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Asymmetric Dynamics of Inflation Inertia in Some Selected Non-Eurozone European Countries[1]

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ABSTRACT
Relevance. Inflation inertia refers to the persistence of inflation over time and can be caused by a variety of factors, including expectations about future inflation, the structure of the economy, and the behavior of economic agents. Over the past two decades, the European economy has grappled with a range of challenges and currently seeks to mitigate the negative impacts of the global pandemic.
Research objective. Persistent inflation can lead to uncertainty, decreased investment, and a loss of confidence in an economy. Non-eurozone economies can also face challenges in controlling inflation due to such factors as the lack of monetary integration with the eurozone, limited access to the European Central Bank's resources, and the lack of a unified currency. Hence, for a more effective monetary policy in these countries, it is necessary to measure and understand the inflation inertia. This paper offers a novel empirical study of the dynamics of inflation inertia for seven EU economies that are not part of the eurozone.
Data and methods. To achieve the research objective, three non-linear unit root tests are employed to consider both structural changes and regime switching. These tests allowed for the inclusion of almost all non-linear dynamics observed in the inflation series. In addition, the tests involve the use of the dynamic rolling windows sample approach in order to provide more sensitive measurements of the effect of time-varying shocks on inflation inertia.
Results. According to the static sample analysis of 200 observations, Bulgaria, Croatia, and the Czech Republic have inflation inertia. Sweden, Romania, Hungary, and Poland do not have inflation inertia when non-linear regime switching dynamics and structural change are considered. However, Croatia and the Czech Republic show a mostly non-stationary inflation in dynamic rolling windows sampling. Hungary has persistent inflation even though it was not detected in the static sample analysis. The shocks of inflation fade out in Bulgaria, Poland, Romania, and Sweden with non-linear dynamics. If non-linear dynamics is ignored, it can lead to misleading results in economic time series.
Conclusions. Inflation inertia can be influenced by a variety of factors, including the global pandemic, global or regional conflicts and monetary policy preferences. The successful management of inflation inertia in Romania and Sweden may serve as a model for other economies that have demonstrated an ability to effectively address and mitigate the challenges posed by inflation inertia.

KEYWORDS
inflation inertia, inflation dynamics, smooth transition, structural change, non-linear unit root tests

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Асимметрическая динамика инерции инфляции в некоторых странах Европы, не входящих в зону евро

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АННОТАЦИЯ
Актуальность. Инерция инфляции относится к постоянству инфляции во времени и может быть вызвана различными факторами, включая ожидания будущей инфляции, структуру экономики и поведение экономических агентов. За последние два десятилетия европейская экономика сталкивалась с рядом вызовов и в настоящее время ищет способы смягчить негативные последствия глобального пандемического кризиса.

КЛЮЧЕВЫЕ СЛОВА
инерция инфляции, динамика инфляции, плавный переход, структурные изменения, нелинейные тесты единичных корней

Цель исследования. Постоянная инфляция может привести к неопределенности, уменьшению инвестиций и утрате доверия к экономике. Экономики, не входящие в зону евро, также могут столкнуться с проблемами в контроле инфляции из-за таких факторов, как отсутствие монетарной интеграции с зоной евро, ограниченный доступ к ресурсам Европейского центрального банка и отсутствие единой валюты. Поэтому измерение и понимание инерции инфляции является параметрической необходимостью для их валютных властей. Эта работа предлагает новый эмпирический исследование, чтобы понять динамику инерции инфляции для семи экономик в Европейском союзе, которые не являются частью зоны евро.
Данные и методы. Чтобы достичь исследовательской цели, используются три нелинейных теста на единую ось, чтобы учитывать как структурные изменения, так и переключение режимов. Эти тесты позволяют включать почти все нелинейные динамики, наблюдаемые в сериях инфляции. Кроме того, тесты используются с подходом Rolling Windows Sample, чтобы предоставить более чувствительные измерения временных шоков на инерцию инфляции.
Результаты. Болгария, Хорватия и Чехия имеют инфляционную инерцию согласно статической выборке из 200 наблюдений. Швеция, Румыния, Венгрия и Польша не имеют инфляционной инерции, когда учитываются нелинейная динамика смены режимов и структурные изменения. Однако Хорватия и Чехия показывают в основном нестационарную инфляцию в динамической выборке скользящих окон. Венгрия показывает устойчивую инфляцию, хотя она не обнаруживается в анализе статической выборки. Шоки инфляции затухают в Болгарии, Польше, Румынии и Швеции с нелинейной динамикой. Игнорирование нелинейной динамики может привести к ошибочным результатам в экономических временных рядах.
Выводы. Наличие инерции инфляции может быть подвержено влиянию различных факторов, включая глобальную пандемию, глобальные или региональные конфликты и предпочтения монетарной политики. Успешное управление инерцией инфляции в Румынии и Швеции может служить моделью для других экономик, которые проявили способность эффективно адресовать и смягчать вызовы, вызванные инерцией инфляции.

ДЛЯ ЦИТИРОВАНИЯ
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欧元区以外欧洲国家通胀的非对称惯性动态

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摘要
现实性：通货膨胀惯性是指通胀随着时间的推移而持续存在。这可由各种因素造成，包括对未来通货膨胀的预期、经济结构和经济主体的行为。欧洲经济在过去20年中面临着一些挑战，目前正在寻找方法来减轻全球疫情危机的负面影响。
研究目标：持续的通货膨胀会导致不确定性、投资减少和对经济失去信心。欧元区以外的经济体也可能因与欧元区缺乏货币一体化、获得欧洲央行资源的机会有限以及没有单一货币等因素而在控制通胀方面面临问题。因此，衡量和了解通货膨胀的惯性对当局来说是货币参数化的必要条件。本文提出了一项新实证研究，以研究不属于欧元区的七个欧盟经济体的通货膨胀惯性动态。
数据与方法：为了实现研究目标，文章使用三个非线性单轴测试来解释结构的变化和模式切换。这些测试允许纳入通胀系列中观察到的几乎所有非线性动态。此外，在模型中，测试与Rolling Windows Sample一起使用，来直观显示临时冲击对通货膨胀惯性的影响。
研究结果：根据200个观测值的静态样本研究，证明保加利亚、克罗地亚和捷克共和国有通货膨胀惯性。瑞典、罗马尼亚、匈牙利和波兰在文章所考虑的非线性制度和结构变化下没有通货膨胀惯性。然而，克罗地亚和捷克共和国在动态滑动窗口样本中显示为非平稳通货膨胀。匈牙利显示出稳定的通货膨胀，尽管在静态样本分析中无法发现。保加利亚、波

关键词
通货膨胀惯性、通货膨胀动态、平稳过渡、结构变化、非线性单轴检测

兰、罗马尼亚和瑞典的通胀冲击正在以非线性动力学方式消退。文章忽略了非线性动力学会导致经济时间序列的结果错误。
结论：通胀惯性的存在可能受到多种因素的影响，包括全球疫情、全球或地区冲突以及货币政策偏好。罗马尼亚和瑞典对通货膨胀惯性的成功管理可以成为其他经济体的典范，这两个国家显示出了有效处理和减轻通货膨胀惯性压力的能力。

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Introduction

Inflation is one of the most important financial indicators used to evaluate the financial performance of a country. Like many other indicators, inflation is measured through time series data, reflecting the change in the general level of prices. These time series data have all the econometric properties that can be interpreted in economic terms. Econometrically, the stationarity of inflation series can be related to the concept of inflation persistence also known as inflation inertia in financial theory. From this perspective, inflation inertia can be defined as the inflation series reverting to the long-term equilibrium and/or targeted inflation level quite late. Therefore, the inflation series being non-stationary is the most significant proof of inflation inertia in a related country[2].

Inflation inertia is a phenomenon that requires a careful analysis before any macroeconomic policy-making decisions are taken or any measures for coping with inflation or for any other purposes are implemented. High inflation is a major impediment to economic growth (Mallick & Sousa, 2012). Moreover, inflation inertia will also increase the cost of monetary and public finance policies aimed at combating inflation because it will negatively affect inflation expectations in the long term (Gaglianone et al., 2018).

As Pratap et al. (2021) argue, there are two basic approaches to inflation inertia modeling. The first approach models the inflation with its own lagged values, ignoring the effects of the other financial indicators. This approach is called reduced-form persistence. By including the rational expectations hypothesis into financial analysis, inflation inertia starts to be modeled together with the other factors that will affect expectations. The second approach is known as structural inertia. I am going to use unit root tests to empirically analyze inflation intertia. As it is known that unit root tests depend on time series models where variables are modeled with their own lag, the approach in this study could be described as reduced-form approach according to the classification of Pratap et al. (2021).

There are many studies that investigate inflation intertia by applying unit root tests (e.g., Novaes 1993; Gottschalk 2003; Özcan et al. 2004; Roache 2014; Oliveira and Petrassi 2014). In their studies, Gottschalk (2003) and Oliveira and Petrassi (2014) highlight non-linear dynamics and use non-linear unit root tests. Both of these studies use unit root tests developed within the framework of non-linear dynamics, which is called 'structural break'. Gottschalk (2003) chose the dates of the six stabilization attempts made in Brazil in 1986-1994 as structural break dates. For the case of Brazil, break dates were determined exogenously, as Perron (1989) suggested. However, Zivot and Andrews (1992) replaced this approach in non-linear root tests by methods that estimate the break date endogenously. The study by Oliveira and Petrassi (2014) is a good example of the empirical applications where the break is determined endogenously. In the study by Kim and Perron (2009), unit root tests were applied for 23 industrialized and 17 developing economies and inflation inertias were estimated both for the countries and break dates.

This study aims to analyze the phenomenon of inflation inertia and its asymmetrical dynamics for seven non-eurozone European economies that have been able to adopt independent monetary policies (Bulgaria, Croatia, Czechia, Hungary, Poland, Romania and Sweden) by applying three unit root tests. Thus, I will be able to show how successful are the anti-inflation policies in these countries that were developed and implemented without the assistance of the European Central Bank. To achieve this aim, this study introduces a new empirical design. I am going to start with the linear Dickey and Fuller (1981) test. Then, I am going to conduct the Leybourne et al. (1998) test using smooth transition functions for modeling structural breaks. Finally, I will conduct the Özcan and Yurdakul (2022) test, which considers structural breaks and regime switching dynamics.

[2] Roache, M. S. K. (2014). Inflation persistence in Brazil-a cross country comparison. International Monetary Fund.

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Another feature that makes this study different from the previous research is the application of the three aforementioned unit root tests with the rolling window sample method. The rolling window sample method was used for unit root tests in Gaglianone et al. (2018) and in Morales-Arias and Moura (2013). The rolling windows approach provides an opportunity to analyze the inflation dynamics of the seven non-Eurozone European countries periodically. Moreover, since structural breaks and regime switching will be considered for each period, a more precise measurement of inflation inertia will be possible. The rolling window method will be particularly useful for the analysis of narrow sample data, including the last two years characterized by the pressure of the COVID-19 pandemic.

The study comprises the following section that provides an overview of the research literature and offers a more detail explanation of the phenomenon of persistent inflation. The third section describes the methodology; the fourth section deals with the empirical findings. In the last part, the findings will be interpreted, and the study will be finalized by pointing out various policy implications.

Theoretical framework

Inflation inertia refers to the tendency for inflation to persist over time, meaning that it tends to remain stable or continue to increase or decrease rather than fluctuate randomly. Theoretical frameworks for understanding inflation inertia typically focus on how inflation is influenced by various economic factors and how these factors interact with each other. Inflation is an important macroeconomic indicator because it affects the cost of living and overall standards of living in a country (Kiseleva, 2018).

One of the key theoretical frameworks for understanding inflation inertia is the concept of the "Phillips curve," which was developed by economist A.W. Phillips in the 1950s. The Phillips curve is a graphical representation of the inverse relationship between unemployment and inflation. According to this model, when unemployment is low, there is typically more demand for goods and services, leading to upward pressure on prices (inflation). Conversely, when unemployment is high, there is less demand for goods and services, leading to downward pressure on prices (deflation). The Phillips curve has been influential in shaping monetary policy in many countries, with central banks often using interest rate adjustments to try to maintain low unemployment and stable inflation. However, the Phillips curve has also been subject to criticism and revision over the years, as it does not always accurately predict the relationship between unemployment and inflation (Cogley & Sbordone, 2008; Stock & Watson, 2008).

Another important theoretical framework is based on the concept of monetary policy expectations. This refers to the influence that expectations about future monetary policy decisions can have on current inflation rates. For instance, if people expect that the central bank will raise interest rates in the future to combat rising inflation, this may lead to a decrease in demand for goods and services in the present, which could help to curb inflation. On the other hand, if people expect that the central bank will keep interest rates low to stimulate economic growth, this may lead to increased demand for goods and services and potentially higher inflation. Monetary policy expectations can be influenced by a variety of factors, including changes in the central bank's official interest rate targets, statements made by central bank officials, and changes in the broader economic environment (Ball & Croushore, 1995; Gürkaynak et al., 2007).

The concept of inflation expectations is another important discussion topic that helps us understand inflation inertia. It points to the degree to which people expect inflation to continue into the future. Inflation expectations can be influenced by a variety of factors, including past inflation rates, the state of the economy, and the actions of the central bank. If people expect that inflation will continue to rise in the future, this may lead to increased demand for goods and services in the present, which could put upward pressure on prices and contribute to higher inflation. On the other hand, if people expect that inflation will remain stable or decline in the future, this may lead to decreased demand for goods and services in the present, which could put downward pressure on prices and help curb inflation (Carlson & Parkin, 1975; Coibion et al., 2020).

The cost-push inflation hypothesis is a significant conceptual framework for comprehending the persistence of inflation. This concept is underpinned by the idea that rising costs for businesses can lead to higher prices for goods and services, which can contribute to inflation. Cost-push inflation can be caused by a variety of factors, in-

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cluding rising raw material costs, labor costs, and energy costs. If businesses are faced with rising costs and are unable to pass these costs on to consumers in the form of higher prices, they may be forced to cut back on production or go out of business. This can lead to a decrease in the supply of goods and services, which can put upward pressure on prices and contribute to inflation. Moreover, it should be emphasized that almost all countries have been negatively affected by such inflation, especially after the COVID-19 pandemic (Abeles & Panigo, 2015; Dmitrieva & Ushakov, 2011; Seelig, 1974).

Understanding the role of cost-push inflation, monetary policy and, inflation expectations in shaping inflation inertia is important for central banks and policymakers, as they can try to influence these expectations through their actions and communication strategies. However, policymakers should periodically, consistently, and accurately identify the stickiness of inflation before considering all of these inflation theories (Kurozumi, 2016; Pfajfar & Santoro, 2010).

In the following sections of this paper, I am going to describe the empirical tools that can be used for this purpose. I am also going to bring to light the time path of inflation stickiness for selected countries.

Method and Data

Until the publication of Perron's path-breaking paper in 1989, Dickey-Fuller type unit root tests were estimated with linear autoregressive models in terms of parameters. In Perron's study (1989), structural breaks observed in time series were included in autoregressive models with the help of binary variables, which gave rise to a new wave of research literature using unit root tests. Despite the important contribution made by Zivot and Andrews (1992) , who proposed a new estimation algorithm that predicts the break date endogenously, in the following years, the nonlinear autoregressive models still had a serious deficiency. Since structural breaks were modeled with binary variables in early studies, structural changes in the form of a sudden jump or decrease in financial variables could be modeled. For this reason, structural changes were called breaks. However, in practice, due to various economic realities such as sticky prices, agreements and contracts between financial agents, the structural change in some financial variables does not occur suddenly, but happens gradually over time.

Leybourne Newbold and Vougas (1998) (hereafter I would refer to their approach as the LNV approach), who analyzed this situation in detail and modeled the structural change with a logistic function, opened a new page in the nonlinear unit root test literature. The LNV approach consists of two steps. With the time series examined in the first step, the parameters of the following models are estimated:

$$\textit{Model A}: y_t = \delta_1 + \delta_2 S_t(\gamma,\tau) + \upsilon_t \quad (1)$$
$$\textit{Model B}: y_t = \delta_1 + \varphi_1 t + \delta_2 S_t(\gamma,\tau) + \upsilon_t \quad (2)$$
$$\textit{Model C}: y_t = \delta_1 + \varphi_1 t + \delta_2 S_t(\gamma,\tau) + \varphi_2 t S_t(\gamma,\tau) + \upsilon_t \quad (3)$$

The $\upsilon_t I(0)$ in this model is an error term and $S_t(\gamma,\tau)$ is a logistics function expressed as in the following:

$$S_t(\gamma,\tau) = (1 + \exp\{-y[t - \tau T]\})^{-1} \quad (4)$$

In equation (4), the parameter γ represents the speed of transition and must be greater than zero. The parameter τ is the parameter that indicates the mid-point of transition, and T indicates the number of observations. Since Equation (4) is a nonlinear function, Equation (1), (2) and (3) must be estimated by using the nonlinear least square (NLS) method. Although Leybourne et al. (1998) suggested the Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm while doing this, later Vougas (2006) proved that the sequential quadratic programming (SQP) optimization method gave better results. In the second step of the LNV approach, the residues ($\hat{\upsilon}_t$) obtained from the models for which parameter estimates were made in the first step are subjected to the Dickey and Fuller (1981) test:

$$\Delta\hat{\upsilon}_t = \rho\hat{\upsilon}_{t-1} + \sum_{i=1}^{k}\delta_i\Delta\hat{\upsilon}_{t-i} + \varphi_t \quad (5)$$

Here, φ_t is an error term that provides standard assumptions and k is the optimal lag number. The statistic t calculated for $\hat{\rho}$ is the unit root test recommended by the LNV approach. The unit root test statistics named for each of equations (1), (2), and (3) as s_α, $s_{\alpha(\beta)}$ and $s_{\alpha\beta}$ respectively, and the hypotheses tested by the LNV process can be represented as follows:

$$H_0: y_t = \mu_t,\ \ \mu_t = \mu_{t-1} + \varepsilon_t \qquad H_1: \text{Stationary } y_t \text{ with } (1), (2), (3) \quad (6)$$

$$H_0: y_t = \mu_t,\ \ \mu_t = \kappa + \mu_{t-1} + \varepsilon_t \qquad H_1: \text{Stationary } y_t \text{ with } (2), (3) \quad (7)$$

The two-step method in accordance with the LNV approach has formed an important foundation for nonlinear unit root tests. Following this method, Sollis (2004) replaced the Dickey and

Fuller test in the second step with Enders and Granger (1998). Thus, the first nonlinear unit root test that takes into account both structural change and regime switching was revealed. In Sollis (2004), instead of equation (5), the following threshold autoregressive (TAR) model suggested by Enders and Granger (1998) was estimated.

$$\Delta \upsilon_t = I_t\rho_1\upsilon_{t-1} + (1 - I_t)\rho_2\upsilon_{t-1} + \sum_{i=1}^{k}\xi_i\Delta\upsilon_{t-i} + \varpi_t \quad (8)$$

Here, ϖ_t is the error term that provides the standard assumptions, and I_t is an indicator function that takes the value 1 when $\upsilon_{t-1} \geq 0$, and 0 when $\upsilon_{t-1} < 0$. For equation (8), the unit root null hypothesis was established as H_0: $\rho 1 = \rho 2 = 0$ and an F statistic was proposed to test this hypothesis.

The test described in Özcan and Yurdakul (2022) will be used in this study in combination with the LNV approach with Caner and Hansen (2001) unit root testing. Caner and Hansen's threshold unit root test is a more complex but more advanced unit root test than EG threshold unit root test, from which Sollis (2004) utilized. The TAR model of Caner and Hansen estimated in the second step of the updated LNV approach in the study by Özcan and Yurdakul (2022) is as follows:

$$\begin{aligned}\Delta \upsilon_t &= \Gamma_t\left(\rho_1\upsilon_{t-1} + \sum_{i=1}^{k}\phi_{1i}\Delta\upsilon_{t-i}\right)\\ &+(1-\Gamma_t)\left(\rho_2\upsilon_{t-1} + \sum_{i=1}^{k}\phi_{2i}\Delta\upsilon_{t-i}\right) + \omega_t\end{aligned} \quad (9)$$

In Equation (9), Γ_t is another indicator function equals 1 when $\Delta\upsilon_{t-d} < \tau$, and 0 when $\Delta\upsilon_{t-d} \geq \tau$. τ is the estimated threshold value, d is the delay parameter, and k is the appropriate lag number as in other autoregressive models. Here, the unit root null hypothesis is the same as in Enders and Granger (1998) and it is H_0: $\rho 1 = \rho 2 = 0$. However, in Özcan and Yurdakul (2022), there is more than one alternative hypothesis shown as follows:

$$H_{10}: \rho_1 \neq 0 \text{ and/or } \rho_2 \neq 0 \quad (10)$$
$$H_{20}: \rho_1 < 0 \; and \; \rho_2 < 0 \quad (11)$$
$$H_{21}: \rho_1 < 0 \; and \; \rho_2 = 0 \quad (12)$$
$$H_{22}: \rho_1 = 0 \text{ and } \rho_2 < 0 \quad (13)$$

Of the hypotheses above, (10) is the alternative hypothesis of unrestricted stationary. (10), (11) and (12) are restricted stationary alternative hypotheses. In order to test the hypothesis represented by Equation (10) against the null hypothesis, the Wald statistics proposed by Caner and Hansen are calculated as follows:

$$R_{2T} = t_1^2 + t_2^2 \quad (14)$$

The Wald statistic for other alternative hypotheses is:

$$R_{1T} = t_1^2 1_{\{\hat{\rho}_1<0\}} + t_2^2 1_{\{\hat{\rho}_2<0\}} \quad (15)$$

The values indicated by t in Equation (14) and (15) are the standard t statistics calculated for the relevant $\hat{\rho}$ estimations. Similar to the LNV approach, test statistics are named according to the model in which residues are estimated. For example, test statistics are expressed as ${}^{\alpha}R_{1T}$ ve ${}^{\alpha}R_{2T}$ if the residues are obtained from Model A (Equation 1), if from Model B (Equation 2), as ${}^{\alpha(\beta)}R_{1T}$ ve ${}^{\alpha(\beta)}R_{2T}$, if from Model C (Equation 3), as ${}^{\alpha\beta}R_{1T}$ ve ${}^{\alpha\beta}R_{2T}$. There are two important points to consider in test statistics and alternative hypotheses. The first of these is that if the $\hat{\rho}$ values are estimated negatively, the values of the R_{1T} and R_{2T} statistics will be equal to each other. The second important point is the meaning of the alternative hypotheses Equation (12) and (13). These two alternative hypotheses mean partial stationarity. Null hypothesis here cannot be interpreted as pointing to the fact that the series is stationary; this concept is quite new to the unit root tests literature. In this study, alternative hypotheses directly expressed by Equation (10) and (11) will be considered. Caner and Hansen and Özcan and Yurdakul studies can be consulted for the details that need to be focused in applied studies and for extensive information about the simulation studies of test statistics.

Inflation data for the 7 analyzed countries are obtained from the annual rate of change of the monthly Harmonized Index of Consumer Prices (HICP) series. All data are taken from the Eurostat database and consist of observed values for the period between January 2002 and December 2021.

Results

Static Sample Analysis

First, a broad period of 200 observations from May 2005 to December 2021 for 7 non-Eurozone countries is considered. Smooth transition models for each country's inflation series are estimated in Equations (1), (2) and (3) and the estimated values are presented in Table 1. In addition, estimated smooth transition graphs for each country are presented in the Appendix to show how well each model captures the structural change in the inflation series of countries. According to these findings, inflation in Bulgaria and the Czech Republic might have been affected by the 2008 global financial crisis, while price increases in Croatia, Hungary, Romania, Poland, and Sweden seem to

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have been affected by the European debt crisis, which started at the end of 2009 and reached its peak in 2013. In addition, according to the results in Table 1, Model B for Croatia and Model A for Poland and Sweden were used to estimate the structural change on prices caused by the global pandemic for 2021. Another important parameter of the smooth transition models is the speed of transition, γ. The models with the highest estimate of this parameter are Model A for the Czech Republic and Model A for Hungary. Accordingly, the Czech Republic experienced sharp decreases in inflation between 2007 and 2008 and Hungary, between 2012 and 2013.

Table 1

Estimated Parameters of Smooth Transition

Model A							
	Bulgaria	Croatia	Czech Republic	Hungary	Poland	Romania	Sweden
δ_1	8.643	3.004	3.398	5.047	1.923	6.656	1.416
δ_2	-7.358	-2.297	-1.571	-2.877	9.974	-4.440	5.947
γ	0.800	1.030	17.499	7.719	0.118	0.969	0.368
τ	0.233	0.502	0.221	0.464	1.000	0.383	0.999
Mid-Point Date	03/2009	08/2013	12/2008	01/2013	12/2021	09/2011	12/2021
Model B							
	Bulgaria	Croatia	Czech Republic	Hungary	Poland	Romania	Sweden
δ_1	8.564	3.786	3.075	4.193	0.448	8.843	1.393
δ_2	-7.724	5.907	-3.056	-18.742	-15.548	6.450	-3.278
φ_1	0.004	-0.021	0.015	0.101	0.102	-0.065	0.021
γ	0.751	0.368	2.785	0.044	0.055	0.310	0.106
τ	0.234	0.973	0.223	0.421	0.456	0.753	0.375
Mid-Point Date	03/2009	07/2021	01/2009	04/2012	11/2012	11/2017	07/2011
Model C							
	Bulgaria	Croatia	Czech Republic	Hungary	Poland	Romania	Sweden
δ_1	5.137	3.506	0.265	5.090	1.150	8.938	0.527
δ_2	-3.833	-6.563	0.055	-12.778	-13.960	-3.732	-2.077
φ_1	0.166	-0.010	0.146	-0.001	0.054	-0.066	0.071
φ_2	-0.166	0.035	-0.134	0.066	0.037	0.057	-0.052
γ	0.634	0.614	1.211	0.268	0.083	0.417	0.080
τ	0.224	0.514	0.218	0.495	0.493	0.742	0.293
Mid-Point Date	01/2009	11/2013	12/2008	07/2013	05/2013	08/2017	03/2010

Source: estimated by the author by using Eurostat Database https://ec.europa.eu/eurostat/databrowser/bookmark/bbdad358-3238-4c11-8e72-ee12fac49e45?lang=en (Accessed: 15.10.2022)

Table 2

Empirical Application of Unit Root Tests to Inflation Series										
	τ_τ	s_α	$s_{\alpha(\beta)}$	$s_{\alpha\beta}$	${}^{\alpha}R_{1T}$	${}^{\alpha}R_{2T}$	${}^{\alpha(\beta)}R_{1T}$	${}^{\alpha(\beta)}R_{2T}$	${}^{\alpha\beta}R_{1T}$	${}^{\alpha\beta}R_{2T}$
Bulgaria	-2.009	-2.540	-2.560	-2.466	20.313	20.313	19.862	19.862	17.442	17.442
Croatia	-2.011	-2.384	-3.210	-2.932	26.556	26.556	29.737	29.737	39.329	39.329
Czech Republic	-2.822	-2.274	-2.544	-2.324	23.543	23.543	24.784	24.784	20.218	20.218
Hungary	-1.734	-2.263	-3.514	-3.736	10.591	10.591	37.491*	37.491*	38.608*	38.608*
Poland	-0.290	-2.090	-3.381	-3.416	10.739	10.739	26.820*	26.820*	33.119*	33.119*
Romania	-1.903	-2.588	-2.861	-3.183	23.797*	23.879*	32.189*	32.189*	37.702*	37.702*
Sweden	-1.664	-2.987	-3.152	-3.147	24.249*	24.249*	26.501	26.538	26.011	26.011
The superscript * indicates rejection of unit root null hypothesis for significance at 5% according to critical values for $T = 200$.										

Source: estimated by the author by using Eurostat Database https://ec.europa.eu/eurostat/databrowser/bookmark/bbdad358-3238-4c11-8e72-ee12fac49e45?lang=en (Accessed: 15.10.2022)

The results of Dickey and Fuller (1981) (τ_τ), LNV (s_α, $s_{\alpha(\beta)}$, $s_{\alpha\beta}$) and Özcan and Yurdakul (${}^{\alpha}R_{1T}$, ${}^{\alpha(\beta)}R_{1T}$, ${}^{\alpha\beta}R_{1T}$, ${}^{\alpha}R_{2T}$, ${}^{\alpha(\beta)}R_{2T}$, ${}^{\alpha\beta}R_{2T}$) unit root tests applied for each country on the static sample of 200 observations are given in Table 2. According to the calculated test statistics, the unit root null hypothesis could not be rejected for the inflation series of Bulgaria, Croatia and the Czech Republic. For Hungary, Poland, Romania, and Sweden, Özcan and Yurdakul test statistics may reject the unit root null hypothesis for the inflation series. Based on these results, for the three countries where the unit root null hypothesis could not be rejected, the impact of shocks on inflation becomes permanent instead of diminishing over time. Therefore, there is inflation inertia in Bulgaria, Croatia and the Czech Republic for the static sample of 200 observations. Furthermore, it can be concluded that there is no inflation inertia for the other four countries if the non-linear regime switching dynamics is taken into account along with the structural change.

Rolling Window Sample Analysis

The rolling window sample approach is the application of the relevant econometric analyzes to the data sets obtained by keeping the number of observations constant and shifting the sample start and end dates one step further. In this study, the number of observations T was fixed at 100 and the time interval of the first sample was selected as January 2002 – April 2010. This sampling interval was shifted forward month by month and the last sampling interval, 2013 September – 2021 December, was reached. This sample range was shifted forward month by month to reach the last sample range, 2013 September – 2021 December. Thus, a total of 140 samples was obtained and the three unit root tests mentioned in the previous section were applied to each of them. Since the sample size T did not change at all, it was possible to benefit from the 5% significance level critical value for $T = 100$ of all unit root tests. In the appendix, Figures 1 to 7 showcase the time path graphs of the unit root statistics calculated for the inflation series of seven countries. The red line in the graphs denotes the 5% significance level – the critical value for the unit root test. If a value in the graphs is below the red line for the Dickey and Fuller (1981) and LNV unit root tests or above it in the Özcan and Yurdakul test, this means that the unit root null hypothesis could be rejected.

When the findings obtained within the framework of the rolling window approach are evaluated, special attention should be given to the difference in the results presented by the linear Dickey and Fuller (1981) and non-linear LNV and Özcan and Yurdakul tests. Here, it is clearly seen how misleading results can be obtained when non-linear dynamics in an economic time series are not taken into account. However, the results obtained in the static sample approach and the results obtained in the rolling window approach agree with each other. The rolling windows sampling method indicates that the inflation series is not stationary most of the time for Croatia and the Czech Republic. In addition, although the inflation inertia could not be detected in the static sample of T=200 observations, the results obtained through the rolling window approach for Hungary point to persistent inflation. When the non-linear dynamics (structural change and regime switching) are considered, we can see that the shocks of the inflation series fade out in Bulgaria, Poland, Romania and Sweden.

Discussion and Conclusion

In the last two decades, European economies have had to deal with three major crises. The first of these is the global financial crisis originating in the Unites States of America in 2008 and the second one is the European debt crisis of 2011-2014. It can be seen from the Figure 8 and Figure 10 in Appendix that Bulgaria and the Czech Republic achieved success in reducing inflation through their independent monetary policies. They managed to tackle the problem of high inflation, which was one of the outcomes of the crisis of 2008. If the same structural change estimations are taken into account, it can be seen that Croatia and Hungary followed inflation-reducing policies against the European debt crisis that peaked in 2013 and they were successful with these policies. Poland, Romania and Sweden managed to reduce inflation until 2016, but they had inflation with an increasing trend in the following years. The third major crisis faced by Europe is the global pandemic, which began at the end of 2019. Its effects started to be felt after 2020. The impact of the pandemic on inflation was captured by smooth transition models only for Croatia (Model B) and Sweden (Model A). However, if we examine the movements in the inflation series of the Czech Republic, Hungary, and Poland as well as the predicted smooth transition trends, it can be seen that the increase in inflation caused by the pandemic is included in the upward trend observed after the structural change in the relevant countries. Among the seven economies, only the increase in inflation experienced by Romania during the pandemic did not fit in the smooth transition models.

These findings cannot be interpreted independently from the three major crises mentioned above for the seven non-eurozone countries. In static sample analysis, inflation inertia was detected in Bulgaria, Croatia and the Czech Republic, while Özcan and Yurdakul nonlinear unit root tests in the other four countries showed that there was no inflation inertia. When the results obtained through the rolling windows sample approach are first examined for Bulgaria, it is seen how different are the findings calculated through linear unit root testing and non-linear unit root testing. Considering the Özcan and Yurdakul test outputs, it can be said that inflation inertia was overcome after the 2008 crisis, but this success could not be sustained after the European debt crisis. Having overcome the inflation inertia again in 2017, the Bulgarian economy had a stationary inflation for just one year during the pandemic but entered 2022 with inflation inertia. When evaluated within the framework of the Özcan and Yurdakul test, which considers both structural and asymmetrical dynamics, Croatia's results for the period before the debt crisis were similar to those obtained for Bulgaria. Croatia also was struggling with the consequences of the 2008 crisis but failed to eliminate the inertia effect, which influenced inflation after the debt crisis in the long term (with the exception of a few short periods).

For the Czech Republic, the situation is much more alarming. In the rolling windows analysis, the results of all the three unit root tests showed that Czech Republic could not fight inflation inertia effectively, except for very short periods of time.

Although inflation was found stationary in the static sample analysis for Hungary, it appears to have stationary inflation in very few periods in the 140 months investigated in the rolling window sample analysis.

Within the framework of the nonlinear unit root tests, the most successful economies in struggling with inflation inertia are Poland, Romania and Sweden. Although Poland has managed to eliminate the negative effects of the global financial crisis and debt crisis on inflation since 2017, it has not been able to overcome the inflation inertia created by the economic crisis, which showed its effect during the pandemic. Another important empirical finding is that Sweden has consistently managed to prevent the inflation inertia that could have resulted from the global pandemic.

In sum, inflation inertia results from the monetary policy preferences of the central banks. It is important to emphasize that the seven non-eurozone countries selected for this study will be able to shape their monetary policies independently from the European Central Bank. One of the main objectives of this study was to understand how effective the independent monetary policies

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implemented by these countries were for fighting inflation. The empirical findings for Romania and Sweden have shown that it is possible to fight inflation by taking the necessary policy actions. Their experience can inspire policy-makers in other non-eurozone economies with strong ties to Europe (Sánchez, 2011).

Another important issue concerning inertia is the global pandemic experienced in the last three years. The pandemic has put a serious pressure on prices, especially on food prices, by making it difficult for supply chains to function properly and to supply raw materials. Considering all these, it is essential that Bulgaria, Croatia and the Czech Republic should evaluate their monetary policy options in a healthy way and plan a transparent recovery process based on inflation targeting. Meanwhile, the lessons of the global financial crisis and the European debt crisis experienced in the past should also be benefited from, taking into account the individual characteristics of each country.

This study offers a new empirical perspective. A warning, however, should be made that the use of panel data methods should be avoided when examining non-eurozone economies with independent monetary policies. Moreover, future studies should examine each country individually and present a detailed assessment of its monetary policy preferences. Furthermore, future studies should examine the succession of anti-inflation policies of the countries such as Russia and Turkey, which have strong economic ties with Europe but are not EU members. Finally, the experience of the pandemic has undoubtedly presented new economic challenges to the world. Inflation inertia is one of them and the struggle with it will determine the solidity of the foundations of the economy in the post-pandemic world.

Data availability statement

The dataset sample file and R Programming Language code generated during and/or analyzed during the current study are available from the following anonymous repository: https://anonymous.4open.science/r/Inflation_Inertia_Non-Eurozone-9D0E

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Appendix

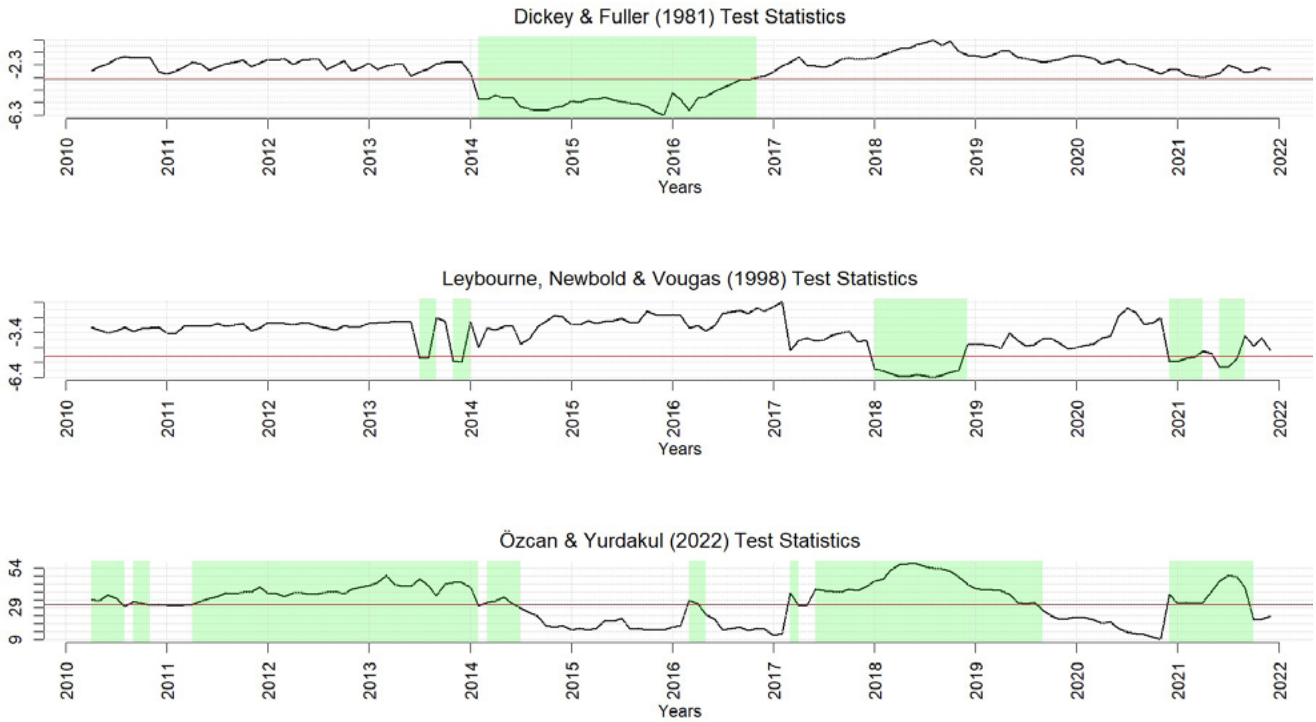

Figure 1. *Rolling Window Unit Root Test Statistics of Bulgaria and Stationary Periods*
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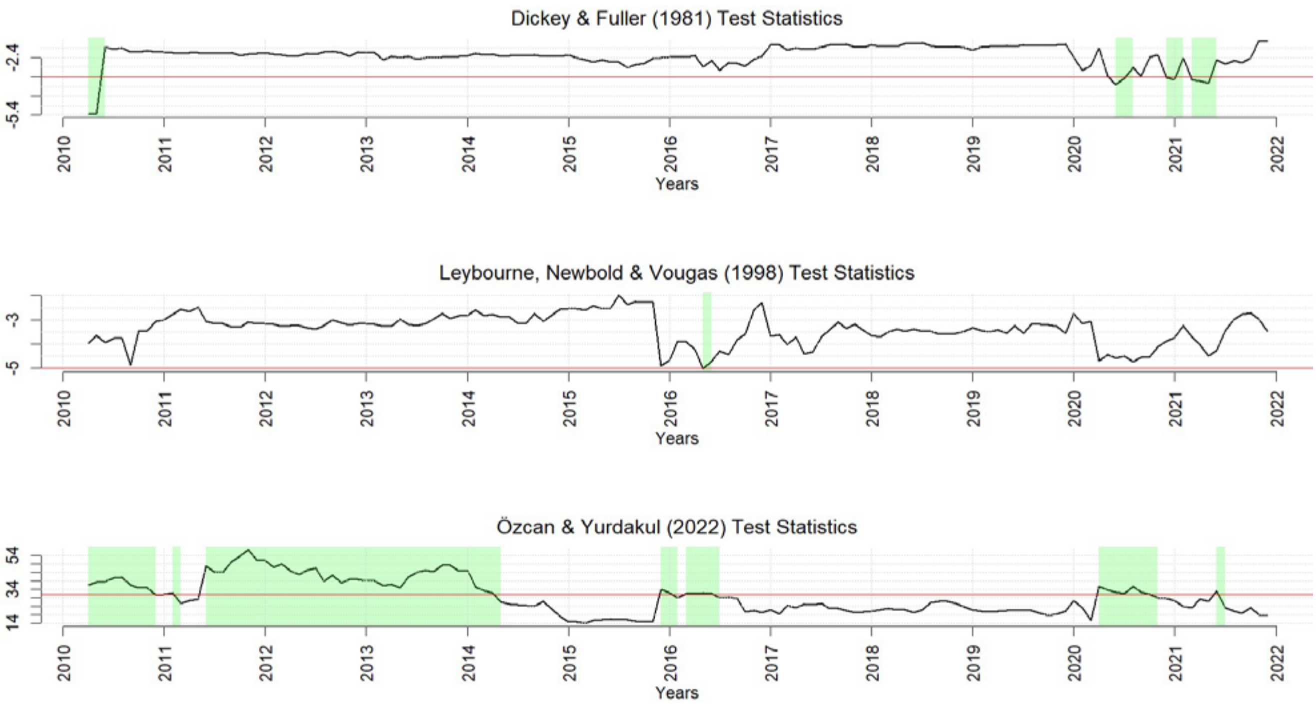

Figure 2. *Rolling Window Unit Root Test Statistics of Croatia and Stationary Periods*
Source: calculated and created by the author.

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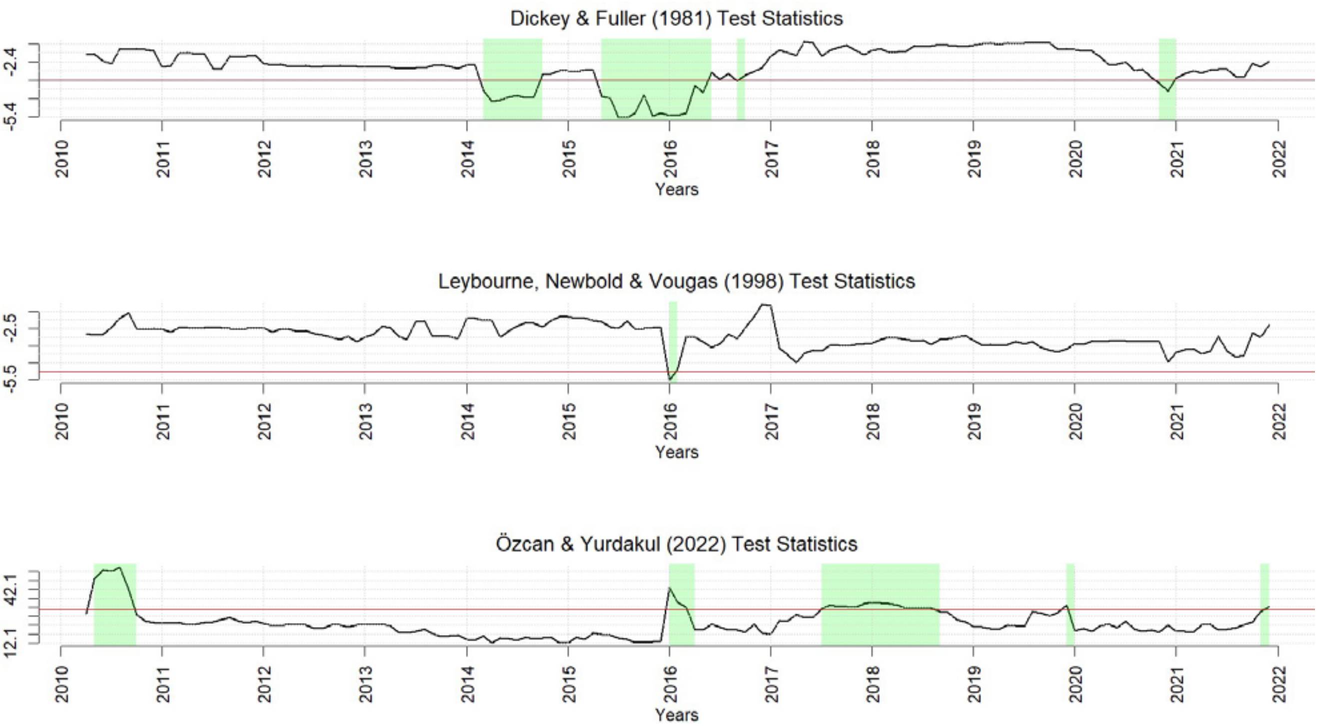

Figure 3. *Rolling Window Unit Root Test Statistics of Czechia and Stationary Periods*
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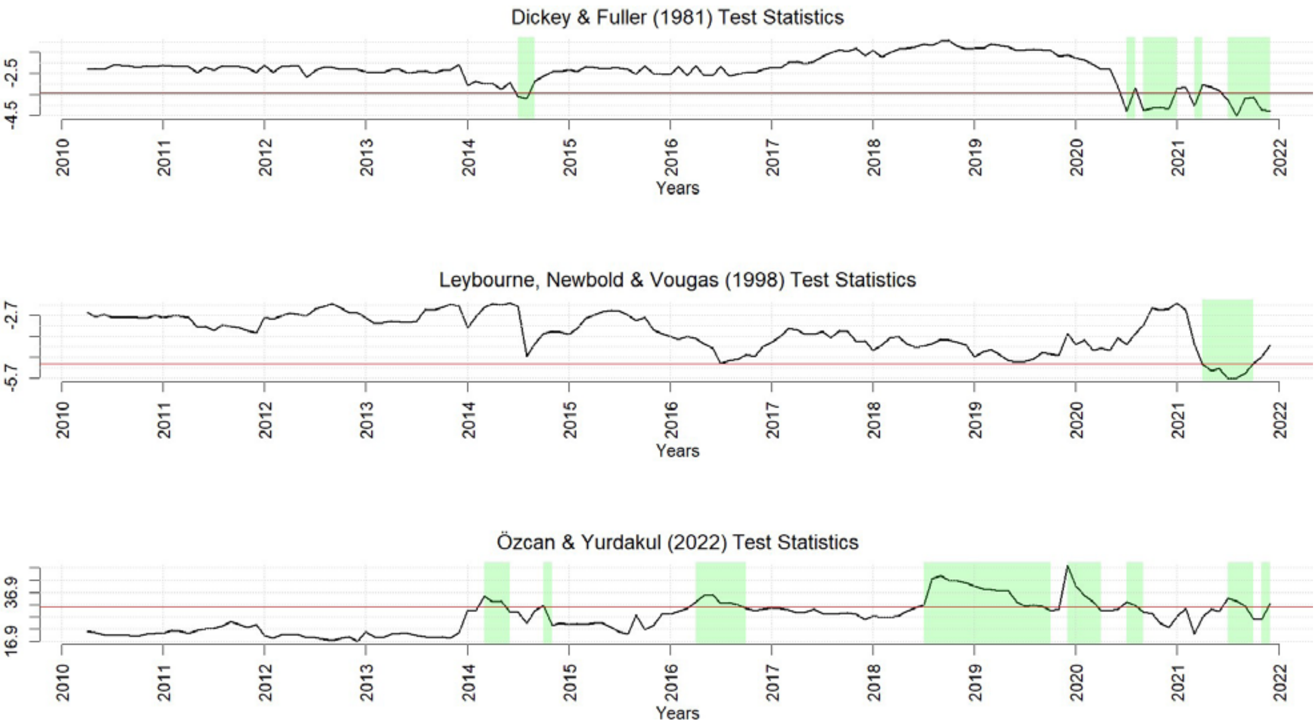

Figure 4. *Rolling Window Unit Root Test Statistics of Hungary and Stationary Periods*
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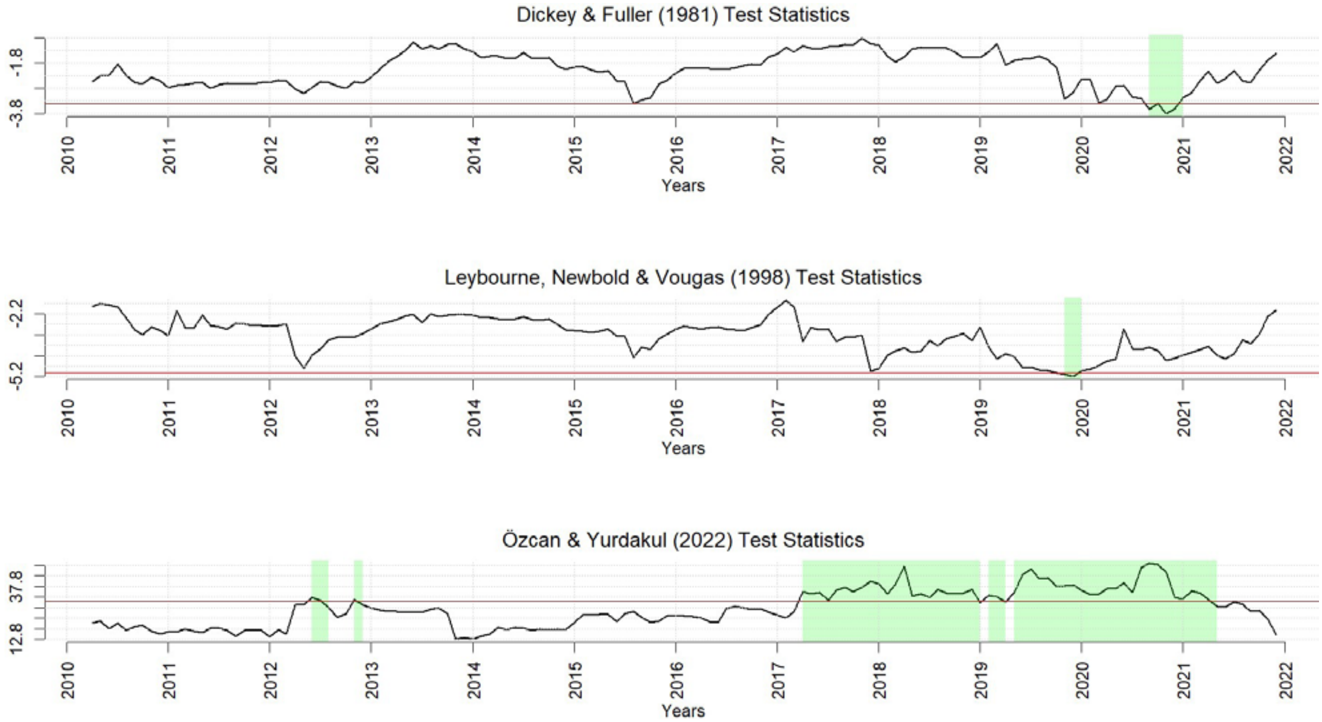

Figure 5. *Rolling Window Unit Root Test Statistics of Poland and Stationary Periods*
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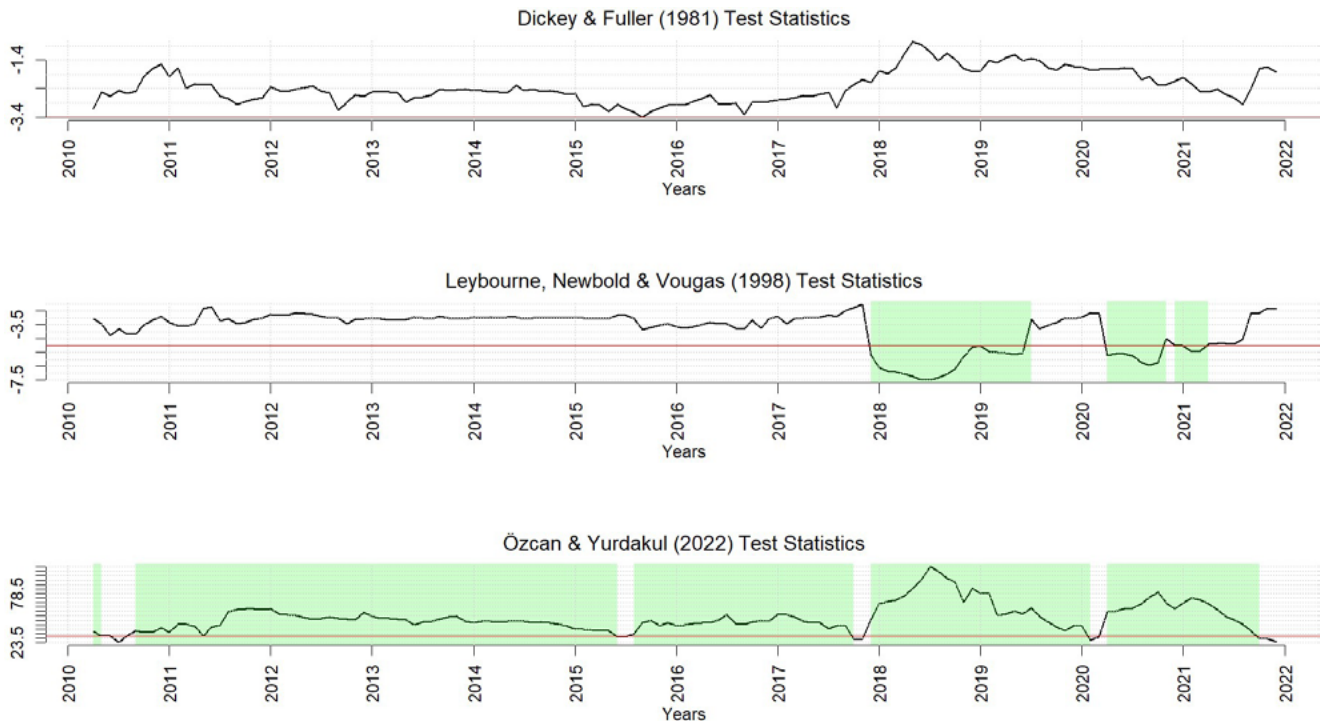

Figure 6. *Rolling Window Unit Root Test Statistics of Romania and Stationary Periods*
Source: calculated and created by the author.

doi 10.15826/recon.2023.9.1.005

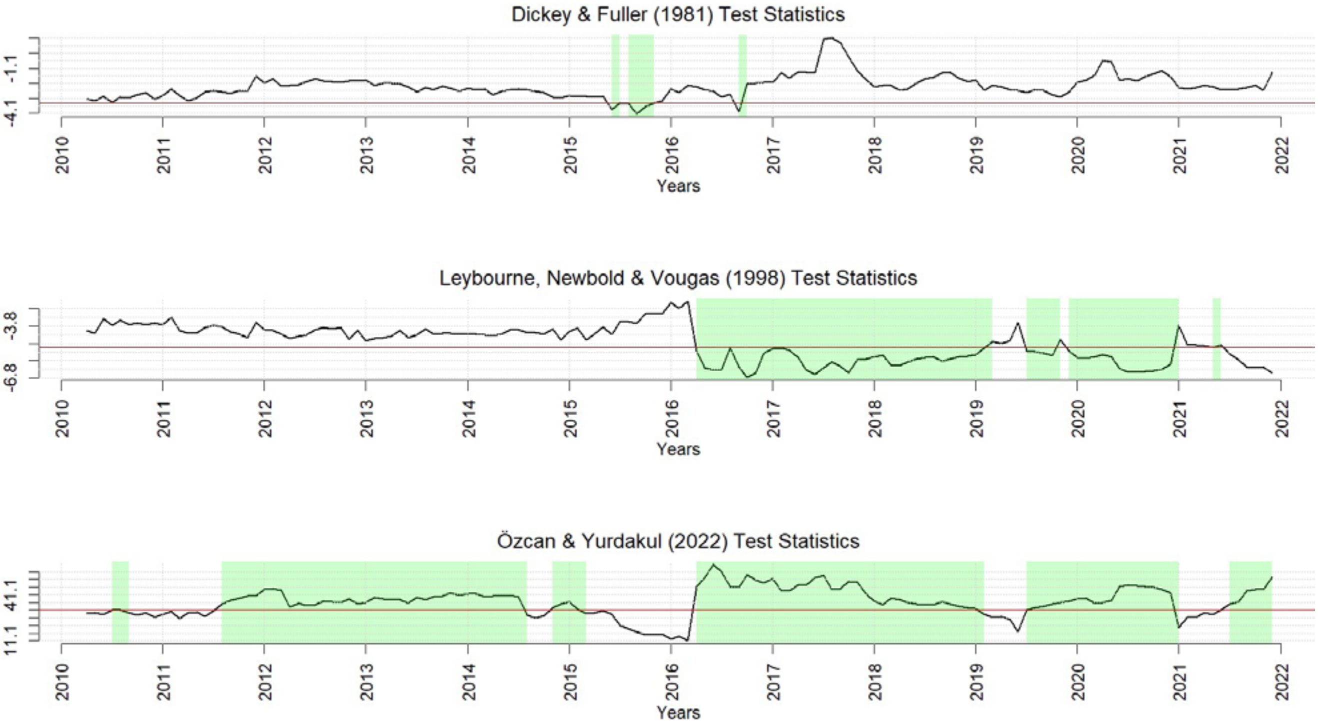

Figure 7. *Rolling Window Unit Root Test Statistics of Sweden and Stationary Periods*
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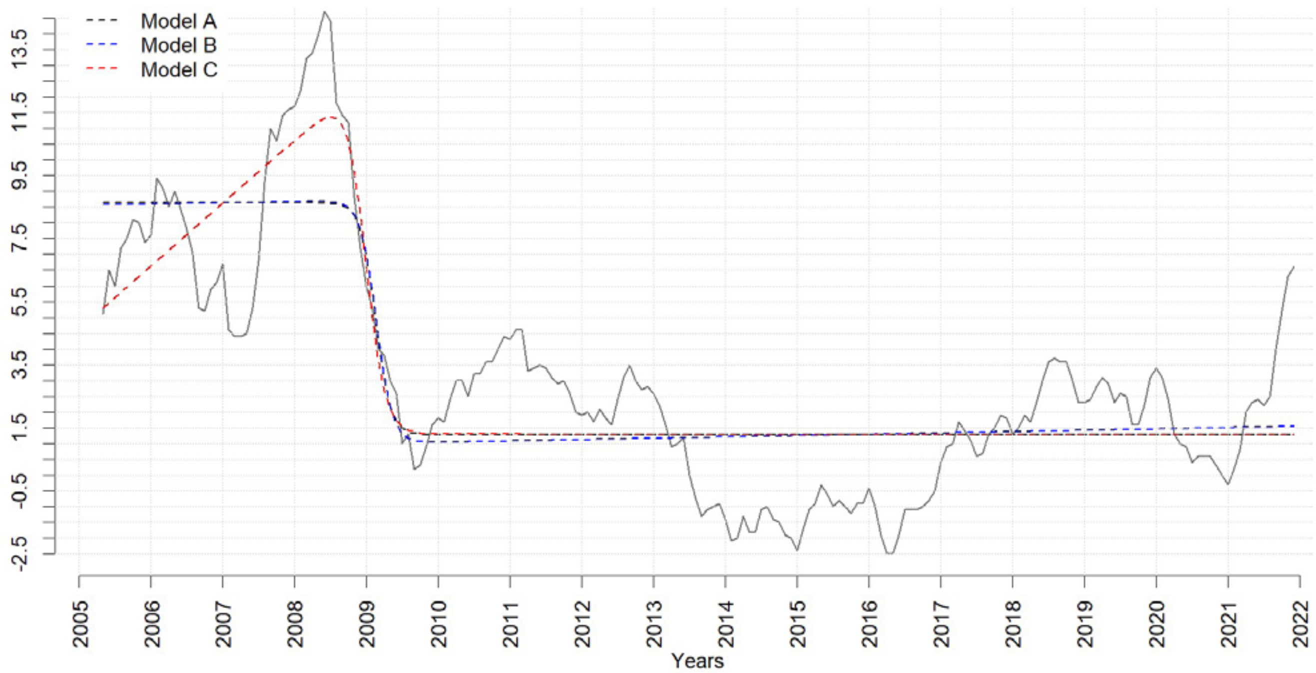

Figure 8. *Inflation of Bulgaria and Fitted Smooth Transitions*
Source: calculated and created by the author.

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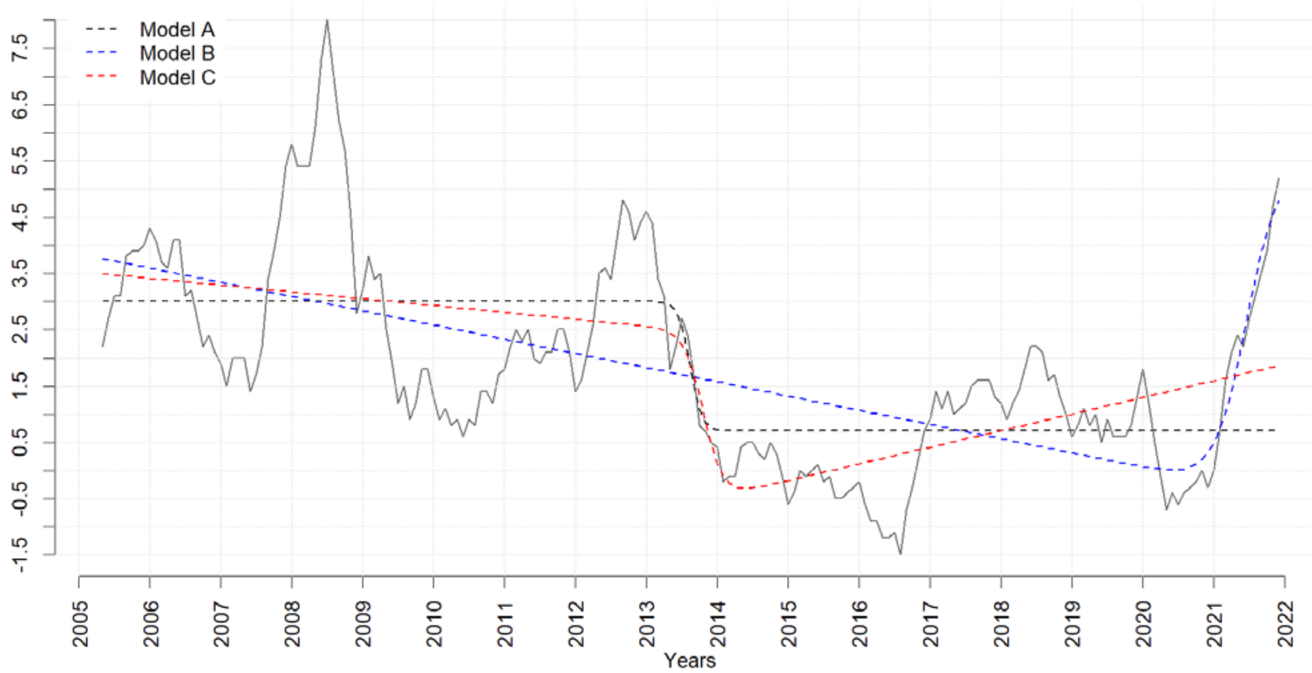

Figure 9. *Inflation of Croatia and Fitted Smooth Transitions*
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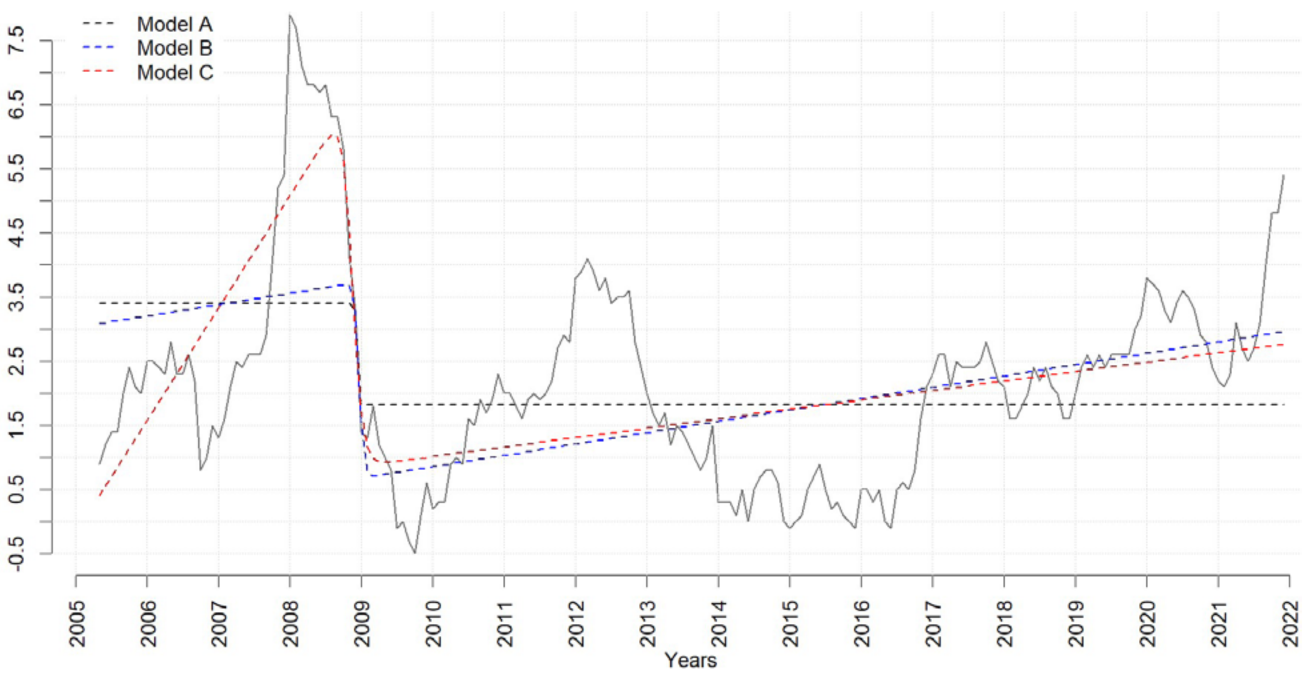

Figure 10. *Inflation of Czechia and Fitted Smooth Transitions*
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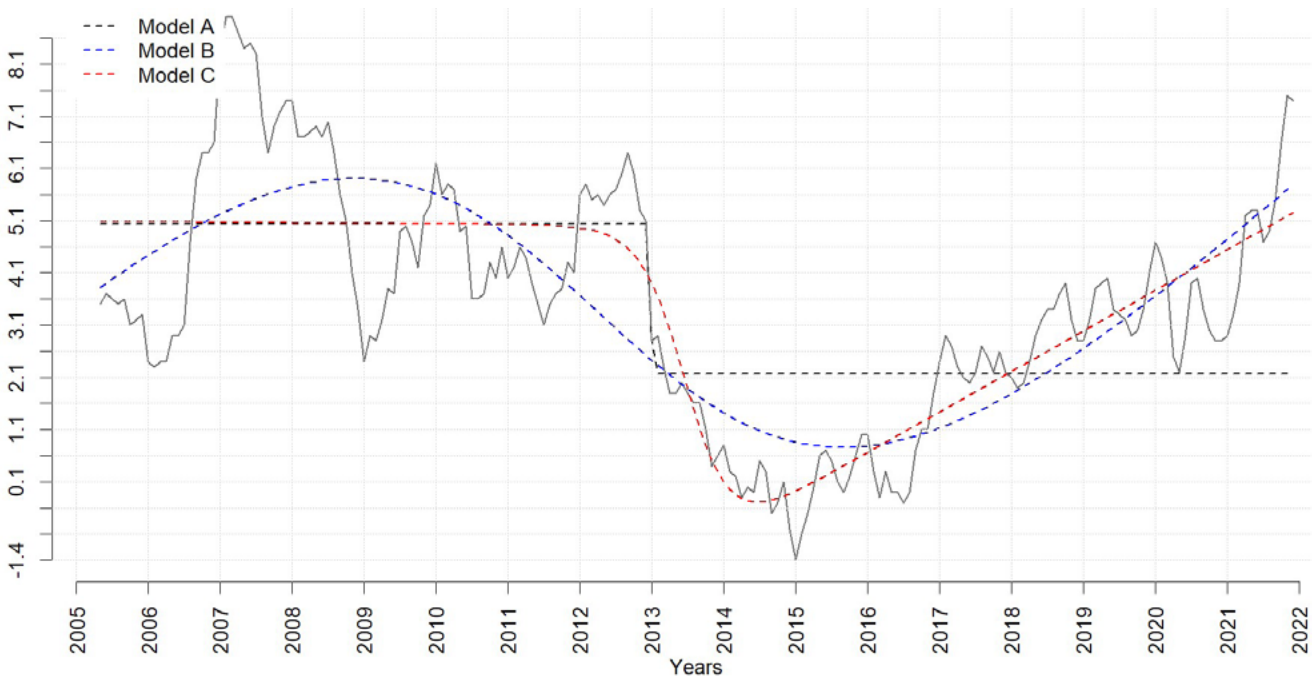

Figure 11. *Inflation of Hungary and Fitted Smooth Transitions*
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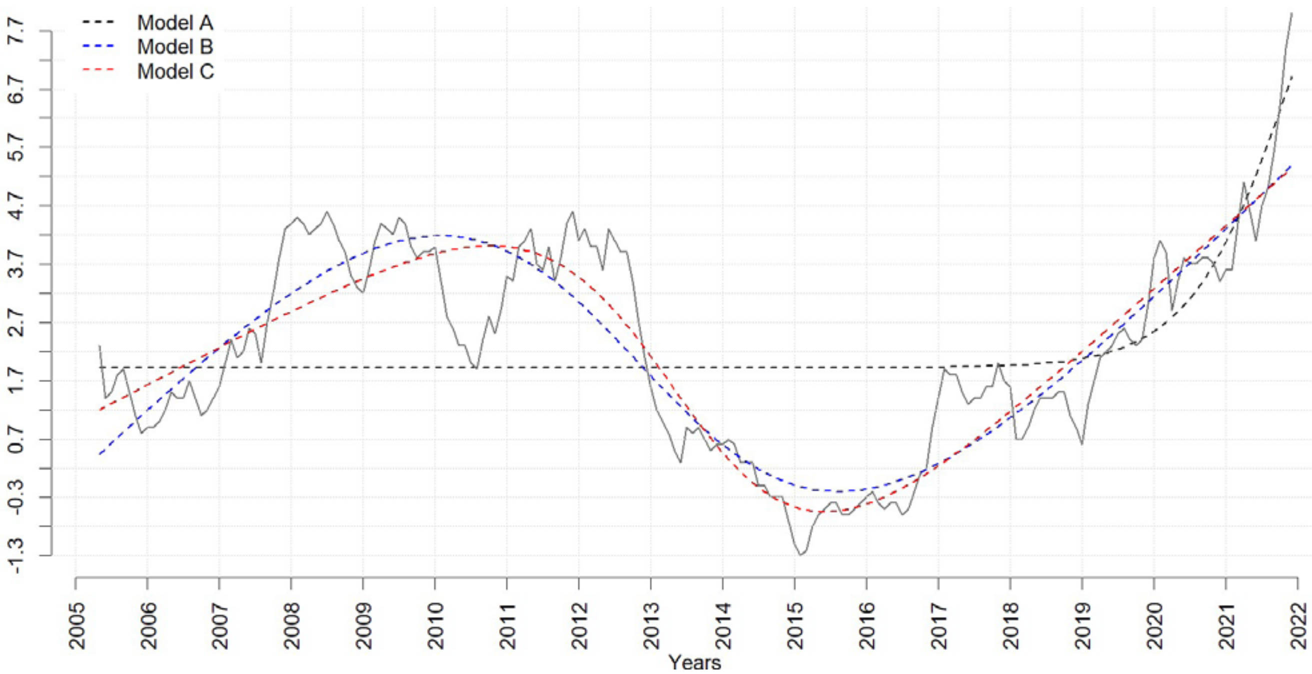

Figure 12. *Inflation of Poland and Fitted Smooth Transitions*
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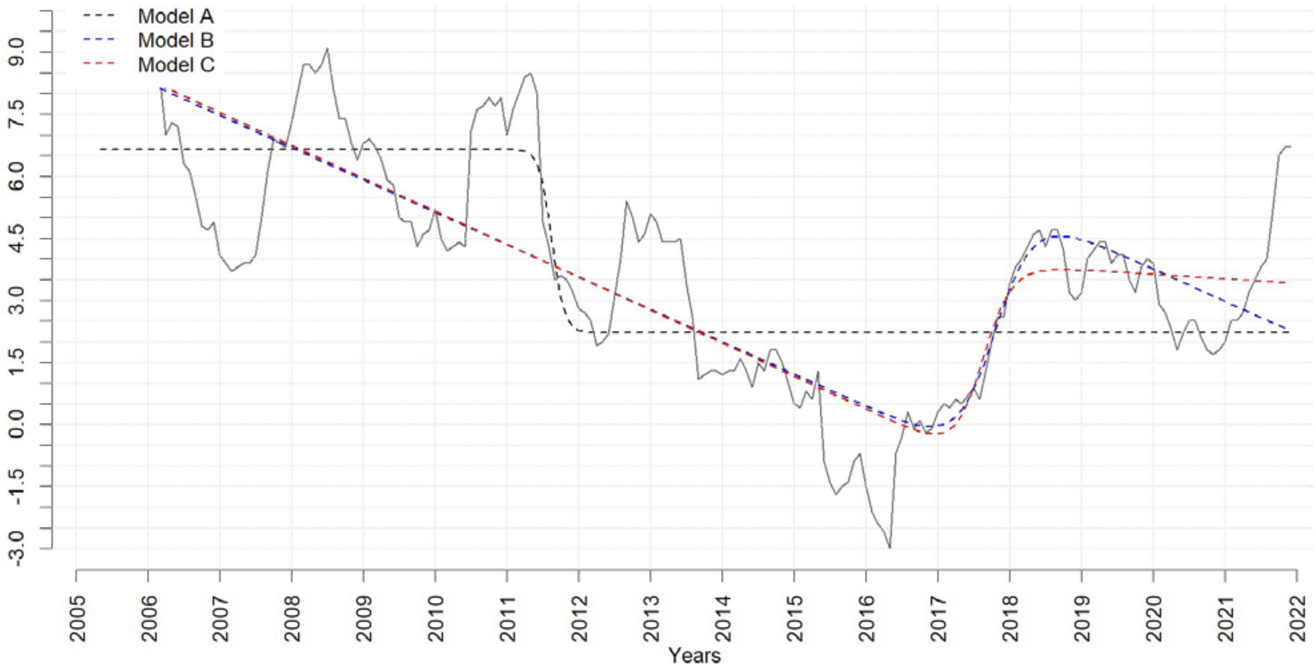

Figure 13. *Inflation of Romania and Fitted Smooth Transitions*
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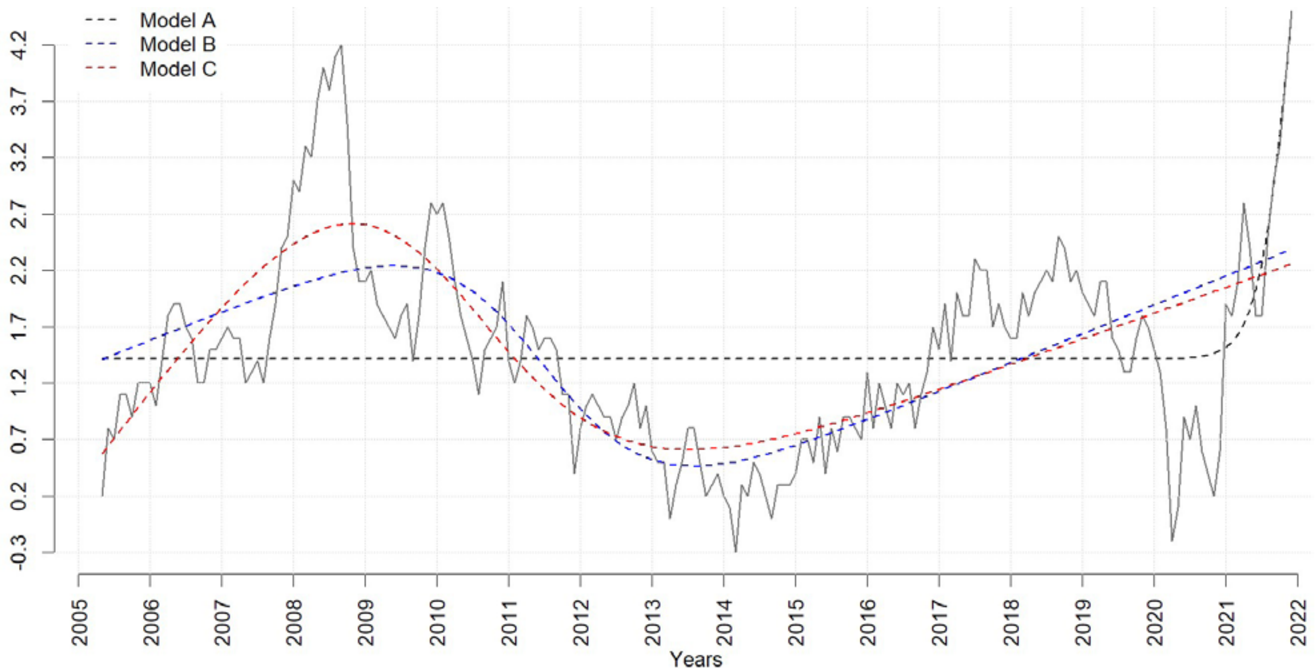

Figure 14. *Inflation of Sweden and Fitted Smooth Transitions*
Source: calculated and created by the author.

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