Threshold Model of the Exchange Rate Pass through Effect: the Case of Croatia

Abstract:

In this paper the exchange rate pass-through effect in Croatia is estimated with the nonlinear (asymmetric) threshold model. In total, 13013 regressions are estimated and a strong case of nonlinearity with the single threshold is proven. According to our estimation there is a threshold at 5.91% of the monthly growth rate of the nominal exchange rate of the German mark (Euro) with a 95% interval between 2.69% and 21.81%. The way in which the nominal exchange rate affects inflation is asymmetric around the threshold. Below the threshold, an effect of change in the nominal exchange rate on inflation is weak or statistically insignificant and above the threshold the effect is strong and significant.

JEL classification code: E31; E58; F31

Key words: threshold regressive model, pass-through effect, exchange rate, inflation, nonlinear econometrics

For helpful comments we thank Walter Enders and Robert Sonora.

Introduction

The paper aims to introduce a nonlinear econometrics to the discussion on the one of the most popular issues of the macroeconomic policy design in Croatian economy. Threshold estimation is used to test exchange rate pass-through (ERPT) effect in Croatian economy. The strength of the impact of the exchange rate changes on the domestic prices (ERPT effect) has several important implications to thinking of the role of the exchange rate in macroeconomic policy design. According to the theory, if the degree of pass-through is high, the nominal exchange rate does not have much impact on the real exchange rate. On the other hand, if the degree of pass-through is low, the exchange rate changes will change the relative prices of tradables and non-tradables, so that the adjustment in trade balances will be relatively prompt. For example, after depreciation, imported goods become more expensive, if pass-through is low, so that expenditure switching from imports to domestic goods will occur and external balances will be corrected in several months (Ito and Sato 2006, p. 3).

Besides relative prices, an important aspect is the interaction between the exchange rate and domestic prices including both tradables and non-tradables. Suppose that a country is experiencing trade deficits and the exchange rate depreciates, then export competitiveness is strengthens, resulting in an improvement in the external balance. However, if domestic prices in general respond to the nominal exchange rate depreciation one-to-one—that is, pass-through not only to import prices but to the CPI in general—then any export competitiveness from nominal depreciation would be cancelled out with zero effect on trade balance. A combination of nominal depreciation and high inflation leaves the export competitiveness unchanged, while corporations and financial institutions that had net foreign-currency liabilities become burdened by larger real debts and nonperforming loans (Ito and Sato 2006, p. 4.).

In the first part of paper theoretical explanations of the exchange rate pass-through theory are briefly explained and several empirical studies of the theory are surveyed. In the second part of the paper data series used in this paper are analyzed. In the third part of paper, a methodology of estimation of the threshold regressive model is presented. In the last part, empirical findings together with limitations, implications and recommendations are presented.

The EPRT effect

A theoretical discussion on the exchange rate pass-through effect should start with the purchasing power parity (PPP) hypothesis. The PPP is the disarmingly simple empirical proposition which states that, once converted to a common currency, national price levels should be equal.[1] The basic idea is that if goods market arbitrage enforces broad parity in prices across a sufficient range of individual goods (the LOOP)[2], then there should also be a high correlation in aggregate price levels. When PPP holds, the real exchange rate is a constant so that movements in the real exchange rate represent deviations from PPP. "While few empirically literate economists take PPP seriously as a short-term proposition, most instinctively believe in some variant of purchasing power parity as an anchor for long-run real exchange rates. Warm, fuzzy feelings about PPP are not, of course, a substitute for hard evidence" (Rogoff 1996, p. 647).

The body of empirical evidence on the PPP assumption converged sufficiently to allow several conclusions to be drawn. Firstly, continuous PPP does not exist in the real world (Lothian and Taylor 1996). Secondly, during the float period after 1974, real exchange rates exhibited random walk behavior (Meese and Rogoff 1983). Third, long span and panel studies that have emerged as a consequence of the power problem manage to reject the null hypothesis of no cointegration for the PPP tests in the very long run or in panel studies (Sarno and Taylor 2002, pp. 62-68). Fourth, empirical tests in Croatia reached similar conclusions. In the short run, PPP does not hold (Pufnik 2002), while in the long run it is quite easy to prove mean reverting properties of the real exchange rate (Tica 2006).

The PPP puzzle remains unsolved. How it is possible to reconcile the enormous short-term real exchange rate volatility with the extremely slow rate at which shocks damp out (Rogoff 1996, p. 647)? Most explanations of short term exchange rate movements point to financial factors such as changes in portfolio preferences, short-term asset bubbles (portfolio balance models), and monetary shocks (monetary models) in the presence of sticky or flexible nominal wages and prices (Rogoff 1996, pp. 647; Sarno and Taylor 2002, pp. 99-110).

[1] "Absolute PPP" is in levels, while according to the "relative PPP" assumption, depreciation of one currency relative to another matches the difference in aggregate price inflation between two countries concerned (Sarno and Taylor 2002, pp. 51; Rogoff 1996, pp. 650).
[2] The low of one price (LOOP) postulates that the same good should have the same price across countries if prices are expressed in terms of the same currency.

Furthermore, equilibrium models and liquidity models explain movements as a permanent consequence of changes in technology and tastes (Sarno and Taylor 2002, pp. 110-123).[3]

The ERPT effect is closely connected with theories of real exchange rate determination (portfolio balance models, monetary models and general equilibrium models) and it might be perceived in two ways within the context of the PPP assumption. First, the low ERPT effect might explain the mechanisms that drive economies away from long run real exchange rate equilibriums, creating big and persistent deviations. Secondly, the low ERPT might justify active exchange rate policy in the economies with appreciated real exchange rate level and price or wage rigidities.

There are many theoretical explanations for the incomplete ERPT effect (Menon 1995). Dornbusch (1987) and Krugman (1987) justifies incomplete pass-through as arising from imperfect competition firms that operate in a market and adjust their mark-up in response to an exchange rate shock. They argue that *pricing to market*, due to imperfect competition is responsible for existence of price differences across countries where oligopolistic firms dominate the market.[4] Devereux and Yetman (2002, p. 348) argue that sticky prices play important role in cross-country variations in ERPT and that as a result, ERPT is endogenous to monetary policy regime. Burstein et al. (2003) emphasize the role of non-traded domestic inputs in the chain of distribution of tradable goods. Another line of reasoning stresses more the role that monetary and fiscal authorities play, by partly offsetting the impact of changes in the exchange rate on prices (Gagnon and Ihrig, 2004; Ito and Sato 2006). Devereux and Engel (2001) and Bacchetta and van Wincoop (2003) explore instead the role of local currency pricing in reducing the degree of ERPT.

There is a large number of studies on the ERPT effect conducted for the case of developed countries (e.g. Anderton 2003; Campa and Goldberg 2004; Campa et al. 2005; Gagnon and Ihrig 2004; Hahn 2003; Ihrig et al. 2006 and McCarthy 2000) and studies conducted for the case of developing countries (e.g. Ito and Sato 2006; Choudhri and Hakura 2006; Frankel et al. 2005; Coricelli, Jazbec and Masten 2004; and Mihaljek and Klau 2001).

---

[3] For the detailed classification of the models of the real exchange rate determination see Tica (2005).

[4] Dornbusch (1987) and Krugman (1987) ascribe pricing to market effect to price discrimination, while Kasa (1992) argued that the rationale underlying pricing to market is an adjustment cost framework, that is a model in which firms face similar menu costs or a model in which consumers face fixed costs when switching between different products.

Prevailing consensus is that movements in the exchange rate and prices do not go one to one in the short to medium run.

In Croatia, the ERPT effect has been a central question of almost all debates on the possible shifts in the macroeconomic policy design since stabilization. Almost all critiques of the post-stabilization macroeconomic policy emphasized growth oriented exchange rate policies and simply assumed or even ignored the strength of the ERPT effect in Croatia (Zdunic 2003; 2004a; 2004b; Nikic 2004; Zdunic and Grgic 1995; Grgic and Zdunic 1999). On the other hand, majority of advocates of the present economic policy simply assumed that the stability of the nominal exchange rate is a crucial factor for price stability in the short run (Babić 2006; Sonje 2000; Nestic 2000; Sonje and Vujcic 2000; Sonje and Skreb 1997; Anusic et. al. 1995).

Until now, several authors directly or indirectly researched the ERPT effect in Croatia. Billmeier and Bonato (2004) showed that the ERPT effect has been low during the post-stabilization period in Croatia. The short run VAR methodology did not result in a relationship between exchange rate and retail price index, while cointegration techniques resulted with a long run ERPT coefficient of roughly 0.3 for the retail price index.[5] Kraft (2003) and Gattin-Turkalj and Pufnik (2002) also estimated modest levels of ERPT effect in Croatia, using the modeling strategy of McCarthy (2000). Results indicate that exchange rate affects the retail price index less than the producer price index. Furthermore, according to the impulse response functions, responses of the CPI to the nominal exchange rates movements were minimal. Maodus (2006) shows that the ERPT effect in Croatia hardly exists, the estimated ERPT coefficient was 0.042 for the CPI. Botric and Cota (2006) used variance decomposition based on VAR model to explain only 6% of inflation variance with exchange rate movements, while Druzic, Tica, Mamic 2006 estimated quite strong ERPT effect in average during 1962-2004.

With exception of Botric and Cota (2006) and Druzic, Tica and Mamic (2006), **all authors highlight possible regime switch threshold**, asymmetric adjustment and endogenity of the ERPT effect as a function of the monetary policy. Billmeier and Bonato (2004)

---

[5] Obviously answer to the question weather VAR or cointegration results are closer to the genuine data generating process is function of the number of cointegrating vectors. If there is a strong cointegration in levels than cointegration results might be taken as more reliable, and vice versa.

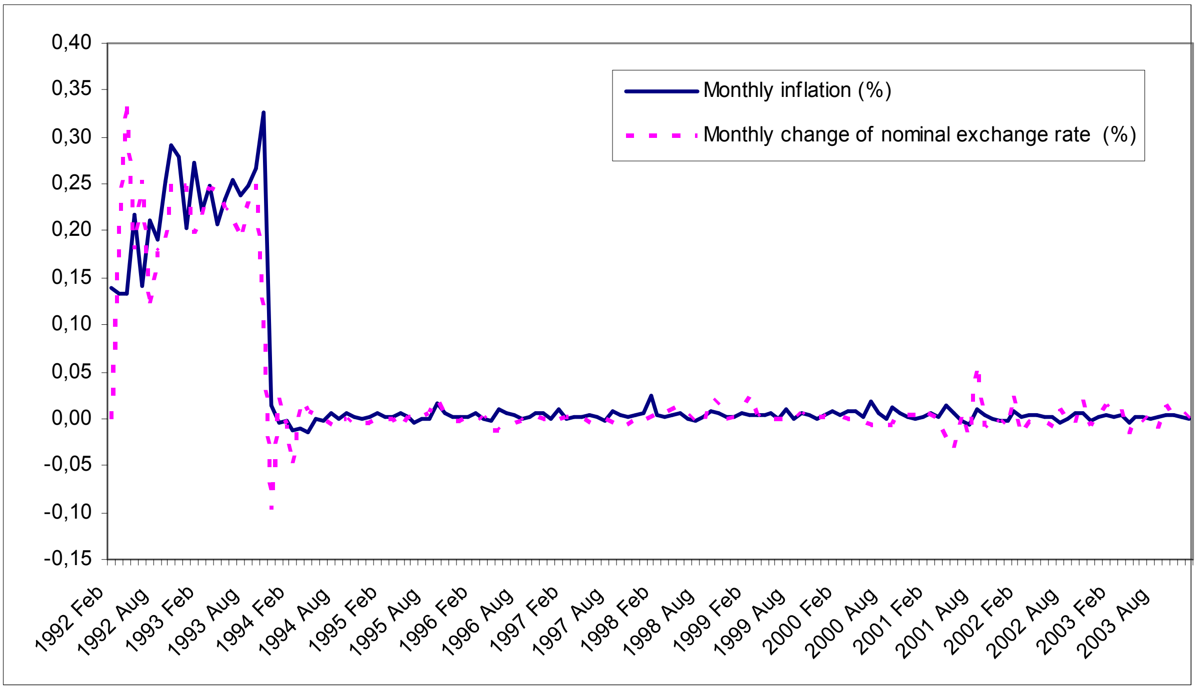
highlighted the fact that policy implications are unclear due to the endogenity of the ERPT effect in regard to the policy regime. Kraft (2003), as well as Maodus (2006) concluded that it is possible that there is some thresholds, due to menu costs, below which agents do not find it worthwhile to alter prices; or asymmetries in which agents react differently to appreciation and depreciation. Beside these purely theoretical considerations, there have not been any empirical tests of possible nonlinearities, thresholds and asymmetries in the surveyed literature on Croatia.

Data description

In this paper data series for the monthly retail price index and the monthly (end of the period) exchange rate of the German mark is used in order to estimate the ERPT effect in Croatia. All data are log differenced and the exchange rate is defined in such a way that a positive growth rate represents depreciation and *vice versa*. Authors do not have intent to claim that the nominal exchange rate is the only explanatory variable of the inflation in Croatia. The threshold (TAR) model of the ERPT effect in Croatia simply explores the possibility of threshold in a single relationship between the two variables.

Due to several reasons the data series span between February 1992 and December 2003. In January 1992, Croatia became an independent country so it seems reasonable to start at that point. Furthermore, the 323% devaluation in January 1992 is a big outlier in the data set, so the first observation is simply ignored in further analysis. The explanation for such an early end of the time series is the fact that the retail price index was replaced by the consumer price index in December 2003. Therefore, in order to avoid data problems, only the period covered with the RPI is covered in the research.

Figure 1: Monthly inflation and end of period monthly nominal exchange rate of German mark (dlogs, positive growth rate=depreciation)



Source: CNB 2007

Methodology

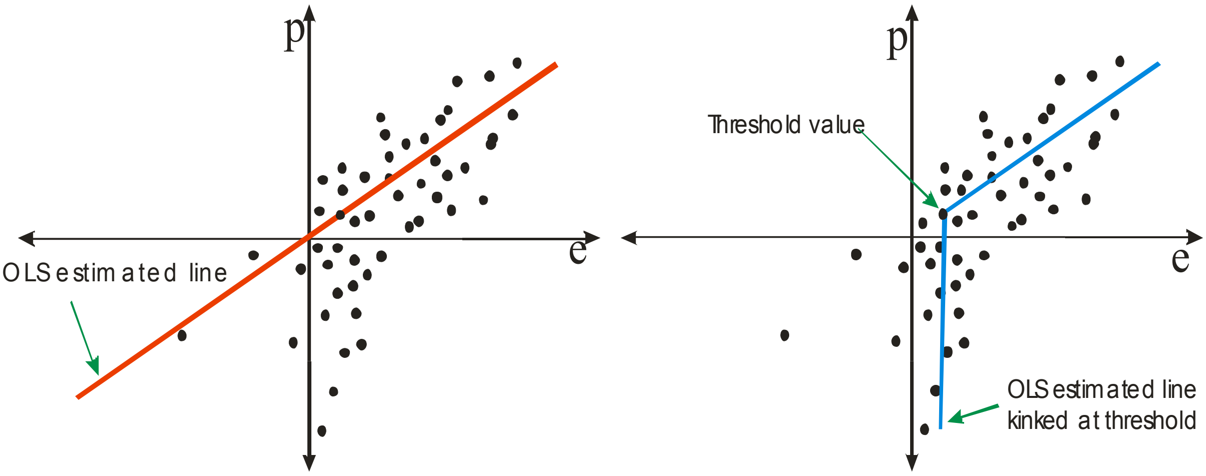
This paper uses a nonlinear econometric approach in modeling possible explanation for the low ERPT effect in a highly dollarized economy such as Croatia. Having in mind speculation about existence of a potential threshold in theoretical and in empirical papers[6] the mainstream VAR methodology (McCarthy 2000; Billmeier and Bonato 2004; Kraft 2003 and Maodus 2006) is replaced with threshold approach.

It is a well known fact that during the pre stabilization period, domestic prices in general have strongly responded to the nominal exchange rate depreciation (Anusic et. al. 1995; Sonje and Skreb 1997; Druzic, Tica, Mamic 2006) and that after the successful stabilization process, the nominal exchange rate moved between -9 and 6% monthly without a strong and obvious effect on inflation. The behavior between inflation and the nominal exchange rate implies that there might be a level of devaluation that acts as a threshold between two regimes of the ERPT effect in Croatia. According to the theoretical model,

[6] See Taylor 2000; Carranza et. al. 2004; Campa and Goldberg 2004; Kraft 2002 and Maodus 2006 for speculations about potential threshold.

below a hypothetical threshold the nominal exchange rate affect prices differently (less strong or/and significant) than above the threshold (Figure 2).

Figure 2: Graphical comparison of OLS and Threshold model



Source: Enders 2004, p. 389.

Such a regime switching model might be estimated with the simple OLS threshold regressive model (Enders 2004, pp. 396):

$$\begin{aligned} \pi_t &= I_{t-d}\left[\alpha_1 + \sum_{i=0}^{k} \beta_{1i}\Delta e_{t-i}\right] + (1 - I_{t-d})\left[\alpha_2 + \sum_{i=0}^{k} \beta_{2i}\Delta e_{t-i}\right] + \varepsilon_t \\ I_{t-d} &= 1 \; if \;\; \Delta e_{t-d} \geq \tau \\ I_{t-d} &= 0 \; if \;\; \Delta e_{t-d} < \tau \end{aligned} \tag{1}$$

According to equation 1, inflation π is a function of nominal exchange rate growth e. Time lag of independent variable are represented by i, and delay parameter of threshold variable are represented by d. Variable I_{t-d} is a dummy variable, $I_{t-d}=1$ if growth of nominal exchange rate e_{t-d} is equal or larger than a threshold τ and $I_{t-d}=0$ if growth of nominal exchange rate e_{t-d} is smaller than a threshold τ. Having in mind that we are working with monthly data maximum size of delay parameter and lag length is set to twelve $k=0...12$, $d=0...k$.

Obviously in order to estimate the model it is necessary to estimate a threshold value. Enders (2004, p. 413.) and Chan (1993) offer quite intuitive three step methodology for threshold selection process:

1. First step is to sort the threshold variable from lowest to the highest value. In our sample threshold variable is the growth rate of the nominal exchange rate of the German mark.

2. Second step is to estimate a TAR model in the form of equation 1 using successive values of the growth rate of the nominal exchange rate as thresholds. After estimation Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC) data[7] are saved for every observation (threshold) of the nominal exchange rate. Only middle 80% of sorted thresholds (observations) are used and for AIC and SBC estimates the number of observations (T) is kept constant in all regressions.

3. Third step is to create a graph of successive values of sum of squared residuals. If there is a single threshold, there should be a single trough in the graph. If there are several thresholds, there should be several troughs in the graph. With respect to model selection criteria, the model with lowest sum of square residuals, AIC or SBC is the model that represents the nonlinear data generating process most accurately.

It should be noted here that the sole assumption of a threshold makes a residual unit root test or a cointegration tests between two variables questionable. If there is a threshold, variables are not cointegrated and also their stationarity can be proven below or/and above the threshold, but not with a linear unit root test. For example in our case, if there is a threshold that divides Croatian economy into two regimes, inflation and growth rates of the nominal exchange rate are going to be cointegrated above the threshold (large growth rates of the nominal exchange rate) and residuals of the regression will have stochastic trend below the threshold. Combined in a single regression, residuals power to reject the null hypothesis of unit root will depend on the number of observations above and below of the threshold (Enders 2004, pp. 429-433.).

---

[7] Actually in the original three step methodology Enders (2004, pp. 413) suggests sum of square residuals, but in the case where optimal values of i depend on delay parameter d, AIC and SBC are recommended. SSR permanently decreases with more lag length, while AIC and SBC punish lag introduction (Enders 2004, pp. 399).

Empirical results

Equation 1 is estimated for all successive values of thresholds with both an independent variable lag length *i* and a threshold delay parameter *d* going from 0 to 12. In total, 91 TAR models combining various lag length *i* and delay parameters *d* have been estimated for each of successive values of 143 thresholds. In total, according to our methodology, 13013 regressions have been estimated.

Table 1 and Table 2 show the results for the minimum AIC and SBC values.[8] For each combination of lag length *i* and threshold delay parameter *d*, only the AIC and SBC value for the regression with minimum AIC and SBC is represented in the tables. Due to the amount of the estimated data (13013 thresholds, AICs and SBCs), remaining AIC and SBC values for each *i* and *d* combination are omitted.

[8] Following equation are used in mathlab for the estimation of the model selection criteria: AIC=Tln(SSR)+2n and SBC=Tln(SSR)=nln(T), *n* in number of parameters and *T* is number of usable observations.

Table 1: The minimum AIC is for each combination of *i* lags and *d* delay parametars.

i\d	0	1	2	3	4	5	6	7	8	9	10	11	12
0	903,54	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1	847,37	842,83	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	839,13	837,62	843,92	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	793,76	794,02	826,91	820,43	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	733,51	733,51	771,13	804,00	775,74	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	719,08	686,46	740,05	797,07	757,65	764,83	0,00	0,00	0,00	0,00	0,00	0,00	0,00
6	690,66	680,25	736,32	780,85	734,67	762,50	656,81	0,00	0,00	0,00	0,00	0,00	0,00
7	617,36	648,17	728,20	773,06	722,47	733,01	631,11	732,97	0,00	0,00	0,00	0,00	0,00
8	499,80	624,30	624,65	740,37	635,94	660,44	595,80	685,52	760,36	0,00	0,00	0,00	0,00
9	467,43	469,80	600,34	707,23	625,27	627,59	585,21	601,13	709,98	707,00	0,00	0,00	0,00
10	463,17	**459,50**	459,77	526,48	561,52	556,56	572,05	536,76	594,96	628,29	639,35	0,00	0,00
11	466,91	462,35	461,94	462,03	558,17	556,54	554,62	540,07	546,07	568,74	616,25	561,50	0,00
12	466,40	466,28	466,42	463,26	464,85	466,45	532,29	537,06	525,67	521,82	515,15	627,91	606,24

Table 2: The minimum SBC for each combination of *i* lags and *d* delay parametars.

i\d	0	1	2	3	4	5	6	7	8	9	10	11	12
0	915,04	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1	864,62	860,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	862,13	860,62	866,92	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	822,52	822,77	855,67	849,18	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	768,01	768,01	805,63	838,50	810,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	759,33	726,71	780,31	837,32	797,90	805,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00
6	736,66	726,26	782,32	826,86	780,67	808,50	702,81	0,00	0,00	0,00	0,00	0,00	0,00
7	669,12	699,92	779,96	824,81	774,22	784,77	682,86	784,73	0,00	0,00	0,00	0,00	0,00
8	557,30	681,80	682,15	797,87	693,45	717,94	653,31	743,02	817,86	0,00	0,00	0,00	0,00
9	530,68	533,05	663,60	770,49	688,52	690,84	648,46	664,38	773,23	770,26	0,00	0,00	0,00
10	532,17	**528,51**	528,78	595,49	630,52	625,57	641,05	605,77	663,97	697,29	708,36	0,00	0,00
11	541,67	537,10	536,70	536,78	632,92	631,29	629,37	614,82	620,82	643,50	691,01	636,25	0,00
12	546,90	546,79	546,93	543,77	545,36	546,95	612,80	617,57	606,18	602,33	595,65	708,41	686,75

Table 3 represents the threshold values for the regressions with the smallest values of AIC and SBC presented in Table 1 and Table 2 respectively. As in the previous case, for each value of *i* and *d* only the threshold values for the regression with the smallest AIC and SBC statistics are reported, while other values are omitted.

Table 3: Thresholds for the regression model with smallest SSR, AIC and SBC for each combination of *i* lags and *d* delay parametars.

i\d	0	1	2	3	4	5	6	7	8	9	10	11	12
0	11,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1	11,13	19,63	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	11,13	19,63	12,41	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	12,41	19,68	25,77	12,41	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	11,13	12,41	25,77	12,41	24,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	11,13	26,99	25,77	12,41	24,06	24,96	0,00	0,00	0,00	0,00	0,00	0,00	0,00
6	11,13	20,00	25,77	19,63	24,06	24,96	26,99	0,00	0,00	0,00	0,00	0,00	0,00
7	11,13	21,82	24,06	20,00	24,06	24,96	24,06	24,96	0,00	0,00	0,00	0,00	0,00
8	11,13	21,82	21,82	21,82	24,05	24,06	24,06	24,96	24,05	0,00	0,00	0,00	0,00
9	5,91	21,04	21,82	21,82	21,82	24,05	24,05	24,06	24,06	24,05	0,00	0,00	0,00
10	5,91	**5,91***	21,04	21,04	21,04	21,04	21,82	21,04	24,05	21,82	24,05	0,00	0,00
11	2,44	2,69	5,91	11,13	21,04	21,04	21,04	21,04	21,04	21,82	24,05	21,82	0,00
12	2,23	2,27	2,44	**2,69****	5,91	11,13	21,04	21,04	21,04	21,04	21,04	24,05	24,05

Note: * represents threshold selected by minimum SBC and AIC; ** represents threshold selected by SSR.

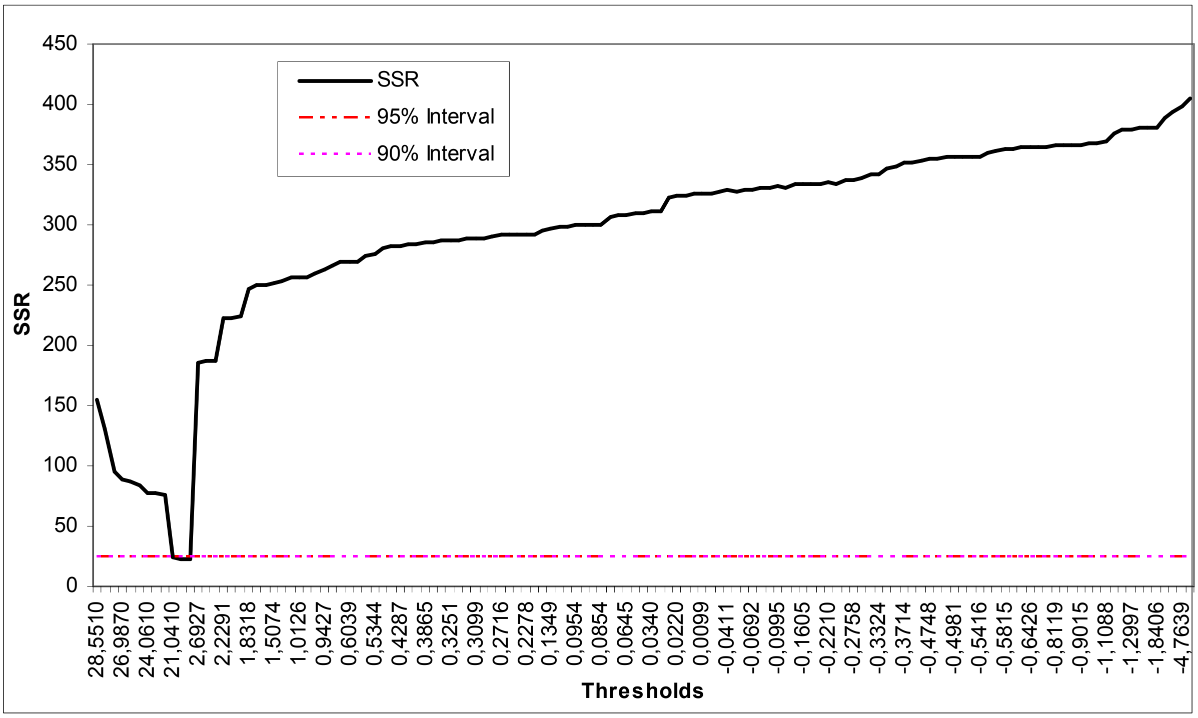
AIC and SBC have indicated regression estimate for the ***i*=10, *d*=1, τ =5.91** as the model with the best fit. Next step is to check for the possibility of the multiple thresholds. According to theory, if there are several thresholds, SSR will have several minima (Enders 2004, pp. 413 and Chan 1993). Nevertheless, Figure 3 quite clearly shows that there is only **one trough** in the data, strongly indicating **presence of nonlinearity with a single threshold**.

Furthermore, Hansen developed methodology for confidence interval testing in threshold estimate (1996, pp. 11, 14). According to him, one of the possible graphical methods to find the region of the critical interval is to plot SSR against threshold τ values and draw a flat line at $SSR\tau + \hat{\sigma}^2 c_\xi(\beta)$. Where $SSR\tau$ is the SSR for a threshold τ of the regression that has minimum SSR statistics, for a given *i* and *d* (We are using the model with i=10 and d=1 that is selected by AIC and SBC). In the leading case of conditional homoskedasticity, $\hat{\sigma}^2$ is given with relationship $E\left[\varepsilon_t^2 \mid e_t\right]$, where ε_t^2 is squared residual, and e_t is threshold variable (the log-differenced nominal exchange rate). The variable $c_\xi(\beta)$ represents critical value for the confidence level of β (Table for critical values is given by Hansen 1996, p. 9).

In the Figure 3, horizontal axis represents all possible thresholds and vertical axis represents sum of square residual (SSR) for each threshold. It should be highlighted here that horizontal axis has only observations that actually occurred during the analyzed period. The 95% and 90% critical value calculated according to Hansen's (1996) methodology are plotted as dotted lines. Unfortunately, their values are to close to tell, 95% confidence interval is 24.45 and 90% confidence interval is 24.18, while SSR for the threshold 5.91 is 23.13 (Figure 3 and Table 5).

The 95% confidence interval crossed the $SSR\tau$ line between 2.69 and 5.91 on the left side and between 21.04 and 21.81 on the right side $\hat{\Gamma}^*$=(2.69, 21.81). The 90% confidence interval crossed the $SSR\tau$ line between 2.69 and 5.91 on the left side and between 11.13 and 21.04 on the right side $\hat{\Gamma}^*$=(2.69, 21.04) (Figure 3 and Table 5). Only three observations are within the 95% confidence interval (5.91, 11.13 and 21.04) and only two observations are within the 90% confidence interval (5.91, 11.13). Therefore, the interval bands are not wide, quite contrary there are only three possible thresholds within the asymptotic 95% confidence interval and only two within the asymptotic 90% confidence interval. Obviously, total of six regime shifts throughout analyzed period can offer strong evidence of threshold that is larger than zero (Figure 3 and Table 5).

Figure 3: SSR, thresholds and 95% confidence interval for the model indicated by AIC and SBC (*i*=10, *d*=1)



These results show that there is reasonable evidence for a two-regime specification, but there is considerable uncertainty about the value of the threshold. In other words, threshold definitely exists within the interval, but it is highly uncertain where exactly. On the other hand, it is 95% certain that the threshold is above the growth rate of nominal exchange rate of 2.69 (and below 21.81). Translated into economic policy the confidence band that is between 2.69 and 21.81 (or 21.04 for 90% interval) is quite big, but still useful.

In regard to the problems with causality, it is possible to claim that in the period of high inflation causality goes from prices to exchange rate (competitiveness issues). Nevertheless, such a statement does not undermine our conclusion. It only means that process is nonlinear in the context of causality also. In that case, during the low inflation, causality is from the exchange rate to prices and the ERPT effect is low and/or not significant. On the other hand, during high inflation period, causality reverses and connection between the variables is significant and strong.

After the existence of nonlinearity with single threshold has been proven and intervals estimated, the TAR model with minimum AIC and SBC was re-estimated. As tables clearly indicate the regression model with dependent variable lag length *i*=10, delay parameter *d*=1 and threshold τ =5.91 resulted with the smallest AIC and SBC compared to 13012 estimated regression models.

Table 4 presents the regression estimate for the *i*=10, *d*=1, τ =5.91 model. It is more than obvious that all coefficients multiplied with I_{t-1} are statistically significant, while only three coefficients multiplied with 1- I_{t-1} are statistically significant at 5%. In other words, the lagged values of the nominal exchange rate significantly and strongly affect inflation in period *t* if nominal depreciation in the period *t-1* is equal or larger than 5.91% per month (with 95% critical value threshold interval between 2.69% and 21.81%). If the growth rate of the nominal exchange rate is lower, the effect of the nominal exchange rate on inflation almost does not exist. Only three coefficients are significant (*i*=1, 6 and 8) and all of them are rather small (0.03-0.07).

Table 4: E-views output for the model *d*=1, *i*=10

Dependent Variable: P				
Method: Least Squares				
Date: 10/22/07 Time: 12:51				
Sample: 1992M12 2003M10				
Included observations: **131**				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
A	-95.70820	3.505537	-27.30201	0.0000
E00A	-2.774725	0.119023	-23.31253	0.0000
E01A	9.625794	0.335530	28.68834	0.0000
E02A	-8.540003	0.317735	-26.87777	0.0000
E03A	10.11078	0.412720	24.49793	0.0000
E04A	-8.526058	0.352641	-24.17770	0.0000
E05A	8.923482	0.368490	24.21636	0.0000
E06A	-3.416781	0.146601	-23.30671	0.0000
E07A	-4.208781	0.192368	-21.87881	0.0000
E08A	6.226217	0.246164	25.29294	0.0000
E09A	-2.099821	0.095627	-21.95836	0.0000
E10A	-0.512022	0.040502	-12.64189	0.0000
B	0.318164	0.044428	7.161397	0.0000
E00B	0.069531	0.041412	1.678981	0.0961
E01B	-0.024167	0.044824	-0.539155	0.5909
E02B	-0.010156	0.028938	-0.350963	0.7263
E03B	0.004367	0.022654	0.192784	0.8475
E04B	0.007420	0.021681	0.342253	0.7328
E05B	0.026288	0.020711	1.269315	0.2071
E06B	-0.041530	0.020723	-2.004083	0.0476
E07B	0.000115	0.021098	0.005454	0.9957
E08B	-0.034926	0.019747	-1.768721	0.0798
E09B	0.012722	0.019589	0.649454	0.5174
E10B	-0.010605	0.014430	-0.734935	0.4640
R-squared	0.997124	Mean dependent var		2.611450
Adjusted R-squared	0.996506	S.D. dependent var		7.866283
S.E. of regression	0.464961	Akaike info criterion		**1.470317***
Sum squared resid	**23.13220**	Schwarz criterion		**1.997071***
Log likelihood	-72.30580	Durbin-Watson stat		1.901801

Note: In E-views, AIC and SC are calculated according to following equations: AIC=-2(l/T)+2(n/T) and SC is calculated as SC=-2(l/T)+nlog(T)/T Variable *l* is the value of the log of the likelihood function with the *n* parameters estimated using T observations. Following equation are used in Matlab for the estimation of the model selection criteria: AIC=Tln(SSR)+2n and SBC=Tln(SSR)=nln(T).
In the table variable *E00* represents $E_{t=0}$, *E01* represents $E_{t=1}$, etc. *A* represents I_{t-1} and *B* represents $1-I_{t-1}$.

The White heteroskedasticity test of the residuals has resulted with TR^2 statistics equal to 7.34. Having in mind that critical value for 24 degrees of freedom is 36.415, it is obvious that the null hypothesis that all coefficients are jointly equal to zero (no ARCH errors) can not be rejected. In other words proof of homoskedasticity in the residuals confirms even further our findings related with threshold interval.

Conclusion

Translated to the level of macroeconomic policy design findings of this research can be summed in a single sentence. In order to keep inflationary expectations and prices low and stable, monetary authorities should avoid depreciation/devaluation rate that are larger than

2.69% monthly (estimated threshold is 5.91%, but the lower boundary of 95% critical value interval is 2.69% depreciation/devaluation rate).

Although mathematical techniques cannot replace economic reasoning and intuition, the results are consistent with the **intuitive** expectations and theoretical speculations of the authors that have already researched the ERPT effect in Croatia (Billmeier and Bonato 2004, Kraft 2003 and Maodus 2006).

Economic reasoning behind the threshold and threshold variable is quite clear. If we assume that movements of the nominal exchange rate represent inflationary anchor, the selected econometric model suggests that monetary authorities in Croatia must keep the nominal exchange rate growth rates below threshold value in order to keep inflationary expectation in check.

The fact that the model has been estimated on historical data series which ends in December 2003 should also be addressed. As already explained we have used the retail price indices (RPI) and the nominal exchange rate of the German Mark in order to estimate our model and neither the RPI index nor the German currency exists any more. Basically, we have faced the trade off between fusing the RPI and the CPI in a single index in order to estimate the model with Euros vs. estimating our model with the official data series.

In terms of policy relevance we do not see any difference between these two approaches. If it is acceptable to combine RPI/CPI indices for the 1992:1 and 2007:12 period in a single index, our results will be considered as useful for economic policy. On the other hand, if it is not acceptable to combine indices, our results are exercises in economic history (although quite recent economic history!). We leave this conclusion for the readers of the paper to reach.

There are several limitations to this research. At this point in time only 13013 regression forms have been estimated. The true generating process for the relationship between inflation and prices is obviously nonlinear, but it is still questionable does the equation presented in this paper represent the genuine data generating process for the pass-through effect in Croatia. Interval estimation technique, asymmetric number of lags in the regression, autoregressive terms, a moving average threshold or an intercept uninfluenced by threshold might improve the performance of the model. Another significant limitation is the difficult task of identifying the right form of the nonlinearity. In this research, we have simply assumed that pass-through process is a threshold process, although it is possible that other forms of nonlinearity might perform much better.

Translated to the recommendation for future work, there are at least two ways in which future applied nonlinear econometric research on the pass-through effect should proceed. This paper explores only limited number of regressions and only one form of nonlinear process. Estimation of other regression forms and alternative nonlinear models will definitively improve our understanding of the pass-through effect in Croatia.

References

Anderton, R., 2003. "Extra-Euro Area Manufacturing Import Prices and Exchange Rate Pass-Through", *ECB Working Paper No. 219*.

Anusic, Z. et. al., 1995.: *A Road to Low Inflation, The Government of the Republic of Croatia*; Zagreb.

Babic, M., 2006. *Od dezinflacije u zaduzenosti hrvatska privreda 1994-2004;* Binoza Press.

Bacchetta, P. and van Wincoop, E., 2003. "Why do Consumer Prices React Less than Import Prices to Exchange Rates?", *Journal of European Economic Association*, 1, 662-670.

Billmeier, A., Bonato, L., 2004. “Exchange Rate Pass-Through and Monetary Policy in Croatia”, *Journal of Comparative Economics*; Vol. 32, Issue 3, pp. 426-444. also published in **Billmeier, A., Bonato, L., 2002.** “Exchange Rate Pass-Through and Monetary Policy in Croatia”, *IMF Working Paper No. 109.*

Botric, V.; Cota, B., 2006. "Sources of Inflation in Transition Economy: The Case of Croatia", *Ekonomski pregled*, Vol. 57, No.12, pp. 835-55.

Burstein, A., Neves, J. and Rebelo, S., 2003. "Distribution Costs and Real Exchange Rate Dynamics During Exchange-Rate-Based-Stabilizations", *Journal of Monetary Economics*, 50, 1189-1214.

Campa, J. and Goldberg, L., 2004. "Exchange Rate Pass-Through into Import Prices", *CEPR Discussion Paper No. 4391.*

Campa, J., Goldberg, L. and González-Mínguez, J., 2005. "Exchange Rate Pass-Through to Import Prices in the Euro Area", *Federal Reserve Bank of New York Staff Paper No. 219.*

Carranza, L., Galdon-Sanchez, J. and Biscarri, J., (2004). “Exchange Rate and Inflation Dynamics in Dollarized Economies”, *Faculty Working Papers from School of Economics and Business Administration*, University of Navarra, Working Paper No.10/04, May 2004

Chan, K. S., 1993. "Consistency and Limiting Distribution of the Least Squares Estimator of a Threshold Autoregressive Model", *The Annals of Statistics*, 21, 520-33.

Choudhri, E. and Hakura, D., 2006. "Exchange Rate Pass-Through to Domestic Prices: Does the Inflationary Environment Matter?", *Journal of International Money and Finance*, 25, 614-639.

CNB 2007. *Statistički pokazatelji*, Croatian National Bank. Available from: (http://www.hnb.hr/statistika/hstatistika.htm?tsfsg=f77d02b773916768a6208a85ae007a93)

Coricelli, F., Jazbec, B. and Masten, I., 2004. "Exchange Rate Policy and Inflation in Acceding Countries: The Role of Pass-through", *William Davidson Institute Working Papers Series 2004-674.*

Devereux, M. and Engel, C., 2001. "Endogenous Currency of Price Setting in a Dynamic Open Economy Model", *NBER Working Paper No. 8559.*

Devereux, M. and Yetman, J. 2002. "Price-Setting and Exchange rate Pass-through: Theory and Evidence, Price Adjustment and Monetary Policy Conference, Central bank of Canada, Available from: http://currencymuseum.ca/en/conference/2002/Devereux_Yetman-v3.pdf

Dornbusch, R., 1987. "Exchange Rates and Prices", *American Economic Review*, 77, 93-106.

Druzic, I., Tica, J. and Mamic, A. (2006). "The Challenge of Application of Phillips Curve: Case of Croatia", *ZIREB*, Special Conference Issue, December 2006, pp. 45-59.

Enders, A., 2004. Applied Econometric Time Series, Hoboken: John Wiley and Sons, 2nd edition.

Enders, W., Falk, B. L. and Siklos, P., 2007. "A Threshold Model of Real U.S. GDP and the Problem of Constructing Confidence Intervals in TAR Models" Studies in Nonlinear Dynamics & Econometrics, Volume 11, Issue 3.

Engle, Robert F. 1982. "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdome Inflation" *Econometrica*, 50, 166-76.

Frankel, J., Parsley, D. and Wei, S., 2005. "Slow Pass-Through Around the World: A New Import for Developing Countries", *NBER Working Paper No. 11199.*

Gagnon, J. and Ihrig, J., 2004. "Monetary Policy and Exchange Rate Pass-Through", *International Journal of Finance and Economics*, 9, 315-338.

Gattin-Turkalj, K., and Pufnik, A. (2002). "Koeficijent prijenosa tečaja na cijene", *Discussion paper*, Croatinal National Bank, mimeo.

Grgic, M. and Zdunic, S., 1999. "Exchange Rate and Protection Policy in Croatian Development Strategy", *Zagreb International Review of Economics and Business*, Zagreb, vol. 2, issue 1, pp. 83-98.

Hansen, B. E., 1996. "Sample Splitting and Threshold Estimation", Boston College Working Papers in Economics with number 319.

Hahn, E., 2003. "Pass-Through of External Shocks to Euro Area Inflation", *European Central Bank Working Paper No. 243.*

Ihrig, J., Marazzi, M. and Rothenberg, A. 2006. "Exchange Rate Pass-Through in the G-7 countries", International Finance Discussion Paper No. 851, Federal Reserve Board of Governors.

Ito, T., and Sato, K., 2006. "Exchange Rate Changes and Inflation in Post-Crisis Asian Economies: VAR Analysis of the Exchange Rate Pass-Through," Discussion papers 06018, Research Institute of Economy, Trade and Industry (RIETI)

Kasa, K., 1992. "Adjustment costs and Pricing-to-Market: Theory and Evodence", *Journal of International Economics, 32, 1-30.*

Kraft, E., 2003. "Monetary Policy under Dollarization: The Case of Croatia", *Comparative Economic Studies*, 45, br. 3, pp. 256-277. also published in **Kraft, E., 2002.** "Monetary Policy under Dollarization: The Case of Croatia" (online), draft version, 8th Dubrovnik Economic Conference, Available from: http://www.hnb.hr/dub-konf/8-konferencija-radovi/kraft-case-of-croatia.pdf?

Krugman, P., 1987. "Pricing to Market When the Exchange Rate Changes" S. Arndt and J. Richardson, real-Financial Linkages Among Open Economies, Cambridge Massachusetts, MIT Press.

Lothian, J. R., Taylor, M. P., 1996. "Real Exchange Rate Behavior: The recent float from the perspective of the past two centuries", *Journal of Political Economy*, 104, pp. 488-509.

Maoduš, V., 2006. ."Pass-through of Exchange Rate Changes to Domestic Inflation: the case of Croatia", Discussion paper, Master thesis.

McCarthy, J., 2000. "Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialised Economies", *Federal Reserve Bank of New York Staff Report No. 111.*

Menon, J., 1995. "Exchange Rate Pass-Through" *Journal of Economic Surveys*, 9, 2, 197-231.

Meese, R. A., Rogoff, K., 1983. "Empirical models of the exchange rate: do they fit out of sample", *Journal of International Economics*, 14, pp. 3-24.

Mihaljek, D. and Klau, M., 2001. "A Note on the Pass-Through from Exchange Rate and Foreign Price Changes to Inflation in Selected Emerging Market Economies", *BIS Papers*, 8, 69-81.

Nestic, D., 2000. "Visoka razina cijena u Hrvatskoj - Neki uzroci i posljedice", *HNB Povremene publikacije – istrazivanja*, I, 2 ozujak.

Nikic, G., 2004. "Gospodarski aspekti pristupa Hrvatske Europskoj uniji - proteklih deset godina i deset godina ispred nas", *Ekonomski pregled*, 3-4, 197.

Pufnik, A., 2002. "Purchasing Power Parity as a long-run Equilibrium: Co-integration Test in the case of Croatia (1991-1996)", *Croatian Economic Survey*, 1996-1999, 4: 29-54.

Rogoff, K., 1996. "The Purchasing Power Puzzle", *Journal of Economic Literature,* 34 (2), pp. 647-668.

Sonje, V., Vujcic, B., 2000. "Hrvatska u drugoj fazi tranzicije, 1994. – 1999", *HNB Povremene publikacije – istrazivanja*, I, 4 lipanj.

Sarno, L., Taylor, M. P., 2002. *The Economics of Exchange Rates, Cambridge University Press*, Cambridge,

Sonje, V., 2000. "Tecaj i proizvodnja nakon velike ekonomske krize i tijekom tranzicijskog razdoblja u Srednjoj Europi", *HNB Povremene publikacije – istrazivanja*, I, 6 rujan.

Sonje, V. and Skreb, M., 1997. "Exchange Rate and Prices in a Stabilization Program: The Case of Croatia", in M. Blejer i M. Skreb, eds., *Macroeconomic Stabilization in Transition Economies*, Zagreb, pp. 212-233**.**

Taylor, John B. 2000. “Low inflation, pass-through, and the pricing power of firms,” *European Economic Review*, 44, 1389-1408.

Tica, J., 2005. "Makroekonomska analiza realnog tečaja u tranzicijskim uvjetima hrvatskog gospodarstva", unpublished dissertation, Faculty of Economics and Business.

Tica, J. 2006. "Long Span Unit Root Test of Purchasing Power Parity: Case of Croatia", Ekonomski Pregled, 57, 12, pp. 856-881.

Zdunic, S., 2003. "Relativne cijene, tecaj i konkurentnost hrvatskoga gospodarstva - uz desetu godisnjicu Stabilizacijskog programa", *Ekonomski pregled*, 11-12, 859.

Zdunic, S., 2004a. "Politika stabilizacije i razvoja u hrvatskoj 90-ih", *Ekonomski pregled*, 3-4, 256.

Zdunic, S., 2004b. "Relativne cijene i izvori rasta - komparativna analiza", *Ekonomski pregled*, 11-12, 853.

Zdunic, S., Grgic, M., 1995. *Politika intervalutarnog tecaja i zastite u strategiji razvitka hrvatskog gospodarstva*, Ekonomski institut Zagreb, Hrvatska gospodarska komora Zagreb, Zagreb.

Zorzi, M. C., Hahn, E. and Sanchez, M. 2007. "Exchange rate Pass-thorugh in Emerging Markets", Working paper series No. 739.

Appendix 1

Table 5: The significance interval and SSRs, AICs and SBCs for all threshold in the all regressions with 9 lags and delay parameter of 1

Threshold	SSR	95% Interval	90% Interval	AIC	BIC
28,5510	155,3000	24,44998605	24,19714791	708,9400	777,9400
28,2380	130,1200	24,44998605	24,19714791	685,7700	754,7700
27,8070	95,3400	24,44998605	24,19714791	645,0300	714,0300
26,9870	88,3440	24,44998605	24,19714791	635,0400	704,0500
25,7680	87,8570	24,44998605	24,19714791	634,3200	703,3200
24,9590	84,0050	24,44998605	24,19714791	628,4400	697,4500
24,0610	76,9900	24,44998605	24,19714791	617,0200	686,0300
24,0460	76,9880	24,44998605	24,19714791	617,0200	686,0200
a21,8180	76,4800	24,44998605	24,19714791	616,1500	685,1500
ab21,0410	24,2850	24,44998605	24,19714791	465,8700	534,8800
ab11,1300	23,1810	24,44998605	24,19714791	459,7700	528,7800
***ab5,9102**	**23,1320**	**24,44998605**	**24,19714791**	**459,5000**	**528,5100**
ab2,6927	185,1400	24,44998605	24,19714791	731,9700	800,9700
2,4409	186,6500	24,44998605	24,19714791	733,0300	802,0400
2,2652	186,6400	24,44998605	24,19714791	733,0200	802,0300
2,2291	222,2300	24,44998605	24,19714791	755,8900	824,8900
2,1397	222,9500	24,44998605	24,19714791	756,3100	825,3100
2,0198	224,3100	24,44998605	24,19714791	757,1100	826,1100
1,8318	246,9700	24,44998605	24,19714791	769,7100	838,7200
1,5247	249,2900	24,44998605	24,19714791	770,9400	839,9400
1,5215	250,3200	24,44998605	24,19714791	771,4800	840,4800
1,5074	251,3200	24,44998605	24,19714791	772,0000	841,0000
1,4061	252,9900	24,44998605	24,19714791	772,8700	841,8700
1,0185	256,4700	24,44998605	24,19714791	774,6600	843,6600
1,0126	256,7000	24,44998605	24,19714791	774,7800	843,7800
0,9970	256,7100	24,44998605	24,19714791	774,7800	843,7900
0,9457	259,3000	24,44998605	24,19714791	776,1000	845,1000
0,9427	262,9600	24,44998605	24,19714791	777,9300	846,9400
0,9034	266,0500	24,44998605	24,19714791	779,4600	848,4700
0,8565	269,1000	24,44998605	24,19714791	780,9600	849,9600
0,6039	269,1900	24,44998605	24,19714791	781,0000	850,0000
0,5794	269,7400	24,44998605	24,19714791	781,2700	850,2700
0,5678	273,7000	24,44998605	24,19714791	783,1800	852,1800
0,5344	275,8500	24,44998605	24,19714791	784,2000	853,2100
0,5228	280,3600	24,44998605	24,19714791	786,3300	855,3300
0,4351	282,0900	24,44998605	24,19714791	787,1300	856,1400
0,4287	282,4900	24,44998605	24,19714791	787,3200	856,3200
0,4053	283,4200	24,44998605	24,19714791	787,7500	856,7500
0,4044	284,0500	24,44998605	24,19714791	788,0400	857,0400
0,3865	285,1000	24,44998605	24,19714791	788,5200	857,5300
0,3568	285,7800	24,44998605	24,19714791	788,8300	857,8400
0,3453	286,6300	24,44998605	24,19714791	789,2200	858,2300
0,3251	286,9700	24,44998605	24,19714791	789,3800	858,3800
0,3210	287,6100	24,44998605	24,19714791	789,6700	858,6700
0,3182	288,7900	24,44998605	24,19714791	790,2100	859,2100
0,3099	289,3800	24,44998605	24,19714791	790,4700	859,4800
0,2987	289,3800	24,44998605	24,19714791	790,4700	859,4800
0,2778	290,3300	24,44998605	24,19714791	790,9000	859,9100
0,2716	291,7000	24,44998605	24,19714791	791,5200	860,5200
0,2668	291,7200	24,44998605	24,19714791	791,5300	860,5300
0,2439	291,7300	24,44998605	24,19714791	791,5400	860,5400
0,2278	292,1900	24,44998605	24,19714791	791,7400	860,7400
0,1996	292,3600	24,44998605	24,19714791	791,8200	860,8200
0,1496	294,7800	24,44998605	24,19714791	792,8900	861,9000
0,1349	296,8700	24,44998605	24,19714791	793,8200	862,8300
0,1343	298,4700	24,44998605	24,19714791	794,5300	863,5300
0,1081	298,2400	24,44998605	24,19714791	794,4200	863,4300
0,0954	299,5500	24,44998605	24,19714791	795,0000	864,0000
0,0937	300,4700	24,44998605	24,19714791	795,4000	864,4100
0,0862	299,7600	24,44998605	24,19714791	795,0900	864,1000
0,0854	300,7600	24,44998605	24,19714791	795,5300	864,5300
0,0677	306,8600	24,44998605	24,19714791	798,1600	867,1600
0,0648	308,6600	24,44998605	24,19714791	798,9200	867,9300
0,0645	308,1700	24,44998605	24,19714791	798,7200	867,7200

0,0622	309,4300	24,44998605	24,19714791	799,2500	868,2500
0,0448	309,6800	24,44998605	24,19714791	799,3600	868,3600
0,0340	311,5100	24,44998605	24,19714791	800,1300	869,1300
0,0309	311,4900	24,44998605	24,19714791	800,1200	869,1200
0,0308	321,9600	24,44998605	24,19714791	804,4500	873,4500
0,0220	323,6700	24,44998605	24,19714791	805,1400	874,1500
0,0112	324,9200	24,44998605	24,19714791	805,6500	874,6600
0,0107	325,4800	24,44998605	24,19714791	805,8700	874,8800
0,0099	325,5300	24,44998605	24,19714791	805,8900	874,9000
-0,0246	326,5700	24,44998605	24,19714791	806,3100	875,3200
-0,0386	326,7500	24,44998605	24,19714791	806,3800	875,3900
-0,0411	328,2300	24,44998605	24,19714791	806,9800	875,9800
-0,0433	328,2200	24,44998605	24,19714791	806,9700	875,9800
-0,0523	328,4800	24,44998605	24,19714791	807,0800	876,0800
-0,0692	328,9600	24,44998605	24,19714791	807,2700	876,2700
-0,0735	330,7900	24,44998605	24,19714791	807,9900	877,0000
-0,0907	331,2600	24,44998605	24,19714791	808,1800	877,1900
-0,0995	331,5600	24,44998605	24,19714791	808,3000	877,3000
-0,1122	331,3700	24,44998605	24,19714791	808,2200	877,2300
-0,1205	333,1100	24,44998605	24,19714791	808,9100	877,9200
-0,1605	333,8300	24,44998605	24,19714791	809,1900	878,2000
-0,1607	333,6600	24,44998605	24,19714791	809,1200	878,1300
-0,1743	334,0600	24,44998605	24,19714791	809,2800	878,2900
-0,2210	334,7000	24,44998605	24,19714791	809,5300	878,5400
-0,2433	334,6700	24,44998605	24,19714791	809,5200	878,5300
-0,2473	336,8700	24,44998605	24,19714791	810,3800	879,3900
-0,2758	337,7700	24,44998605	24,19714791	810,7300	879,7300
-0,2879	337,9900	24,44998605	24,19714791	810,8200	879,8200
-0,2909	342,1500	24,44998605	24,19714791	812,4200	881,4200
-0,3324	342,5700	24,44998605	24,19714791	812,5800	881,5800
-0,3426	346,7400	24,44998605	24,19714791	814,1700	883,1700
-0,3484	347,8000	24,44998605	24,19714791	814,5600	883,5700
-0,3714	351,6400	24,44998605	24,19714791	816,0000	885,0100
-0,4179	352,3200	24,44998605	24,19714791	816,2600	885,2600
-0,4312	352,7900	24,44998605	24,19714791	816,4300	885,4400
-0,4748	355,1000	24,44998605	24,19714791	817,2800	886,2900
-0,4773	355,5600	24,44998605	24,19714791	817,4500	886,4600
-0,4775	355,7000	24,44998605	24,19714791	817,5100	886,5100
-0,4981	355,8300	24,44998605	24,19714791	817,5500	886,5600
-0,5018	356,1300	24,44998605	24,19714791	817,6600	886,6700
-0,5090	356,1400	24,44998605	24,19714791	817,6700	886,6700
-0,5416	356,8500	24,44998605	24,19714791	817,9300	886,9300
-0,5419	359,8600	24,44998605	24,19714791	819,0300	888,0300
-0,5566	361,1600	24,44998605	24,19714791	819,5000	888,5000
-0,5815	362,5300	24,44998605	24,19714791	820,0000	889,0000
-0,6268	363,2500	24,44998605	24,19714791	820,2600	889,2600
-0,6386	364,4100	24,44998605	24,19714791	820,6800	889,6800
-0,6426	364,9700	24,44998605	24,19714791	820,8800	889,8800
-0,7038	364,7400	24,44998605	24,19714791	820,7900	889,8000
-0,7740	365,2400	24,44998605	24,19714791	820,9700	889,9800
-0,8119	366,3400	24,44998605	24,19714791	821,3700	890,3700
-0,8344	366,7300	24,44998605	24,19714791	821,5100	890,5100
-0,8968	366,4300	24,44998605	24,19714791	821,4000	890,4000
-0,9015	366,0300	24,44998605	24,19714791	821,2500	890,2600
-0,9145	367,4300	24,44998605	24,19714791	821,7600	890,7600
-0,9450	368,2600	24,44998605	24,19714791	822,0500	891,0600
-1,1088	369,9200	24,44998605	24,19714791	822,6400	891,6400
-1,2001	376,1200	24,44998605	24,19714791	824,8200	893,8200
-1,2776	378,9800	24,44998605	24,19714791	825,8100	894,8200
-1,2997	379,3100	24,44998605	24,19714791	825,9200	894,9300
-1,6251	380,1100	24,44998605	24,19714791	826,2000	895,2100
-1,7260	380,8900	24,44998605	24,19714791	826,4700	895,4700
-1,8406	381,2500	24,44998605	24,19714791	826,5900	895,6000
-2,0021	389,0100	24,44998605	24,19714791	829,2300	898,2400
-3,3004	393,0200	24,44998605	24,19714791	830,5800	899,5800
-4,7639	398,4500	24,44998605	24,19714791	832,3700	901,3800
-9,1379	404,8400	24,44998605	24,19714791	834,4600	903,4600

Note: * denotes threshold with minimum AIC and SBC values, **b** denotes 90% interval, **a** denotes 95% interval.

Source: Matlab calculation by authors