(0.03545)	(0.29119)
	[-0.63615]	[0.67768]	[-1.05880]	[-2.12676]	[-0.68329]	[-1.64514]	[0.07570]
D(L_S_EF_SA_IDX(-1))	0.087392	-0.219732	0.751858	0.821901	0.034195	0.067567	-0.054529
	(0.43846)	(0.09327)	(0.14893)	(0.16388)	(0.07352)	(0.03051)	(0.25062)
	[0.19932]	[-2.35580]	[5.04854]	[5.01511]	[0.46512]	[2.21479]	[-0.21758]
D(L_S_EF_SA_IDX(-2))	-1.031614	-0.129436	-0.059204	0.004337	-0.033343	0.026641	0.076329
	(0.48817)	(0.10385)	(0.16581)	(0.18247)	(0.08185)	(0.03397)	(0.27903)
	[-2.11323]	[-1.24640]	[-0.35706]	[0.02377]	[-0.40735]	[0.78435]	[0.27355]
D(L_IVU_IMP_T_SA_IDX(-1))	0.189071	0.299335	-0.233107	-0.322847	0.047219	-0.062081	0.164055
	(0.43890)	(0.09337)	(0.14908)	(0.16405)	(0.07359)	(0.03054)	(0.25087)
	[0.43078]	[3.20603]	[-1.56369]	[-1.96799]	[0.64162]	[-2.03292]	[0.65395]
D(L_IVU_IMP_T_SA_IDX(-2))	0.257721	0.060173	-0.165997	-0.235696	-0.105834	-0.033628	0.077350
	(0.45449)	(0.09668)	(0.15437)	(0.16988)	(0.07621)	(0.03162)	(0.25978)
	[0.56706]	[0.62238]	[-1.07532]	[-1.38746]	[-1.38878]	[-1.06341]	[0.29775]
D(L_PPI_N_SA_IDX(-1))	-0.193119	0.100832	-0.356661	-0.206568	-0.052889	0.097430	0.089067
	(0.86092)	(0.18314)	(0.29242)	(0.32179)	(0.14436)	(0.05990)	(0.49209)
	[-0.22432]	[0.55057]	[-1.21970]	[-0.64194]	[-0.36638]	[1.62650]	[0.18100]
D(L_PPI_N_SA_IDX(-2))	0.855691	0.169545	0.379733	0.542820	0.186177	-0.071678	0.813919
	(0.76650)	(0.16306)	(0.26035)	(0.28650)	(0.12852)	(0.05333)	(0.43812)
	[1.11636]	[1.03979]	[1.45856]	[1.89467]	[1.44857]	[-1.34399]	[1.85775]
D(L_CORE2_U_SA_IDX(-1))	0.577042	-0.577327	-0.562887	-0.457361	0.416875	0.522715	1.627045
	(1.63046)	(0.34685)	(0.55380)	(0.60943)	(0.27339)	(0.11345)	(0.93195)
	[0.35391]	[-1.66450]	[-1.01641]	[-0.75048]	[1.52483]	[4.60764]	[1.74585]
D(L_CORE2_U_SA_IDX(-2))	2.535609	0.183413	1.409324	1.282976	0.107481	0.318162	0.904833
	(1.69283)	(0.36011)	(0.57498)	(0.63274)	(0.28385)	(0.11778)	(0.96759)
	[1.49786]	[0.50932]	[2.45107]	[2.02766]	[0.37866]	[2.70123]	[0.93514]
IBON(-1)	-0.170135	0.052773	-0.050795	-0.122461	0.013848	-0.013467	0.754556
	(0.16695)	(0.03551)	(0.05671)	(0.06240)	(0.02799)	(0.01162)	(0.09543)
	[-1.01909]	[1.48594]	[-0.89577]	[-1.96247]	[0.49469]	[-1.15939]	[7.90730]
IBON(-2)	0.003046	-0.044243	0.038499	0.076623	-0.000834	0.018150	0.003395
	(0.13589)	(0.02891)	(0.04615)	(0.05079)	(0.02278)	(0.00945)	(0.07767)
	[0.02241]	[-1.53053]	[0.83412]	[1.50860]	[-0.03661]	[1.91968]	[0.04371]
C	-0.066068	-0.177894	-0.243666	0.241364	0.255377	0.045355	0.358791
	(0.93835)	(0.19961)	(0.31872)	(0.35073)	(0.15734)	(0.06529)	(0.53635)
	[-0.07041]	[-0.89119]	[-0.76452]	[0.68817]	[1.62310]	[0.69468]	[0.66895]
R-squared	0.270564	0.669142	0.440872	0.432536	0.630454	0.877823	0.962960
Adj. R-squared	0.157096	0.617675	0.353897	0.344264	0.572969	0.858817	0.957198
Sum sq. resids	1701.172	76.98411	196.2604	237.6670	47.82928	8.235636	555.7900
S.E. equation	4.347632	0.924867	1.476710	1.625037	0.728997	0.302501	2.485044
F-statistic	2.384499	13.00143	5.068928	4.900032	10.96730	46.18810	167.1290
Log likelihood	-295.2069	-132.6946	-181.8263	-191.8763	-107.7066	-15.35034	-236.4761
Akaike AIC	5.908703	2.813230	3.749073	3.940501	2.337269	0.578102	4.790022
Schwarz SC	6.287841	3.192367	4.128211	4.319639	2.716406	0.957239	5.169159
Mean dependent	0.889933	0.159972	0.638665	0.885001	1.296000	0.998289	18.03449
S.D. dependent	4.735477	1.495764	1.837148	2.006775	1.115568	0.805075	12.01167

Determinant resid covariance (dof adj.)	3.963819
Determinant resid covariance	1.347368
Log likelihood	-1058.573
Akaike information criterion	22.16329
Schwarz criterion	24.81725

Table 14 - Vector Autoregression Estimates (CORE3)

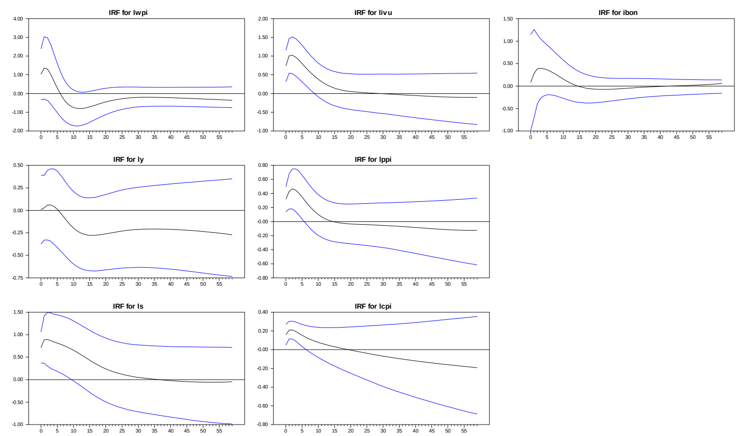
Vector Autoregression Estimates
Sample (adjusted): 2000M04 2008M12
Included observations: 105 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(L_WPI_U_SA_IDX)	L_Y_SA_YINDCL_HPGAP	D(L_S_EF_SA_IDX)	D(L_IVU_IMP_T_SA_IDX)	D(L_PPI_N_SA_IDX)	D(L_CORE3_U_SA_IDX)	IBON
D(L_WPI_U_SA_IDX(-1))	0.212516	-0.012754	0.009868	0.058753	0.100173	0.002016	-0.034796
	(0.14165)	(0.03030)	(0.04839)	(0.05253)	(0.02361)	(0.00851)	(0.08152)
	[1.50025]	[-0.42099]	[0.20393]	[1.11837]	[4.24292]	[0.23678]	[-0.42683]
D(L_WPI_U_SA_IDX(-2))	-0.023265	-0.016892	0.059979	0.058815	0.041804	0.010138	-0.173710
	(0.14800)	(0.03165)	(0.05056)	(0.05489)	(0.02467)	(0.00890)	(0.08517)
	[-0.15720]	[-0.53369]	[1.18639]	[1.07156]	[1.69475]	[1.13966]	[-2.03951]
L_Y_SA_YINDCL_HPGAP(-1)	-0.354283	0.672081	0.226582	0.237704	0.043870	0.065291	0.076325
	(0.52184)	(0.11161)	(0.17826)	(0.19353)	(0.08698)	(0.03136)	(0.30032)
	[-0.67891]	[6.02187]	[1.27108]	[1.22824]	[0.50440]	[2.08167]	[0.25415]
L_Y_SA_YINDCL_HPGAP(-2)	-0.209885	0.089319	-0.146211	-0.345540	-0.060863	-0.057759	0.054504
	(0.51370)	(0.10986)	(0.17548)	(0.19051)	(0.08562)	(0.03088)	(0.29563)
	[-0.40858]	[0.81299]	[-0.83322]	[-1.81375]	[-0.71087]	[-1.87070]	[0.18437]
D(L_S_EF_SA_IDX(-1))	0.040323	-0.230094	0.724956	0.791079	0.038538	0.055120	-0.056581
	(0.43623)	(0.09330)	(0.14902)	(0.16178)	(0.07271)	(0.02622)	(0.25105)
	[0.09243]	[-2.46622]	[4.86495]	[4.88972]	[0.53004]	[2.10226]	[-0.22538]
D(L_S_EF_SA_IDX(-2))	-0.987378	-0.144537	-0.062679	0.003751	-0.018758	0.045231	0.135584
	(0.48338)	(0.10338)	(0.16512)	(0.17927)	(0.08056)	(0.02905)	(0.27818)
	[-2.04267]	[-1.39811]	[-0.37960]	[0.02092]	[-0.23283]	[1.55684]	[0.48739]
D(L_IVU_IMP_T_SA_IDX(-1))	0.324713	0.332009	-0.174807	-0.235626	0.032233	-0.053195	0.169917
	(0.45717)	(0.09777)	(0.15617)	(0.16955)	(0.07620)	(0.02748)	(0.26310)
	[0.71027]	[3.39565]	[-1.11936]	[-1.38974]	[0.42302]	[-1.93593]	[0.64583]
D(L_IVU_IMP_T_SA_IDX(-2))	0.131840	0.064611	-0.183175	-0.274578	-0.122311	-0.055658	-0.010690
	(0.45249)	(0.09677)	(0.15457)	(0.16781)	(0.07542)	(0.02720)	(0.26041)
	[0.29137]	[0.66765]	[-1.18508]	[-1.63623]	[-1.62182]	[-2.04654]	[-0.04105]
D(L_PPI_N_SA_IDX(-1))	-0.114584	0.102122	-0.367466	-0.171793	-0.079669	0.060073	0.115590
	(0.85736)	(0.18336)	(0.29287)	(0.31796)	(0.14290)	(0.05153)	(0.49341)
	[-0.13365]	[0.55693]	[-1.25470]	[-0.54029]	[-0.55753]	[1.16577]	[0.23427]
D(L_PPI_N_SA_IDX(-2))	0.761789	0.150517	0.348293	0.499255	0.160233	-0.070596	0.773576
	(0.76857)	(0.16438)	(0.26254)	(0.28504)	(0.12810)	(0.04619)	(0.44231)
	[0.99118]	[0.91569]	[1.32662]	[1.75155]	[1.25087]	[-1.52824]	[1.74894]
D(L_CORE3_U_SA_IDX(-1))	-0.722803	-0.751811	-0.834890	-1.132020	0.550742	0.665942	1.287831
	(1.98252)	(0.42400)	(0.67722)	(0.73525)	(0.33043)	(0.11916)	(1.14094)
	[-0.36459]	[-1.77312]	[-1.23281]	[-1.53965]	[1.66676]	[5.58872]	[1.12875]
D(L_CORE3_U_SA_IDX(-2))	4.002195	0.428347	1.736207	2.023603	0.124676	0.291477	1.348822
	(2.06776)	(0.44223)	(0.70634)	(0.76686)	(0.34463)	(0.12428)	(1.19000)
	[1.93552]	[0.96860]	[2.45803]	[2.63882]	[0.36176]	[2.34530]	[1.13347]
IBON(-1)	-0.168764	0.048697	-0.048320	-0.122547	0.009100	-0.018042	0.756444
	(0.16367)	(0.03500)	(0.05591)	(0.06070)	(0.02728)	(0.00984)	(0.09419)
	[-1.03115]	[1.39121]	[-0.86429]	[-2.01898]	[0.33362]	[-1.83414]	[8.03110]
IBON(-2)	-0.017099	-0.043061	0.032120	0.069864	-0.003368	0.017664	-0.010173
	(0.13475)	(0.02882)	(0.04603)	(0.04997)	(0.02246)	(0.00810)	(0.07755)
	[-0.12690]	[-1.49415]	[0.69780]	[1.39799]	[-0.14997]	[2.18096]	[-0.13118]
C	0.225672	-0.201085	-0.161543	0.318649	0.333702	0.060118	0.599550
	(0.97413)	(0.20834)	(0.33276)	(0.36127)	(0.16236)	(0.05855)	(0.56061)
	[0.23166]	[-0.96518]	[-0.48546]	[0.88202]	[2.05534]	[1.02678]	[1.06945]
R-squared	0.280601	0.670180	0.442253	0.449026	0.639901	0.914316	0.962968
Adj. R-squared	0.168695	0.618875	0.355492	0.363318	0.583886	0.900987	0.957207
Sum sq. resids	1677.763	76.74260	195.7758	230.7609	46.60655	6.060989	555.6753
S.E. equation	4.317616	0.923415	1.474885	1.601253	0.719618	0.259508	2.484788
F-statistic	2.507461	13.06258	5.097388	5.239068	11.42368	68.59787	167.1648
Log likelihood	-294.4795	-132.5296	-181.6966	-190.3282	-106.3470	0.746039	-236.4653
Akaike AIC	5.894848	2.810088	3.746601	3.911013	2.311372	0.271504	4.789815
Schwarz SC	6.273985	3.189225	4.125738	4.290150	2.690509	0.650641	5.168952
Mean dependent	0.889933	0.159972	0.638665	0.885001	1.296000	0.963441	18.03449
S.D. dependent	4.735477	1.495764	1.837148	2.006775	1.115568	0.824717	12.01167

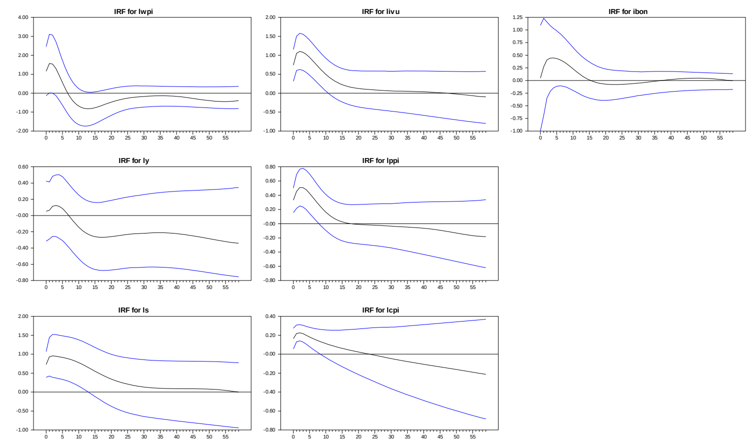
Determinant resid covariance (dof adj.)	2.515880
Determinant resid covariance	0.855190
Log likelihood	-1034.707
Akaike information criterion	21.70871
Schwarz criterion	24.36267

Appendix 4 - Pure sign restriction approach - Outputs for different K

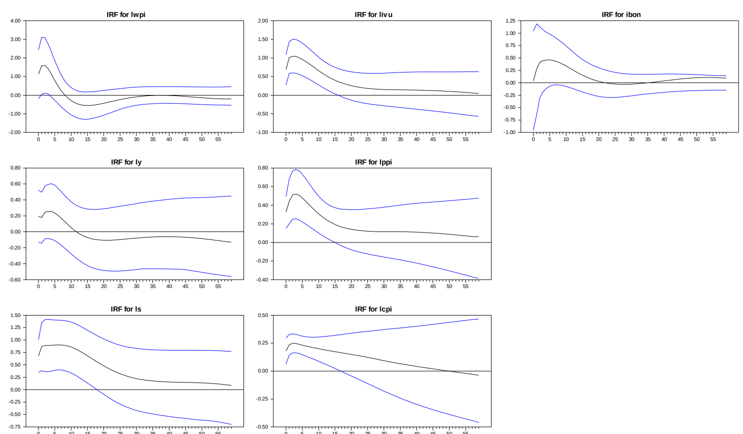
Figure 39 - Impulse responses to an exchange rate shock, using the pure sign restriction approach for K = 2, 5, 11, 23



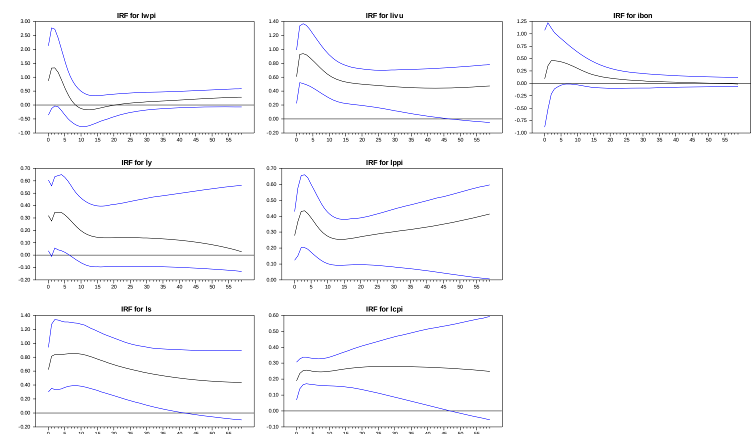
IRF for VAR with pure sign restrictions



IRF for VAR with pure sign restrictions



IRF for VAR with pure sign restrictions



IRF for VAR with pure sign restrictions, K=23

Figure 40 - ERPT into import price index - the pure sign restriction approach for K = 2, 5, 11, 23

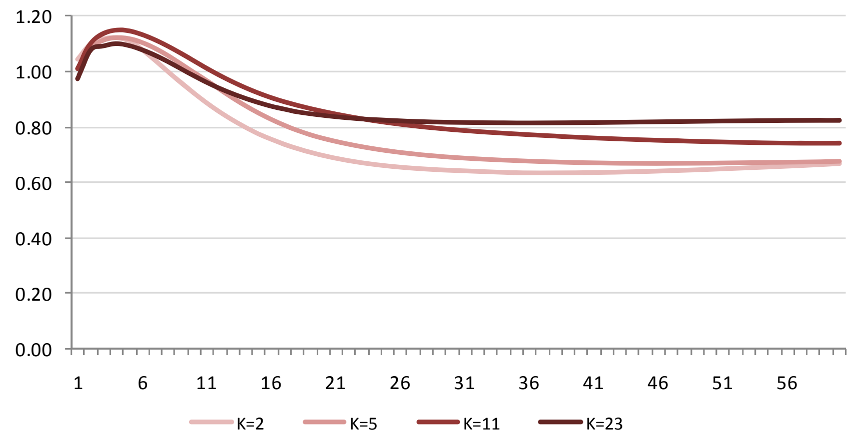


Figure 41 - ERPT into producer price index - the pure sign restriction approach for K = 2, 5, 11, 23

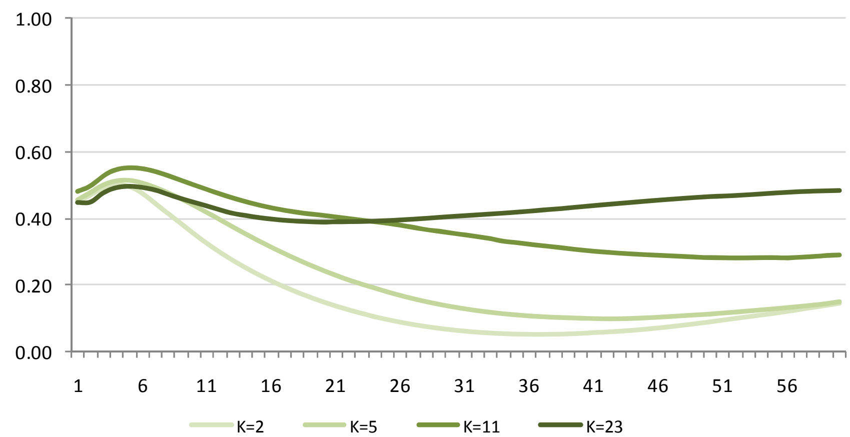


Figure 42 - ERPT into import price index - the pure sign restriction approach for K = 2, 5, 11, 23

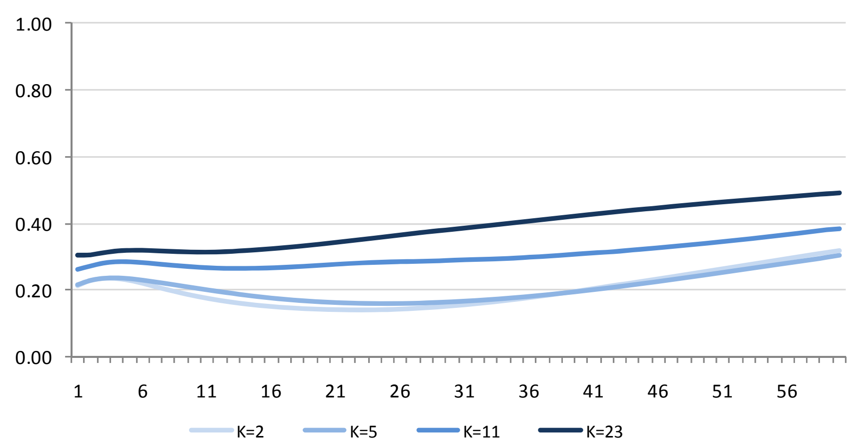
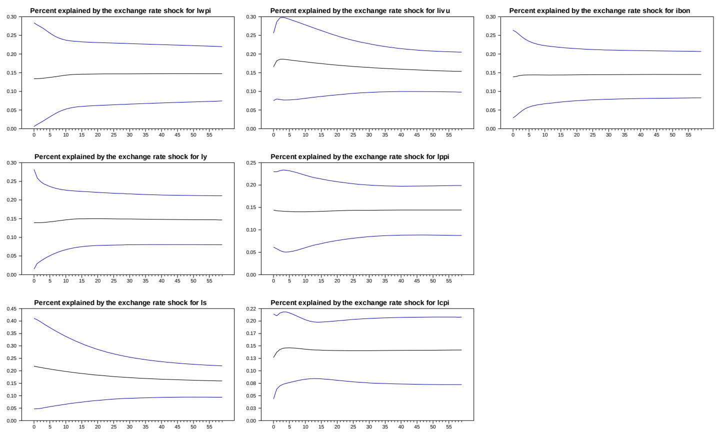
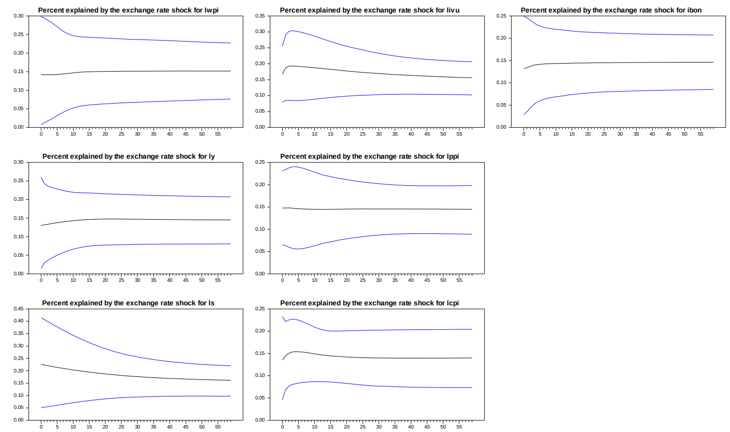


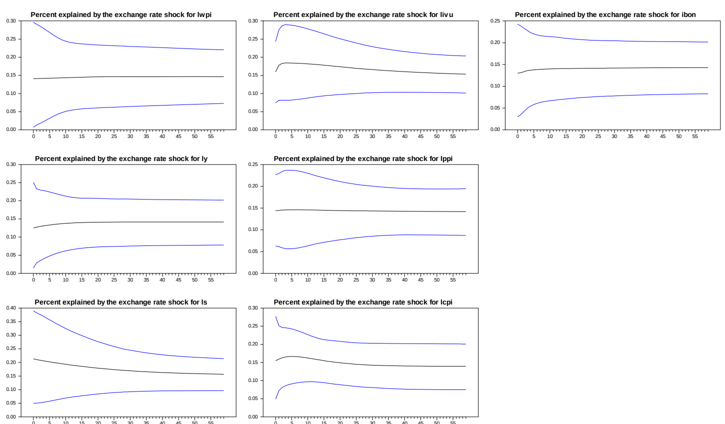
Figure 43 - Variance Decomposition using the pure sign restriction approach for K = 2, 5, 11, 23



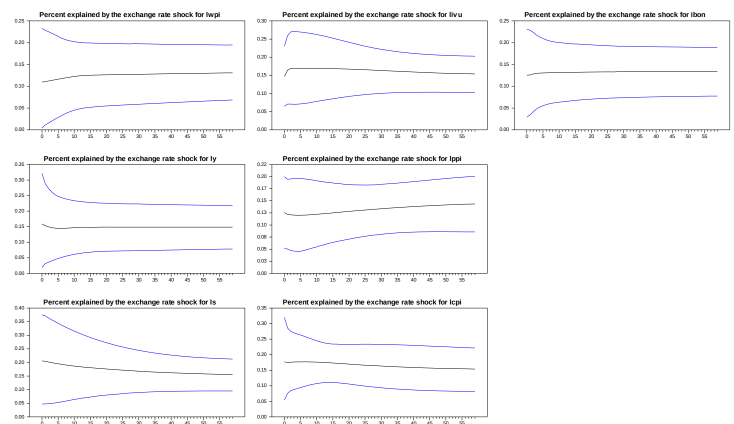
VD for VAR with pure sign restrictions



VD for VAR with pure sign restrictions



VD for VAR with pure sign restrictions



VD for VAR with pure sign restrictions, K=23

Appendix 5 - MS-VAR (MSIAH) - Ox output

```
Ox version 3.30 (Windows) (C) J.A. Doornik, 1994-2003
MSVAR (c) H-M Krolzig, 1996-2004, package version 1.31k, object created on 28-06-2004

---------- Calculate starting values ---------------

It.  0       LogLik = -1020.4321  Pct.Change =100.0000
It.  1       LogLik = -1012.8421  Pct.Change =  0.7438
It.  2       LogLik = -1010.6355  Pct.Change =  0.2179
It.  3       LogLik = -1009.5632  Pct.Change =  0.1061
It.  4       LogLik = -1008.7533  Pct.Change =  0.0802
It.  5       LogLik = -1008.2683  Pct.Change =  0.0481
It.  6       LogLik = -1007.9759  Pct.Change =  0.0290
It.  7       LogLik = -1007.8948  Pct.Change =  0.0080
It.  8       LogLik = -1007.8856  Pct.Change =  0.0009
It.  9       LogLik = -1007.8847  Pct.Change =  0.0001

---------- EM algorithm converged  -----------------

EQ( 1) MSIAH(2)-VAR(2) model of (dl_wpi,lygap,dl_s,dl_ivu,dl_ppi,dl_cpi,ibon)
       Estimation sample: 2000 (4) - 2008 (12)

no. obs. per eq. :        105    in the system :        735
no. parameters   :        268    linear system :        133
no. restrictions :        133
no. nuisance p.  :          2

log-likelihood   : -1007.8847    linear system : -1111.0450
AIC criterion    :    24.3026    linear system :    23.6961
HQ  criterion    :    27.0475    linear system :    25.0583
SC  criterion    :    31.0765    linear system :    27.0578

LR linearity test:   206.3206    Chi(133) =[0.0000] **  Chi(135)=[0.0001] **
DAVIES=[0.0038] **

---------- matrix of transition probabilities ------
          Regime 1  Regime 2
Regime 1    0.9130    0.0870
Regime 2    0.0900    0.9100

---------- regime properties ----------------------
              nObs     Prob.  Duration
Regime 1      49.1    0.5084     11.49
Regime 2      55.9    0.4916     11.11

---------- regime classification -------------------

Regime 1
2002:8 - 2002:8 [0.9997]
2003:2 - 2003:8 [0.9971]
2003:12 - 2004:1 [0.9969]
2004:11 - 2007:7 [0.9979]
2008:7 - 2008:12 [0.9999]
Regime 2
2000:4 - 2002:7 [0.9992]
2002:9 - 2003:1 [0.9975]
2003:9 - 2003:11 [1.0000]
2004:2 - 2004:10 [0.9839]
2007:8 - 2008:6 [0.9959]
```

Appendix 6 - TVAR - Time asymmetry - Ox output

```
Ox version 3.30 (Windows) (C) J.A. Doornik, 1994-2003
MSVAR (c) H-M Krolzig, 1996-2004, package version 1.31k, object created on 28-06-2004


---------- ML estimation results  -----------------

EQ( 1) Switching Regression model of (dl_wpi,lygap,dl_s,dl_ivu,dl_ppi,dl_cpi,ibon)
       Estimation sample: 2000 (4) - 2008 (12)

no. obs. per eq. :        105    in the system :        735
no. parameters   :        266    linear system :        133
no. restrictions :        133
no. nuisance p.  :          0

log-likelihood   :  -991.8622    linear system : -1111.0450

AIC criterion    :    23.9593    linear system :    23.6961
HQ  criterion    :    26.6837    linear system :    25.0583
SC  criterion    :    30.6826    linear system :    27.0578

LR linearity test:   238.3656    Chi(133) =[0.0000] **  Chi(133)=[0.0000] **
DAVIES=[0.0000] **


---------- regime shifts ---------------------------

regime variable indper1

                  nObs     Prob.
Regime 1         60.00    0.5714
Regime 2         45.00    0.4286



---------- regime classification -------------------

Regime 1
2004:1 - 2008:12 [1.0000]

Regime 2
2000:4 - 2003:12 [1.0000]
```

Figure 44 - TVAR model (Time asymmetry) - Prediction error and Standard resids

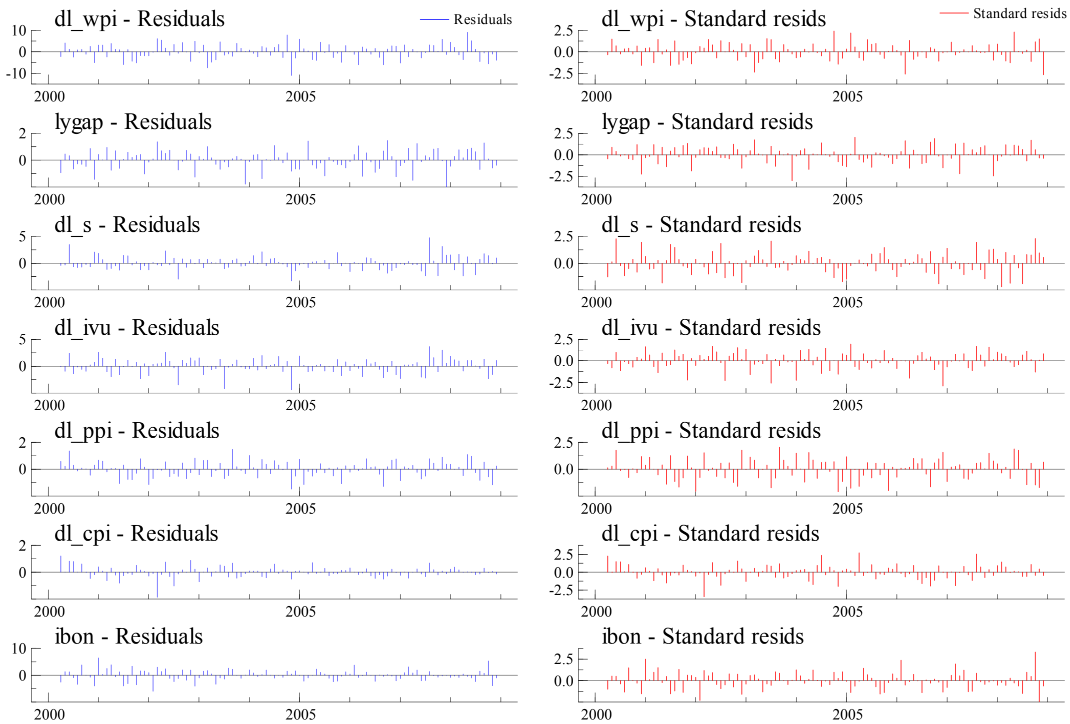


Figure 45 - TVAR model (Time asymmetry) -- Correlogram, Spectral density, Density and QQ Plot of standard resids

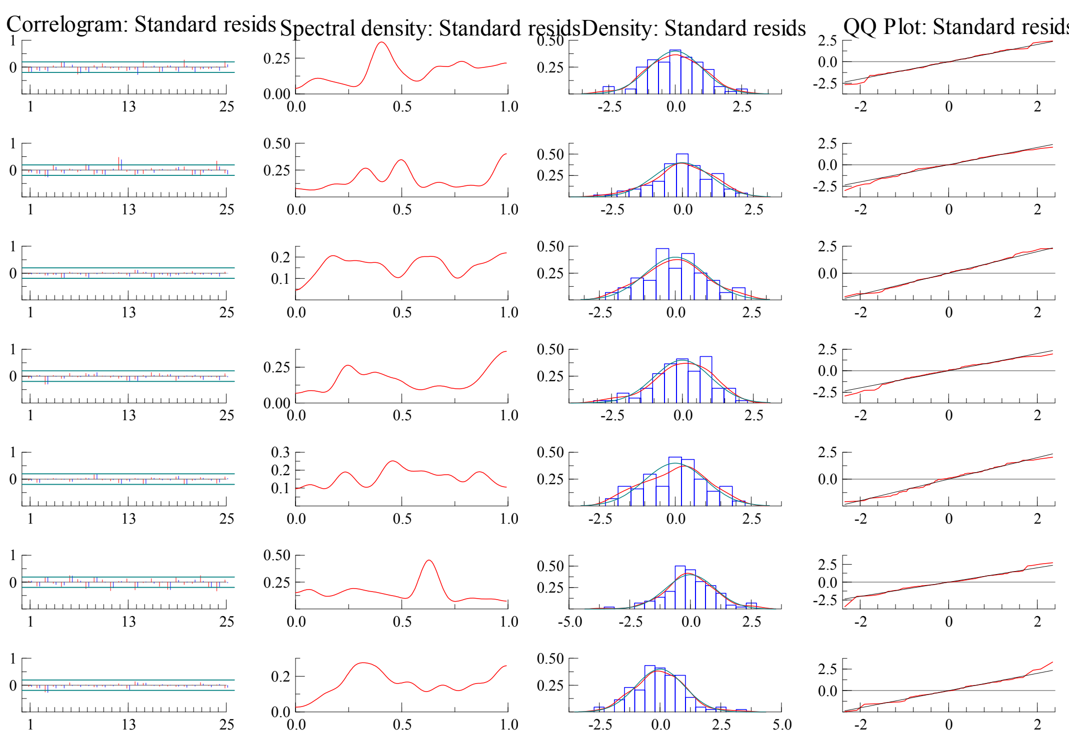
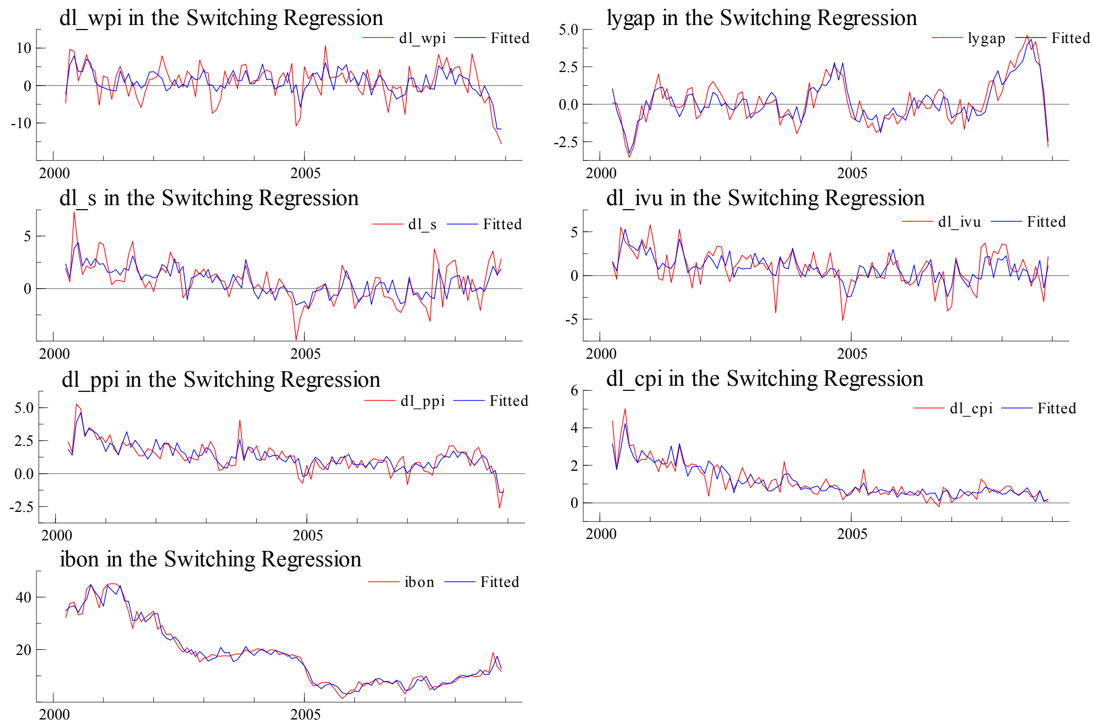


Figure 46 - TVAR model (Time asymmetry) - Actual and fitted values



Appendix 7 - TVAR - sign of the exchange rate change - Ox output

```
Ox version 3.30 (Windows) (C) J.A. Doornik, 1994-2003
MSVAR (c) H-M Krolzig, 1996-2004, package version 1.31k, object created on 28-06-2004

---------- ML estimation results  -----------------
EQ( 1) Switching Regression model of (dl_wpi,lygap,dl_s,dl_ivu,dl_ppi,dl_cpi,ibon)
       Estimation sample: 2000 (4) - 2008 (12)

no. obs. per eq. :        105    in the system :        735
no. parameters   :        266    linear system :        133
no. restrictions :        133
no. nuisance p.  :          0

log-likelihood   :  -957.3842    linear system : -1111.0450
AIC criterion    :    23.3026    linear system :    23.6961
HQ  criterion    :    26.0270    linear system :    25.0583
SC  criterion    :    30.0259    linear system :    27.0578

LR linearity test:   307.3216    Chi(133) =[0.0000] **  Chi(133)=[0.0000] **
DAVIES=[0.0000] **

---------- regime shifts --------------------------
regime variable inddls
                   nObs     Prob.
Regime 1          37.00    0.3524
Regime 2          68.00    0.6476

---------- regime classification -------------------
Regime 1
2002:1 - 2002:1 [1.0000]
2002:8 - 2002:9 [1.0000]
2003:7 - 2003:7 [1.0000]
2004:3 - 2004:3 [1.0000]
2004:5 - 2004:6 [1.0000]
2004:9 - 2005:3 [1.0000]
2005:7 - 2005:9 [1.0000]
2006:1 - 2006:5 [1.0000]
2006:8 - 2007:1 [1.0000]
2007:3 - 2007:7 [1.0000]
2007:10 - 2007:10 [1.0000]
2008:4 - 2008:4 [1.0000]
2008:6 - 2008:7 [1.0000]

Regime 2
2000:4 - 2001:12 [1.0000]
2002:2 - 2002:7 [1.0000]
2002:10 - 2003:6 [1.0000]
2003:8 - 2004:2 [1.0000]
2004:4 - 2004:4 [1.0000]
2004:7 - 2004:8 [1.0000]
2005:4 - 2005:6 [1.0000]
2005:10 - 2005:12 [1.0000]
2006:6 - 2006:7 [1.0000]
2007:2 - 2007:2 [1.0000]
2007:8 - 2007:9 [1.0000]
2007:11 - 2008:3 [1.0000]
2008:5 - 2008:5 [1.0000]
2008:8 - 2008:12 [1.0000]
```

Figure 47 - TVAR model (Exchange rate appreciation - depreciation) - Prediction error and Standard resids

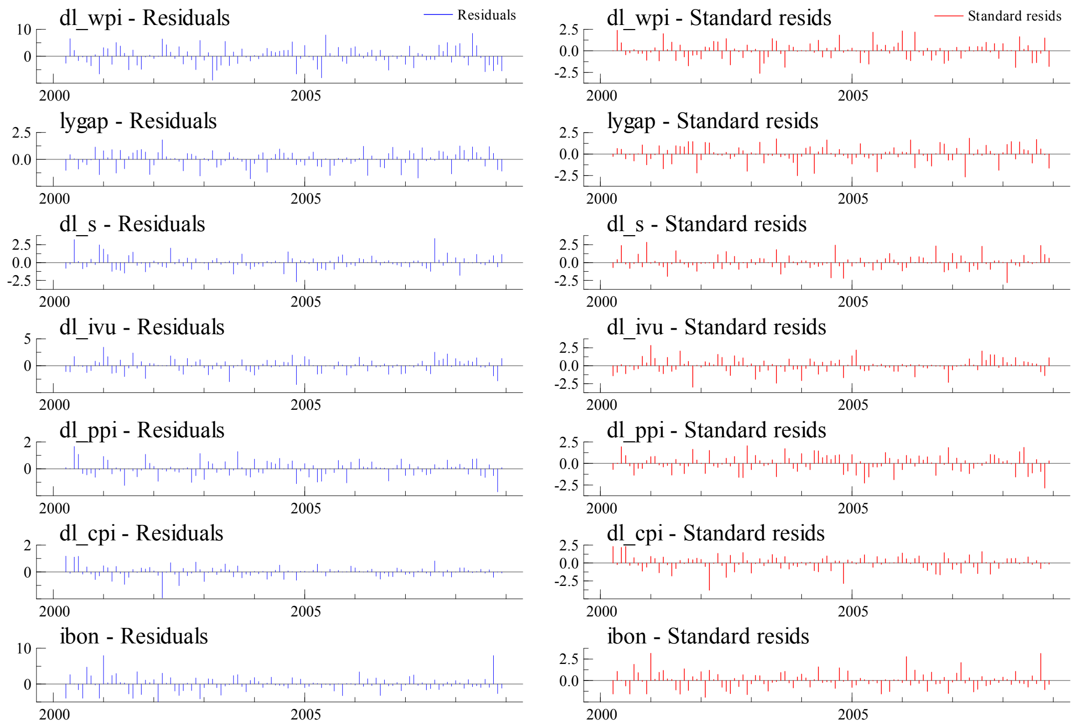


Figure 48 - TVAR model (Exchange rate appreciation - depreciation) - Correlogram, Spectral density, Density and QQ Plot of standard resids

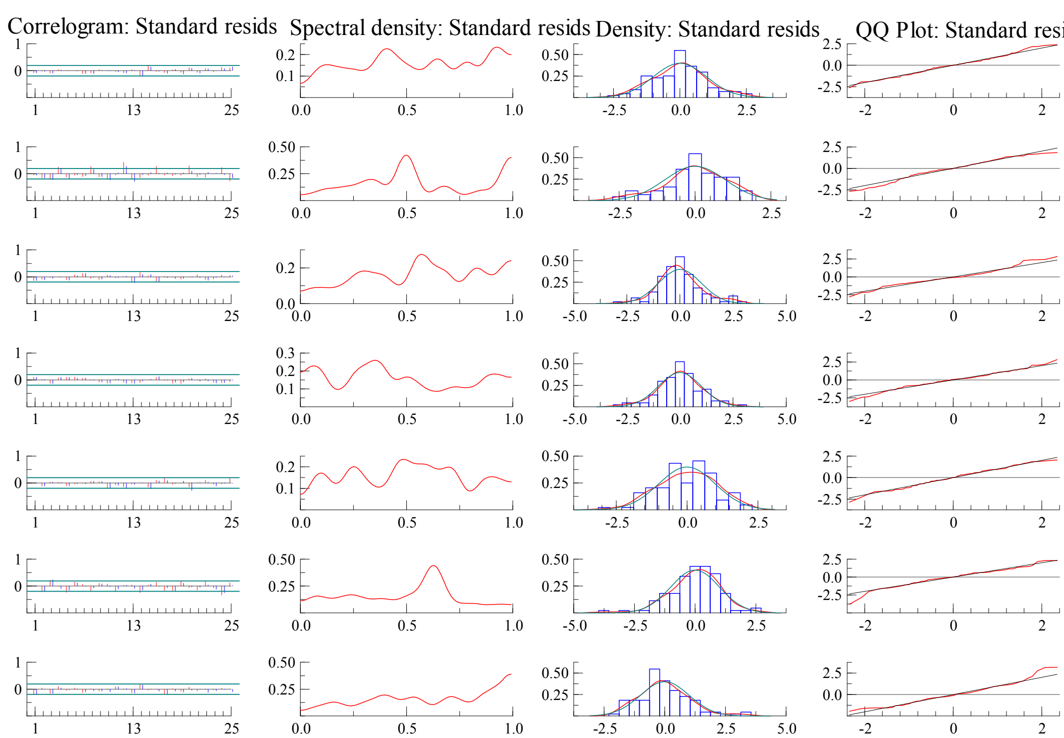
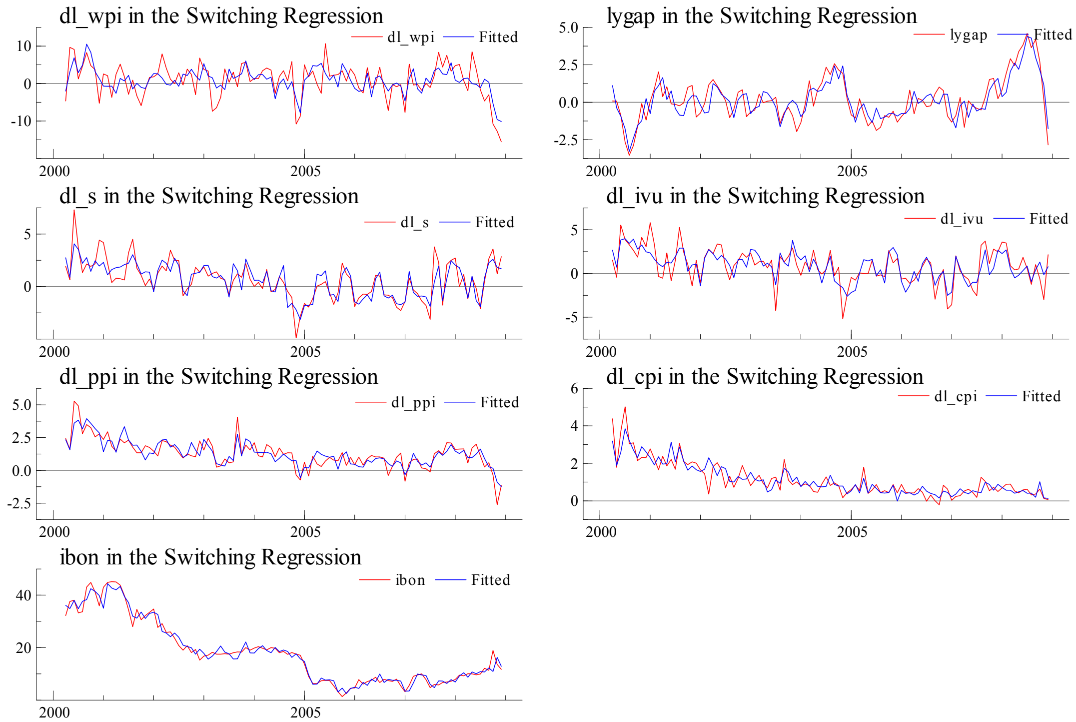


Figure 49 - TVAR model (Exchange rate appreciation - depreciation) - Actual and fitted values



Appendix 8 - TVAR - size of the exchange rate change - Ox output

```
Ox version 3.30 (Windows) (C) J.A. Doornik, 1994-2003
MSVAR (c) H-M Krolzig, 1996-2004, package version 1.31k, object created on  2-07-2004

---------- ML estimation results  -----------------

EQ( 1) Switching Regression model of (dl_wpi,lygap,dl_s,dl_ivu,dl_ppi,dl_cpi,ibon)
       Estimation sample: 2000 (4) - 2008 (12)

no. obs. per eq. :        105    in the system :        735
no. parameters   :        266    linear system :        133
no. restrictions :        133
no. nuisance p.  :          0

log-likelihood   :  -959.5969    linear system : -1111.0450

AIC criterion    :    23.3447    linear system :    23.6961
HQ  criterion    :    26.0691    linear system :    25.0583
SC  criterion    :    30.0681    linear system :    27.0578

LR linearity test:   302.8963    Chi(133) =[0.0000] **  Chi(133)=[0.0000] **
DAVIES=[0.0000] **

---------- regime shifts --------------------------

regime variable indsbig13
                  nObs     Prob.
Regime 1          58.00    0.5524
Regime 2          47.00    0.4476


---------- regime classification -------------------

Regime 1                                       Regime 2
2000:5 - 2000:5 [1.0000]                       2000:4 - 2000:4 [1.0000]
2001:3 - 2001:6 [1.0000]                       2000:6 - 2001:2 [1.0000]
2001:10 - 2002:2 [1.0000]                      2001:7 - 2001:9 [1.0000]
2002:8 - 2002:10 [1.0000]                      2002:3 - 2002:7 [1.0000]
2003:2 - 2003:3 [1.0000]                       2002:11 - 2003:1 [1.0000]
2003:5 - 2003:10 [1.0000]                      2003:4 - 2003:4 [1.0000]
2003:12 - 2004:3 [1.0000]                      2003:11 - 2003:11 [1.0000]
2004:5 - 2004:10 [1.0000]                      2004:4 - 2004:4 [1.0000]
2005:3 - 2005:7 [1.0000]                       2004:11 - 2005:2 [1.0000]
2005:9 - 2005:9 [1.0000]                       2005:8 - 2005:8 [1.0000]
2005:11 - 2005:12 [1.0000]                     2005:10 - 2005:10 [1.0000]
2006:2 - 2006:10 [1.0000]                      2006:1 - 2006:1 [1.0000]
2007:2 - 2007:4 [1.0000]                       2006:11 - 2007:1 [1.0000]
2008:2 - 2008:6 [1.0000]                       2007:5 - 2008:1 [1.0000]
2008:8 - 2008:8 [1.0000]                       2008:7 - 2008:7 [1.0000]
2008:11 - 2008:11 [1.0000]                     2008:9 - 2008:10 [1.0000]
                                               2008:12 - 2008:12 [1.0000]
```

Figure 50 - TVAR model (magnitude of monthly change in exchange rate) - Prediction error and Standard resids

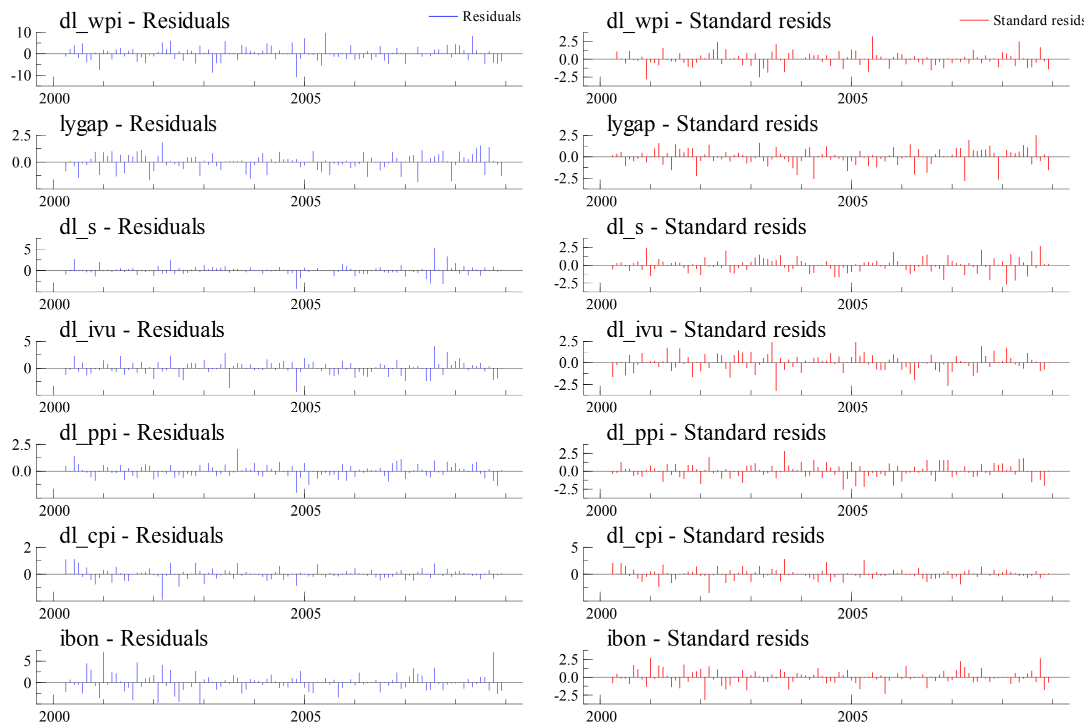


Figure 51 - TVAR model (magnitude of monthly change in exchange rate) - - Correlogram, Spectral density, Density and QQ Plot of standard resids

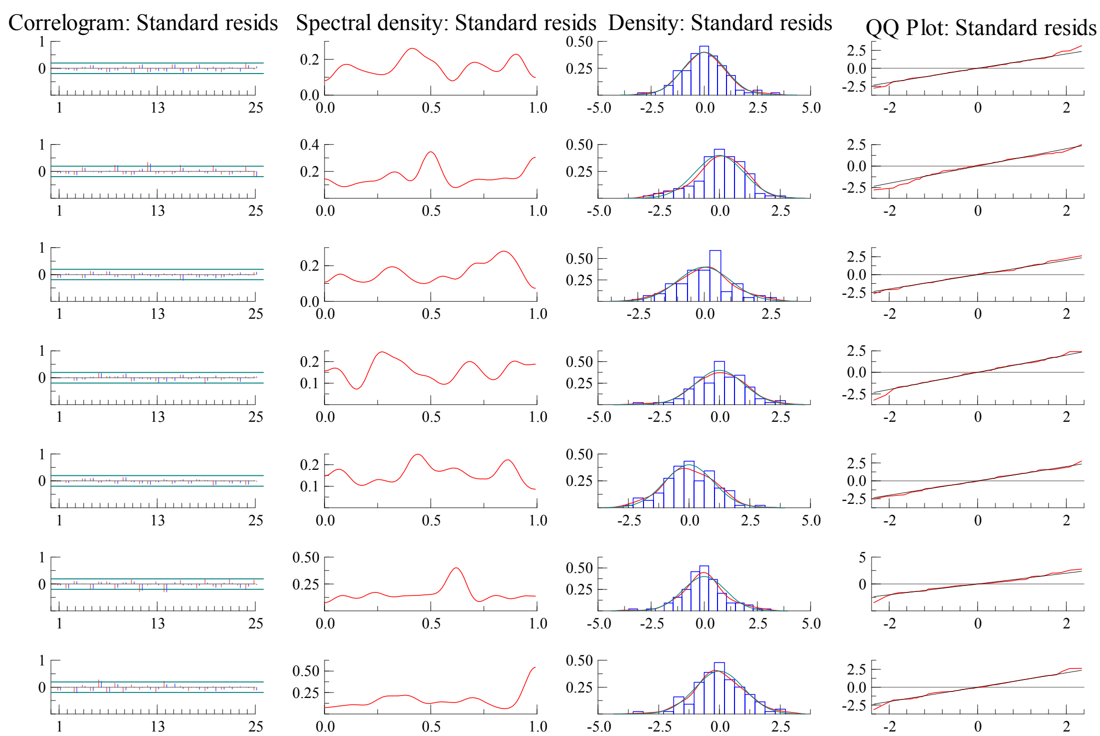
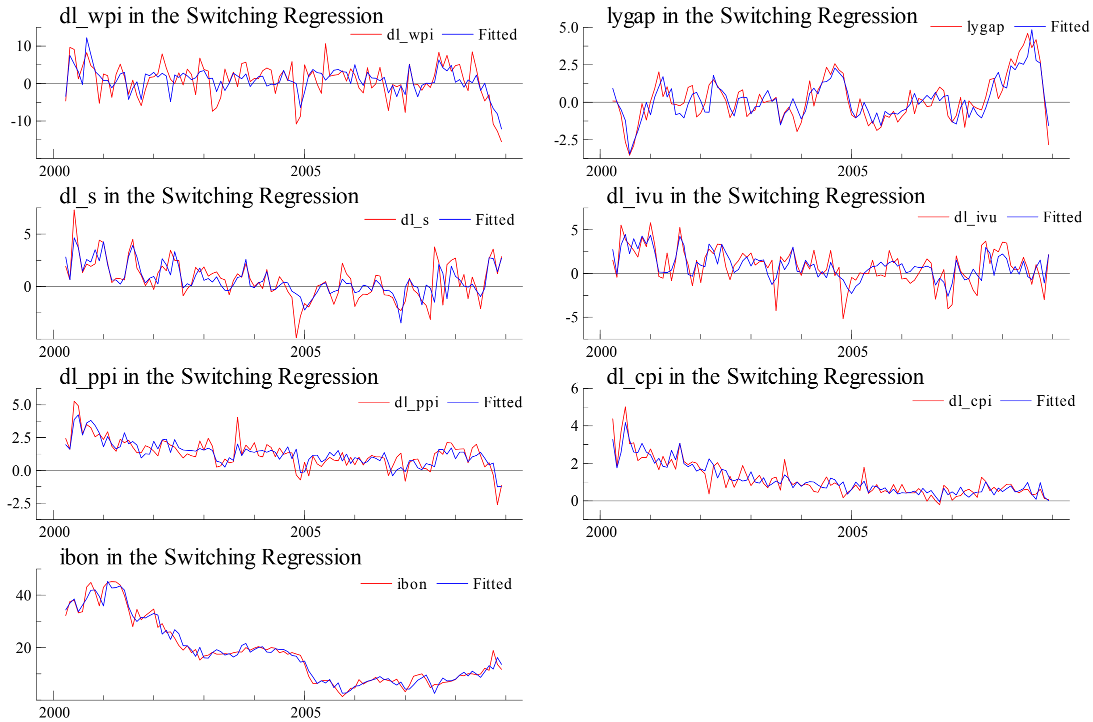


Figure 52 - TVAR model (magnitude of monthly change in exchange rate) - Actual and fitted values



Appendix 9 - TVAR - size of the monthly inflation - Ox output

```
Ox version 3.30 (Windows) (C) J.A. Doornik, 1994-2003
MSVAR (c) H-M Krolzig, 1996-2004, package version 1.31k, object created on 28-06-2004


---------- ML estimation results  -----------------

EQ( 1) Switching Regression model of (dl_wpi,lygap,dl_s,dl_ivu,dl_ppi,dl_cpi,ibon)
       Estimation sample: 2000 (4) - 2008 (12)

no. obs. per eq. :        105    in the system :        735
no. parameters   :        266    linear system :        133
no. restrictions :        133
no. nuisance p.  :          0

log-likelihood   :  -960.4148    linear system : -1111.0450

AIC criterion    :    23.3603    linear system :    23.6961
HQ  criterion    :    26.0847    linear system :    25.0583
SC  criterion    :    30.0836    linear system :    27.0578

LR linearity test:   301.2604    Chi(133) =[0.0000] **  Chi(133)=[0.0000] **
DAVIES=[0.0000] **

---------- regime shifts ---------------------------

regime variable indcpibig
                  nObs     Prob.
Regime 1          64.00    0.6095
Regime 2          41.00    0.3905

---------- regime classification -------------------

Regime 1
2002:3 - 2002:3 [1.0000]
2002:7 - 2002:7 [1.0000]
2002:9 - 2002:9 [1.0000]
2003:1 - 2003:1 [1.0000]
2003:4 - 2003:5 [1.0000]
2003:8 - 2003:8 [1.0000]
2003:11 - 2003:11 [1.0000]
2004:1 - 2004:6 [1.0000]
2004:8 - 2005:3 [1.0000]
2005:5 - 2007:7 [1.0000]
2007:10 - 2008:12 [1.0000]

Regime 2
2000:4 - 2002:2 [1.0000]
2002:4 - 2002:6 [1.0000]
2002:8 - 2002:8 [1.0000]
2002:10 - 2002:12 [1.0000]
2003:2 - 2003:3 [1.0000]
2003:6 - 2003:7 [1.0000]
2003:9 - 2003:10 [1.0000]
2003:12 - 2003:12 [1.0000]
2004:7 - 2004:7 [1.0000]
2005:4 - 2005:4 [1.0000]
2007:8 - 2007:9 [1.0000]
```

Figure 53 - TVAR model (magnitude of monthly inflation) - Prediction error and Standard resids

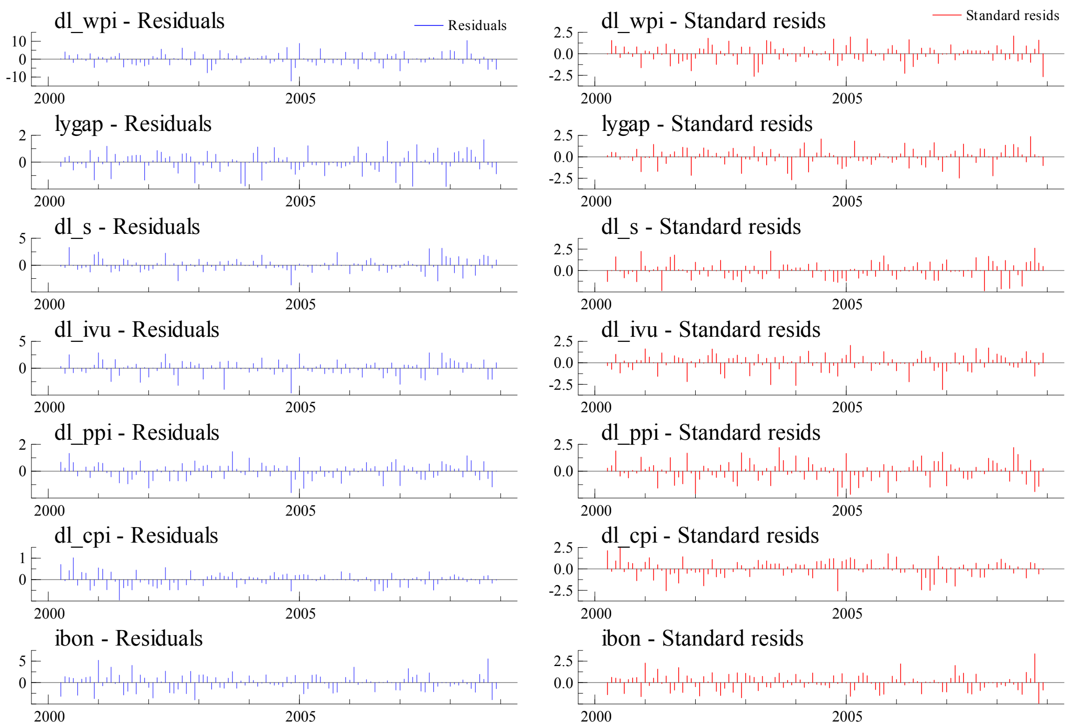


Figure 54 - TVAR model (magnitude of monthly inflation) - - Correlogram, Spectral density, Density and QQ Plot of standard resids

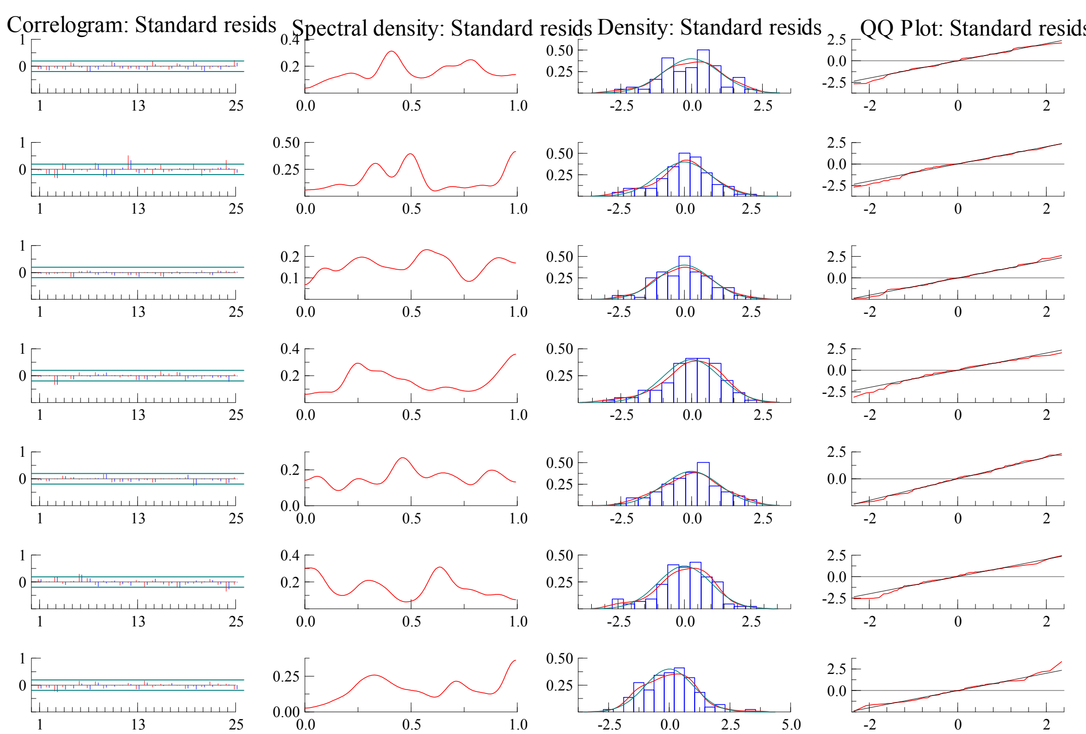
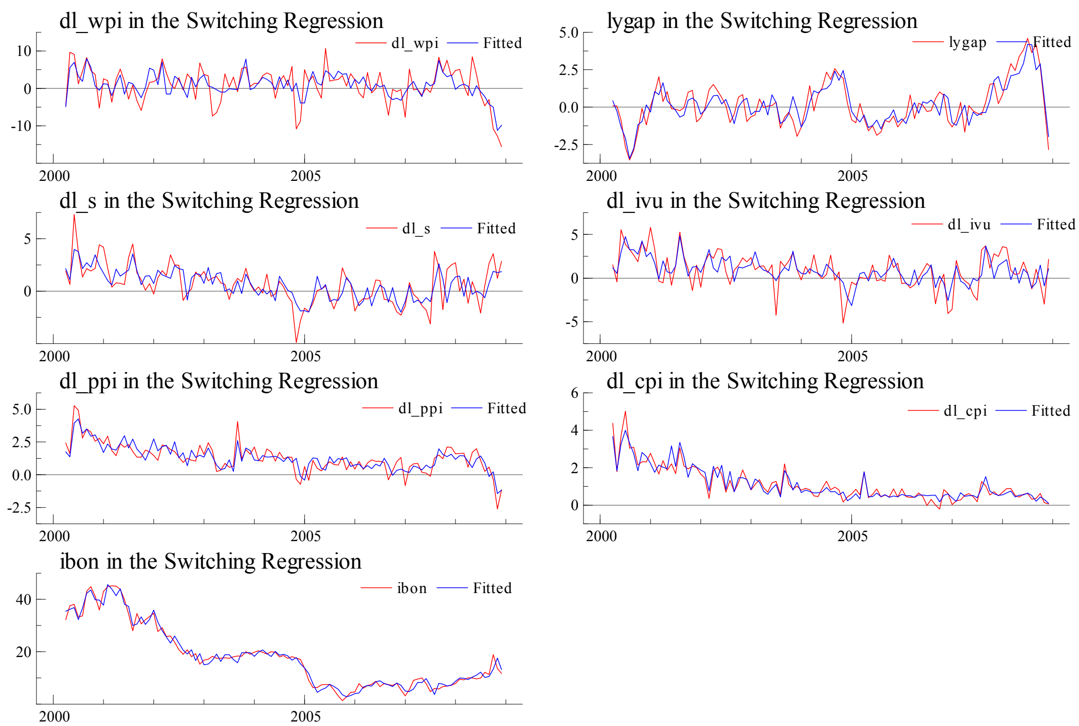


Figure 55 - TVAR model (magnitude of monthly inflation) - Actual and fitted values



Appendix 10 - SETAR - exchange rate - Ox output

```
Ox version 3.30 (Windows) (C) J.A. Doornik, 1994-2003
MSVAR (c) H-M Krolzig, 1996-2005, package version 1.32a, object created on 28-06-2004

---------- ML estimation results  -----------------

EQ( 1) SETAR model of (dl_wpi,lygap,dl_s,dl_ivu,dl_ppi,dl_cpi,ibon)
       Estimation sample: 2000 (4) - 2008 (12)
no. obs. per eq. :        105    in the system :        735
no. parameters   :        267    linear system :        133
no. restrictions :        133
no. nuisance p.  :          1

log-likelihood   :  -928.2021    linear system : -1111.0450
AIC criterion    :    22.7658    linear system :    23.6961
HQ  criterion    :    25.5004    linear system :    25.0583
SC  criterion    :    29.5144    linear system :    27.0578

LR linearity test:   365.6858    Chi(133) =[0.0000] **  Chi(134)=[0.0000] **
DAVIES=[0.0000] **

---------- regime shifts --------------------------
Threshold (dl_s):
      0.88957
                  nObs     Prob.
Regime 1          59.00    0.5619
Regime 2          46.00    0.4381
---------- regime classification -------------------
Regime 1
2000:5 - 2000:5 [1.0000]
2001:3 - 2001:6 [1.0000]
2001:11 - 2002:1 [1.0000]
2002:8 - 2002:10 [1.0000]
2003:5 - 2003:8 [1.0000]
2003:12 - 2004:3 [1.0000]
2004:5 - 2004:6 [1.0000]
2004:8 - 2005:9 [1.0000]
2005:12 - 2006:5 [1.0000]
2006:8 - 2007:7 [1.0000]
2007:10 - 2007:10 [1.0000]
2008:2 - 2008:2 [1.0000]
2008:4 - 2008:4 [1.0000]
2008:6 - 2008:8 [1.0000]

Regime 2
2000:4 - 2000:4 [1.0000]
2000:6 - 2001:2 [1.0000]
2001:7 - 2001:10 [1.0000]
2002:2 - 2002:7 [1.0000]
2002:11 - 2003:4 [1.0000]
2003:9 - 2003:11 [1.0000]
2004:4 - 2004:4 [1.0000]
2004:7 - 2004:7 [1.0000]
2005:10 - 2005:11 [1.0000]
2006:6 - 2006:7 [1.0000]
2007:8 - 2007:9 [1.0000]
2007:11 - 2008:1 [1.0000]
2008:3 - 2008:3 [1.0000]
2008:5 - 2008:5 [1.0000]
2008:9 - 2008:12 [1.0000]
```

Figure 56 - SETAR (exchange rate threshold variable) - Prediction error and Standard resids

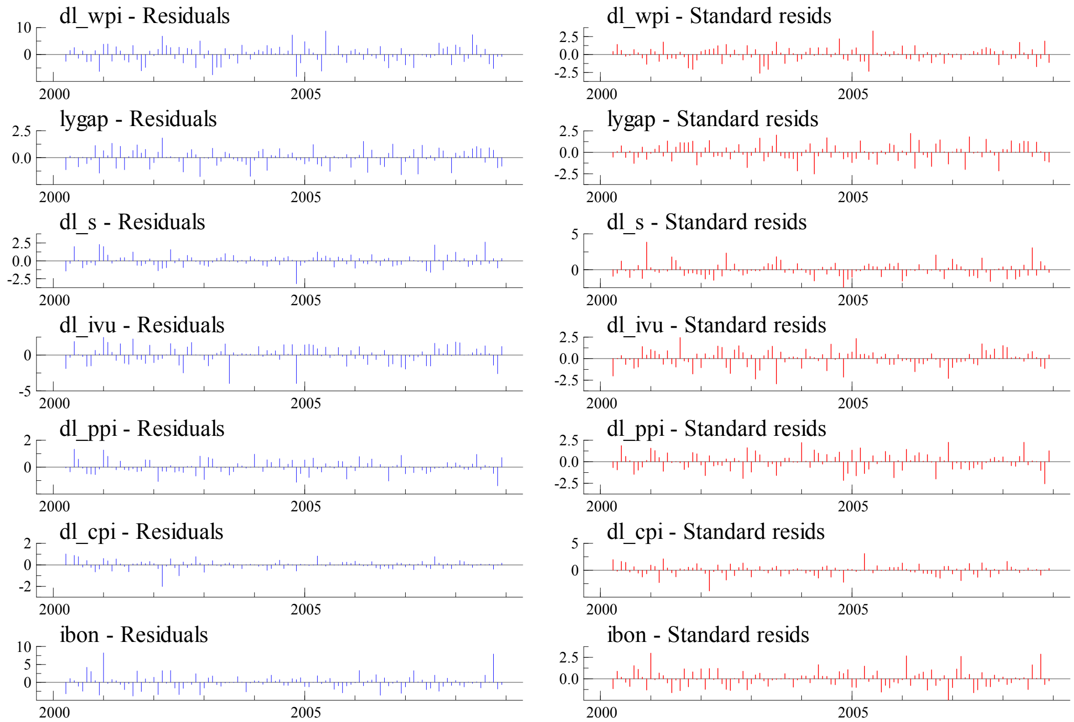


Figure 57 - SETAR (exchange rate threshold variable) - Correlogram, Spectral density, Density and QQ Plot of standard resids

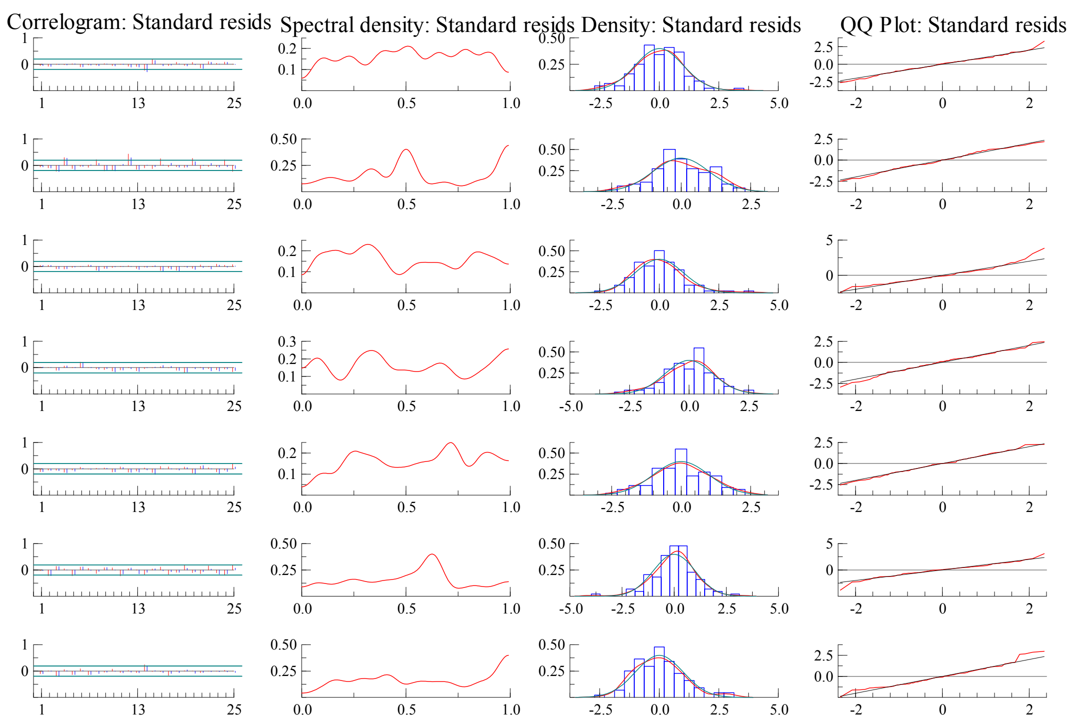
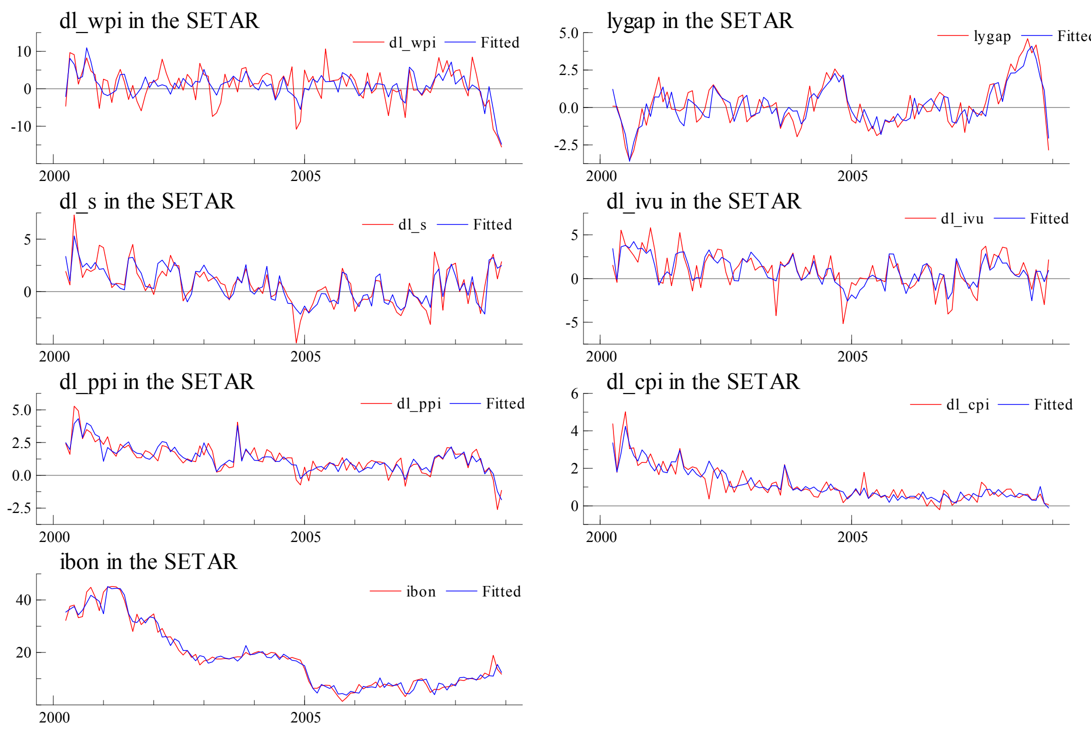


Figure 58 - SETAR (exchange rate threshold variable) - Actual and fitted values



Appendix 11 - SETAR - monthly inflation - Ox output

```
Ox version 3.30 (Windows) (C) J.A. Doornik, 1994-2003
MSVAR (c) H-M Krolzig, 1996-2005, package version 1.32a, object created on 28-06-2004


---------- ML estimation results  -----------------

EQ( 1) SETAR model of (dl_wpi,lygap,dl_s,dl_ivu,dl_ppi,dl_cpi,ibon)
       Estimation sample: 2000 (4) - 2008 (12)

no. obs. per eq. :        105    in the system :        735
no. parameters   :        267    linear system :        133
no. restrictions :        133
no. nuisance p.  :          1

log-likelihood   :  -959.2535    linear system : -1111.0450

AIC criterion    :    23.3572    linear system :    23.6961
HQ  criterion    :    26.0919    linear system :    25.0583
SC  criterion    :    30.1059    linear system :    27.0578

LR linearity test:   303.5830    Chi(133) =[0.0000] **  Chi(134)=[0.0000] **
DAVIES=[0.0000] **


---------- regime shifts --------------------------

Threshold (dl_cpi_1):
       1.6904

                  nObs     Prob.
Regime 1         80.00    0.7619
Regime 2         25.00    0.2381



---------- regime classification -------------------

Regime 1
2000:4 - 2000:4 [1.0000]
2001:4 - 2001:4 [1.0000]
2002:2 - 2002:4 [1.0000]
2002:7 - 2002:11 [1.0000]
2003:1 - 2003:9 [1.0000]
2003:11 - 2005:4 [1.0000]
2005:6 - 2008:12 [1.0000]

Regime 2
2000:5 - 2001:3 [1.0000]
2001:5 - 2002:1 [1.0000]
2002:5 - 2002:6 [1.0000]
2002:12 - 2002:12 [1.0000]
2003:10 - 2003:10 [1.0000]
2005:5 - 2005:5 [1.0000]
```

Figure 59 - SETAR (CPI threshold variable) - Prediction error and Standard resids

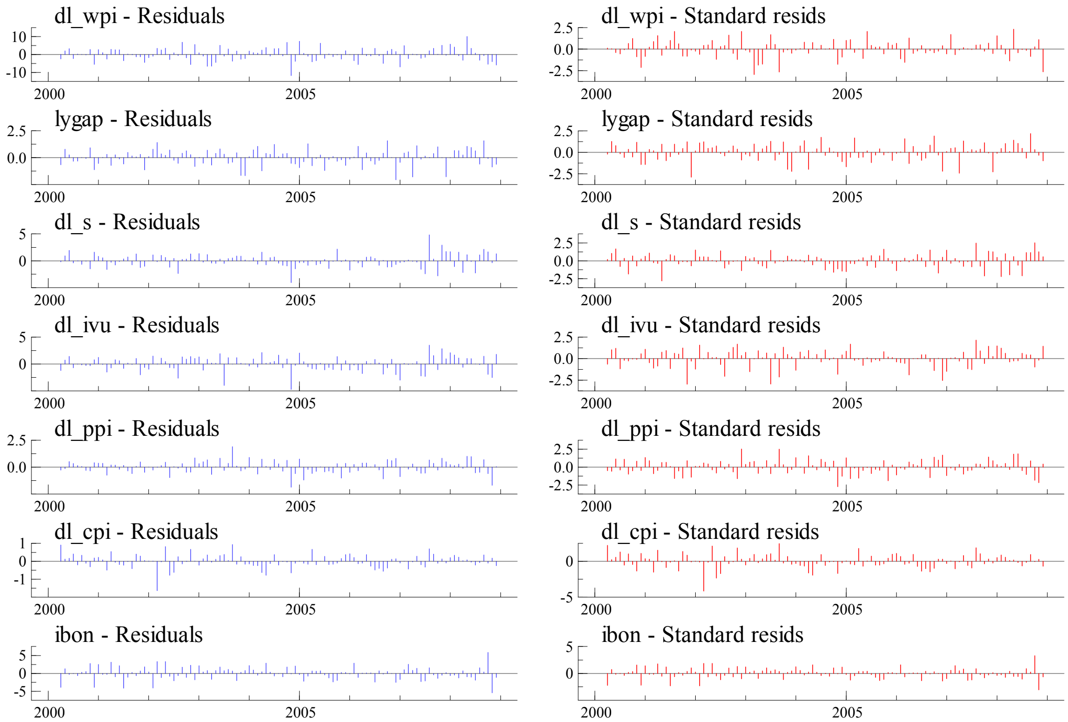


Figure 60 - SETAR (CPI threshold variable) - Correlogram, Spectral density, Density and QQ Plot of standard resids

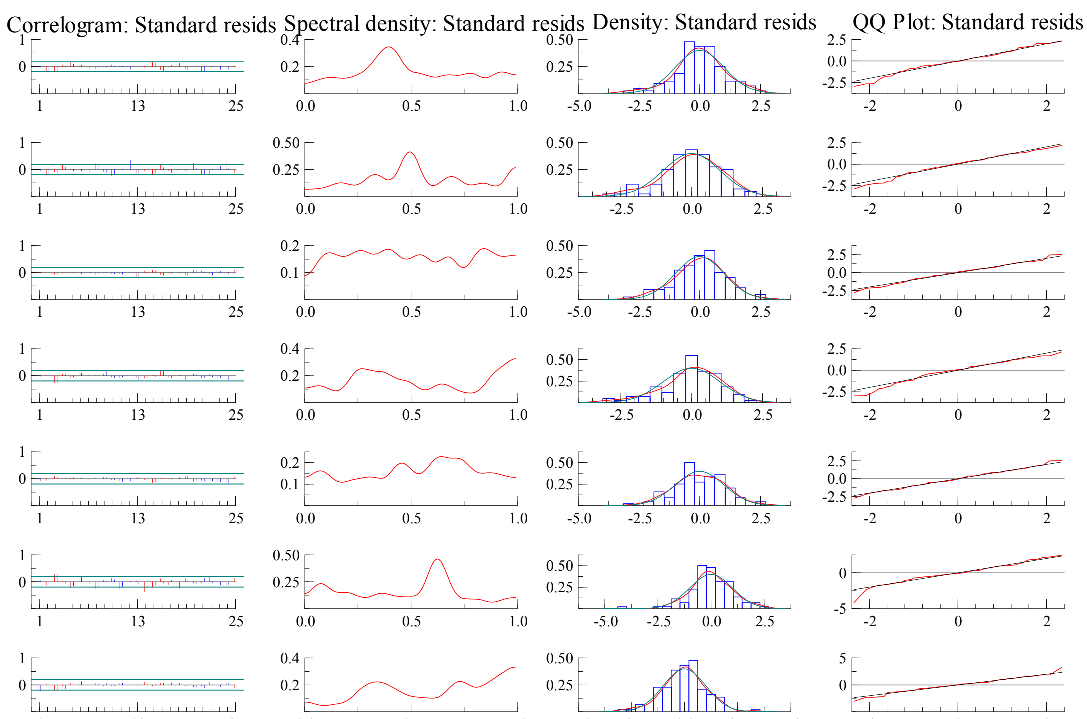


Figure 61 - SETAR (CPI threshold variable) - Actual and fitted values