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Modeling the exchange rate pass-through in Turkey with uncertainty and geopolitical risk: a Markov regime-switching approach

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Abstract

Purpose – This paper aims to investigate the pass-through (PT) effect in Turkey by using quarterly data for the period 1998: Q1-2019: Q2 to understand the dynamic potential effects of exchange rates on domestic prices

Design/methodology/approach – The paper launches several nonlinear models in which the basic determinants of domestic prices in Turkey are determined through Markov regime-switching models (MSMs). Hence, this research follows the variables of the consumer price index (CPI), USD exchange rate, gross domestic product (GDP; demand side of the economy), industrial production index (production side of the economy), economic uncertainty and geopolitical risk index for Turkey.

Findings – This work explores that the exchange rate and demand side of the economy (GDP) follow a positive nonlinear relationship with CPI at both regimes. The production side of the economy (IP) affects negatively the CPI during regime 0. Economic uncertainty influences the CPI positively at Regime 1, while geopolitical risk has a negative association with CPI at Regime 0. Eventually, the paper provides some policy proposals associated with the impacts of GDP, IP, economic uncertainty and geopolitical risk on CPI in Turkey.

Originality/value – One may claim that any PT model, which does not observe the possible structural or regime shifts in estimated parameters, might fail to estimate the coefficients unbiasedly and efficiently. Hence, this work differs from available relevant works in the literature since this paper considers linearity or nonlinearity important and reveals that the relevant PT model follows a nonlinear path rather than a linear

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path, this nonlinear path is converged strongly by MSMs and estimates the significant regime shifts in the constant term and, in parameters of independent variables of PT by MSMs.

Keywords Pass-through effect, Exchange rate, Economic uncertainty, Geopolitical risk, Markov regime-switching, Turkey

Paper type Research paper

1. Introduction

The pass-through (PT) effect is defined as the impact of the changes in exchange rates on domestic prices (Menon, 1996; McCarthy, 2000). It can also measure the effect of exchange rates on the import and export prices (Sekine, 2006). The PT effect will occur completely and timely, when:

- the perfect competition conditions in the markets exist;
- full flexibility of the prices is available; and
- the validity of Purchasing Power Parity appears (Bailliu and Fujii, 2004).

The PT effect, in which a rise in exchange rates leads to an increase in consumer prices, works through two different channels. The first one is the direct effect and it works as follows: When a rise in exchange rates occurs, the local-currency prices of import raw materials goods, intermediate goods, final goods and production costs will increase. The increase in production costs causes consumer prices to rise (Hyder and Shah, 2004). The second one, which is defined as the indirect impact, occurs through the prices of import substitution goods and the prices of export goods and the labor market. With the increment in exchange rates, the reduction of export goods denominated in foreign currency has a positive effect on the competitiveness of countries. Indeed, with the rise of exchange rates, the increases in the demand for import substitution goods and the export goods will raise the prices of these goods (McFarlane, 2002). This later outcome brings about an increase in the supply of goods. The increasing demand for labor due to an increase in the supply of these goods leads to an increase in wages. Therefore, the increase in prices of the relevant goods and wages has effects on domestic prices. In other words, the increase in prices and wages is reflected in consumer prices.

The modeling of exchange rate PT needs to use some macroeconomic factors such as inflation, inflation volatility, interest rate volatility, exchange rate volatility, the output gap, oil price growth, import price, export price, macroeconomic performance money supply and the degree of trade openness in the relevant literature (Junior, 2007; Chang and Tsong, 2010; Lin and Wu, 2012; Shah *et al.*, 2017; Liming *et al.*, 2019; Phuc and Duc, 2019). In addition to these factors, uncertainties are also included in the model in recent works (Balcilar *et al.*, 2015; Roubaud and Arouri, 2018; Bartsch, 2019; Noria and Bush, 2019). In the literature, it has become important to examine uncertainty as one of the main factors determining the PT effect. At this point, a detailed description of the concept of uncertainty might be necessary.

According to Rossi *et al.* (2016), there are two kinds of uncertainty in the literature. One of them points to risk. It is defined by situations where one knows the odds of the unknown.

This unknown indicates the probability distribution of the stochastic events. The second is that, even though rational agents can characterize the distributions, they may not assign the correct possibilities to future results. However, there is no consensus about the definition of uncertainty. The concept of uncertainty is quite important in economics science as well as other sciences. With the liberalization of capital movements since the 1980s, the process of integration of countries into global markets began to gain momentum. This process has led countries to intensively experience external shocks as well as internal shocks. These shocks have brought

uncertainty to the forefront. Uncertainty in economics reflects a lack of information about current events. Due to uncertainty, some policy actions could cause further uncertainty about future outcomes for businesses and households. The economic uncertainty might be derived from different sources such as economic crises, wars, natural disasters, elections, legislation changes, etc. (Čižmešija *et al.*, 2017). The sources of uncertainty can influence the decisions of economic agents; individuals, firms and governments in real and financial sectors (Zhang *et al.*, 2015; Gulen and Ion, 2016; Gil-Pareja *et al.*, 2019; Jiménez-Hernández, 2019). From this point of view, one may claim that economic uncertainty contains financial uncertainty and macroeconomic uncertainty (inflation, exchange rate and growth rate) which can be defined as an evaluation method of the overall economic outlook (Kara, 2019).

As is indicated above, when both direct and indirect channels are considered, uncertainty is one of the most vital factors on PT effect which is commonly seen in developing countries. The degree to which developing countries are integrated into the global economy has gradually been increasing. This degree also increases the level of exposure to external shocks such as risks and uncertainties. According to the World's share of fundamental macroeconomic indicators (export, import, foreign direct investment (FDI), etc.) that indicate the level of integration, Turkey has an important position among these countries. For instance, Turkey's share in total exports and imports in the World is about 1.1% and 1%, respectively, in 2018. For the same year, regarding FDI, the share of inwards is 4% and outwards is 2% approximately. These values point that Turkey is affected by the risks and uncertainties highly, depending on the level of integrated degree into the global economy.

The degree of uncertainties needs to be reduced to achieve macroeconomic stability in the countries which aim at realizing economic growth and development. Another important factor can be the geopolitical risk in the explanation of the PT effect. Geopolitical risk can include continental-based, regional-based and/or country-based geopolitical threats, risks, invasion, terrorist attacks, war(s), etc. There exist several geopolitical risk measurements. The Geopolitical Risk Dashboard (BlackRock, 2019) and EPU Geopolitical Risk (Caldara and Iacoviello, 2012, 2018, 2019a, 2019b) appear to be visible sources of geopolitical risk indexes among other potential ones. The indexes consider mainly global trade tensions, major cyberattack(s), major terror attack(s), gulf tensions, specific trade competitions between leading countries, political conflicts, defense conflicts, etc.

There exist many studies examining the PT effect in a different country or/and country groups through different methods in the literature. Generally, the available studies in the literature have focused on the relationship between the PT effect and inflation targeting and/or monetary policy. Among these studies, one can observe throughout the literature review that no studies considered, besides the influences of basic macroeconomic and financial variables, the influences of economic uncertainty and other risks such as geopolitical risk on PT effect. One can also observe within the relevant literature that the researchers have launched mostly the methodologies of cointegration and causality analyses in which estimated coefficients are fixed for the whole sample data [1].

Therefore, the motivation of this paper lies in three points:

(1) the existing literature does not consider the relationship between the PT effect and economic uncertainty and geopolitical risk among other potential variables;

(2) the papers in the existing literature do not observe either the possible regime shifts in constant terms and estimated coefficients of the variables of PT effects; and

(3) hence, this paper follows the Markov regime-switching model (MSM) estimations to reveal the PT effect in Turkish economy by monitoring structural changes in demand and supply sides of the economy and indices of economic uncertainty geopolitical risk.

Eventually, this paper aims to examine the role of the exchange rate in determining the consumer price index (CPI) together with control variables of GDP, industrial production, economic uncertainty and geopolitical risk in Turkey through different states (regimes). However, economic uncertainty is unobservable and directly immeasurable. So, it can be measured indirectly by considering various indicators such as volatilities (Gulen and Ion, 2016). In recent years, there have been several attempts at measuring uncertainty. Baker *et al.* (2011) claimed that there exists no standard measure of this type of uncertainty. So, the most commonly used indicator of uncertainty is the Economic Policy Uncertainty Index (EPU) as explained in Baker *et al.* (2011) and Davis (2019). Therefore, this paper follows the variables of Consumer price index growth (CPI growth), USD Exchange rate growth (Exchange_g), Gross Domestic Product growth (GDP_g), Industrial production index growth (IP_g), Economic uncertainty (Econ-Uncertainty) and Geopolitical Risk Index (Geo-Risk) for Turkey. This data has been obtained from Federal Reserve Economic Data (FRED 2019) and Economic Policy Uncertainty (2019) for the period 1998: Q1 to 2019: Q2.

The paper is organized as follows. After the introduction section, Section 2 comprises data and empirical methodology, Section 3 reveals the estimation results, Section 4 contains the robustness checking section, and the last section comprises the conclusion and discussion section.

2. Methodology: Markov regime-switching model

The Markov regime-switching (MS) model, one of the nonlinear models pioneered by Hamilton (1989), is widely used in economics and finance literature (Engel and Hamilton, 1990; Bilgili *et al.*, 2012; Doğan and Bilgili, 2014; Ning and Zhang, 2018; Jin *et al.*, 2020). This model has emerged as a leading analysis for the detection and dating of business cycle turning points (Krolzig, 2001). MS model contains various structures that can describe the time-series actions in various regimes (Franses and Dijk, 2003; Doğan and Bilgili, 2014). The model allows the switching between these regimes (or states). Therefore, switching from one state to another state can detect more complicated dynamic behavior of the data. Since the MS model is controlled by an unobservable state parameter following the Markov chain, it can regulate the current value of the state variable that is instantly linked to the past value (Kuan, 2002). Therefore, the MS model examines the nexus among regimens in i and $i-1$ periods. Regime change is described as a probability function in the MS model. Regime periods in the model are determined by ψ_i which is a random factor and cannot be straightly monitored. The probability value of the ψ_i depends on the previous regime period as given in equation (1).

$$\beta\left\{\psi_i = m \mid \psi_{i-1} = n, \psi_{i-2} = k, \ldots\right\} = \beta\left\{\psi_i = m \mid \psi_{i-1} = n\right\} = \beta_{nm} \tag{1}$$

$$\{\beta_{nm}\}, \text{and } n,m = 1,2,3,\ldots,M$$

Simple MS model [equation (2)] and the transition among the regimes by first-order Markov process [from equation (3) to equation (6)] can be written as follows.

$$y_i = \delta_i + \delta_1 R_i + \varepsilon_i \tag{2}$$

$$\beta\left[\psi_i = 1 \mid \psi_{i-1} = 1\right] = a \tag{3}$$

$$\beta[\psi_i = 0|\psi_{i-1} = 1] = 1 - a \tag{4}$$

$$\beta[\psi_i = 0|\psi_{i-1} = 0] = b \tag{5}$$

$$\beta[\psi_i = 1|\psi_{i-1} = 0] = 1 - b \tag{6}$$

where a indicates the probability of being in a crisis, $1 - a$ indicates the probability of exiting the crisis, b is the probability of being in the stable period, and $1 - b$ indicates the probability of exiting the stable period. Also, $\psi_i = 0$ or $\psi_i = 1$ shows the undetected state of the equation (Hamilton, 1989).

The exogenous regime parameters will be determined by the Markov chain with the transition matrix β. Also, the (MxM) dimensional matrix β can be written as follows (Goutte, 2014).

$$\beta = \begin{bmatrix} \beta_{11} & \beta_{12} & \cdots & \beta_{1M} \\ \beta_{21} & \beta_{22} & \cdots & \beta_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_{M1} & \beta_{M2} & \cdots & \beta_{MM} \end{bmatrix}, \tag{7}$$

$$M = \{1, 2, 3, \ldots, \ M \ \}$$

The probability of the transition of the element corresponding to the row n and column m is β_{nm}. The factor in a row n, column m (β_{nm}) represents the density of the switch from the state (or regime) n to state (or regime) m and checks the possibility of a switch from the state (or regime) m to state (or regime) n.

3. Data and estimation output

This paper considers the nexus between PT effect and economic uncertainty, with the variables of CPI, USD exchange rate, Gross domestic product, Industrial production index, Economic uncertainty index and Geopolitical risk index for Turkey. The data has been obtained from St. Louis Federal Reserve Economic Data (FRED, 2019a, 2019b) and Central Bank of the Republic of Turkey (CBRT-EVDS, 2019) for the period 1998: Q1 - 2019: Q2.

The CPI covers all items for Turkey, index 2015 = 100, quarterly, not seasonally adjusted (FRED, 2019a, 2019b; CBRT-EVDS, 2019). Exchange rate (Exchange) depicts the national currency to US Dollar exchange rate: Average of daily rates for Turkey, National Currency Units per US Dollar, quarterly, not seasonally adjusted (FRED, 2019a, 2019b).

GDP denotes:

- Gross Domestic Product by expenditure in constant prices for Turkey,
- Real Net Domestic Product, percent change from preceding period, quarterly, seasonally adjusted annual rate (FRED, 2019a, 2019b).

Industrial Production (IP) Index indicates the production of the total industry in Turkey, index 2015 = 100, quarterly, seasonally adjusted (FRED, 2019a, 2019b).

Turkish economic uncertainty index: Economic uncertainty (Econ-uncertainty) indexes comprise the time series of the World Uncertainty Index (WUI) for 143 countries for the

quarterly period 1996: Q1-2019: Q1. The indices are measured by considering the frequency of the word "uncertainty" in the Economist Intelligence Unit's country reports. The indices have been normalized by considering the total number of words and rescaled by multiplying by 1,000. A higher index number means higher uncertainty and vice versa (EPU: Economic policy uncertainty index, 2019). The date has been derived from FRED (2019c, 2019d).

Turkish geopolitical risk index: Geopolitical risk (Geo-Risk) index (GPR) has been established by Caldara and Iacoviello (2012, 2017, 2019a, 2019b) by counting the occurrence of words related to geopolitical tensions in 11 leading international media [2]. In this sense, the GPR index considers, for instance, the Gulf War, Iraq invasion, Russia-Ukraine crisis and Paris terrorist attacks. GPR index covers monthly data for individual countries-based indexes constructed for 18 emerging economies including Turkey, Mexico, Korea, Russia, Hong Kong, etc. (Caldara and Iacoviello, 2017).

The paper finally launches the growth variables (CPI growth, USD Exchange rate growth, gross domestic product growth and Industrial production index growth) and variables in levels (Economic uncertainty index and Geopolitical risk index).

Table 1 depicts the estimations of alternative nonlinear models of CPI with its possible determinants through MSM1, MSM2, MSM3 and MSM4. Table 1 reveals the transition probabilities and goodness of fit statistics of MS models. All MS models (MSM1, MSM2, MSM3 and MSM4) reach strong convergence by SQPF (feasible sequential quadratic programming) using analytical derivatives and reject the linearity null hypothesis by a 1% significance level.

In Table 1, the MSM1 uses exchange rate growth (Exchange_g) and GDP growth (GDP_g) to explain the nonlinear movements of CPI growth at Regime 0 (less volatile period) and Regime 1 (high volatile period). MSM2 uses additionally the variable of industrial production growth (IP_g). MSM3 considers economic uncertainty as well. MSM4 estimates additionally the variable of geopolitical risk [3].

From MSM1 to MSM4, all estimated coefficients, except IP_g of MSM2, are found significant either at both regimes or at one regime with 1%, 5% and 10% significances [4]. The MSM4 is considered the best final MS model among others in terms of sigma (variance), likelihood, Akaike Information Criteria (AIC) and AIC times number of useful observations (AIC*T) and convergence (optimization of MS CPI model) criteria. The likelihood of MSM4 has the highest whereas the sigma and AIC of MSM4 have the lowest values in the table. In MSM4, the constant term at both Regime 0 and Regime 1 has significant positive signs with 1% significance levels. The exchange rate follows also a significant positive nonlinear relationship with CPI at both regimes.

An increase in exchange rate growth causes an increase in CPI growth. GDP growth which represents an expansion in aggregated expenditure results in a rise in inflation in Turkey. CPI growth variable has positive co-movements with GDP growth at both regimes. In the phase of the contraction period [5] (Regime 0), GDP growth has a significant positive impact on CPI growth with a *t-values* of 3.04. During an expansion period [6](Regime 1), the GDP growth has again a positive influence on inflation with *t-values* of 6.28. IP, which refers to a proxy of the production side of the economy, has a negative association with CPI. IP growth variable during the contraction period reduces the inflation rate with *t-values* of −2.00. The IP growth, on the other hand, has no repercussion on CPI growth during the expansion period of the Turkish economy. The economic uncertainty amplifies the inflation at Regime 1 at 1% significance level. Meanwhile, one observes as well from the table that the CPI does not respond to economic uncertainty during Regime 0. Finally, the geopolitical risk index variable has correlated negatively with CPI at Regime 0 as it has no significant impulses on the inflation rate in Turkey during Regime 1.

Variables	MSM1	MSM2	MSM3	MSM4
Constant	0.0181815	0.0190146	0.0214956	0.0325443
(Regime 0)	[6.25]	[6.77]	[5.64]	[4.489]
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.0844184	0.0840974	0.0598313	0.0727235
(Regime 1)	[10.2]	[10.9]	[6.25]	[5.00]
	(0.000)	(0.000)	0.000	(0.000)
Exchange_g	0.103916	0.0948989	0.0984918	0.0960139
(Regime 0)	[3.60]	[3.32]	[3.68]	[3.67]
	(0.001)	(0.001)	(0.000)	(0.000)
Exchange_g	0.196280	0.192966	0.154293	0.154087
(Regime 1)	[5.53]	[5.17]	[4.25]	[4.40]
	(0.000)	(0.000)	0.000	(0.000)
GDP_g	0.00177550	0.00229493	0.00255074	0.00230061
(Regime 0)	[2.32]	[2.81]	[3.32]	[3.04]
	(0.023)	(0.006)	0.001	(0.003)
GDP_g	0.00703356	0.00704282	0.00870093	0.00897510
(Regime 1)	[4.42]	[4.54]	[6.03]	[6.28]
	(0.000)	(0.000)	(0.000)	(0.000)
IP_g	–	−0.116800	−0.132203	−0.132315
(Regime 0)		[−1.66]	[−2.01]	[−2.00]
		(0.102)	(0.048)	(0.049)
IP_g	–	−0.0416746	−0.142926	−0.101737
(Regime 1)		[−0.337]	[−1.28]	[−0.911]
		(0.737)	(0.206)	(0.365)
Econ-Uncertainty	–	–	−0.00991373	0.00102752
(Regime 0)			[−1.04]	[0.0914]
			(0.304)	(0.927)
Econ-Uncertainty	–	–	0.0839755	0.0855484
(Regime 1)			[3.34]	[3.50]
			(0.001)	(0.001)
Geo-Risk	–	–	–	−0.000117223
(Regime 0)				–[1.77]
				(0.082)
Geo-Risk	–	–	–	−0.000123795
(Regime 1)				[−1.20]
				(0.235)

Table 1.
Markov regime-switching models for CPI growth (1998: Q1– 2019: Q2)

Notes: The dependent variable is CPI growth. The independent variables are given in the first column. The values in brackets are *t-values* and the *t prob*. values are given in parentheses

In Table 2, for MSM4, the probability of switching to Regime 0, as the current regime is 0, [p_{0|0}], is 0.966282. The probability of switching from state 0 (Regime 0) to state 1 (Regime 1) is considerably low [(p_{0|1} = 0.033718]. As the current regime of CPI is state 1 (Regime 1) at time *t*, the probability of CPI jumping from state 1 to state 0 is also low with the value of 0.178535. The probability of CPI remaining at Regime 1, when the current regime of CPI is 1, equals 0.82146.

Figure 1 yields actual and fitted CPI growth (CPI_g) obtained from MSM4. The red line denotes actual CPI_g, the bold blue line depicts fitted CPI_g, the dotted line shows 1 step prediction and the light grey area presents the Regime 1 area. Regime 1 areas explore high volatile periods whereas Regime 0 (white color area) areas capture less volatile inflation periods.

Table 2. Transition probabilities and goodness of fit statistics for MS models: (1998:Q1–2019:Q2)

Statistics	MSM1	MSM2	MSM3	MSM4
Sigma	0.0161828	0.0159953	0.0148196	0.0143143
Linearity Test	98.412 (0.0000)[a]	97.249 (0.0000)	107.05 (0.0000)	111.23 (0.0000)
p_{0|0}	0.966382	0.968864	0.967870	0.966282
p_{1|0}	0.033618	0.031136	0.032130	0.033718
p_{0|1}	0.187263	0.175488	0.173356	0.178535
p_{1|1}	0.81274	0.82451	0.82664	0.82146
log-likelihood	213.071302	214.391491	220.073541	222.595543
AIC*T	−408.142603	−406.782982	−414.147083	−415.191086
AIC	−4.80167768	−4.78568215	−4.87231862	−4.88460101
Convergence	Strong convergence by SQPF[b] using analytical derivatives	Strong convergence by SQPF using analytical derivatives	Strong convergence by SQPF using analytical derivatives	Strong convergence by SQPF using analytical derivatives
Observations	85	85	85	85

Notes: [a]The values in parentheses are *p*. values. [b]SQPF (feasible sequential quadratic programming) follows Ox function MaxSQPF, as is indicated in Lawrence and Tits (2001) (Oxmetrix-PCGive, 2014)

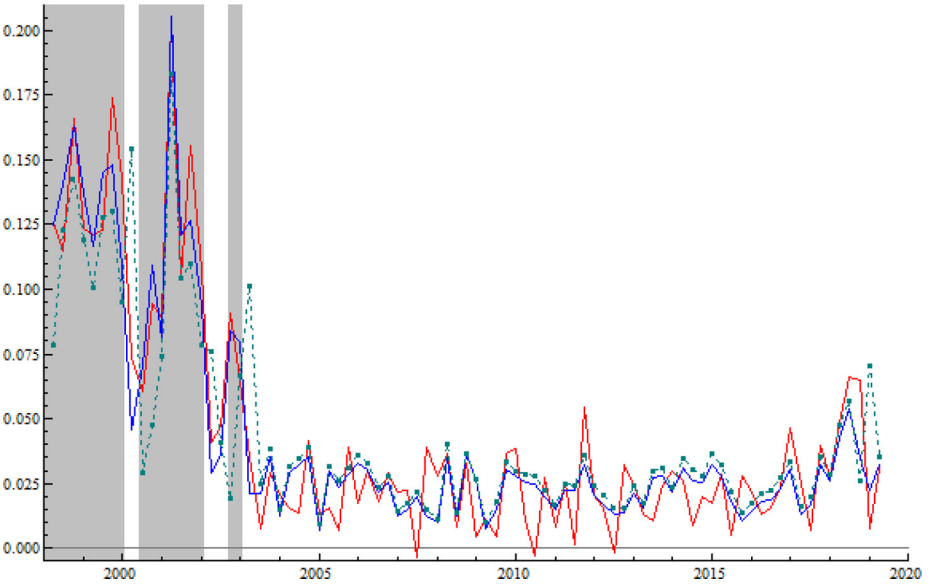

Figure 1.
Actual and Fitted CPI Growth

Following MSM4 estimations, Figures 2(a) and 2(b) reveal the time duration (regime classification) of smoothed probabilities. Figure 2(a) indicates the probability of Regime 0 smoothed (P [Regime 0] Smoothed) and Figure 2(b) shows the probability of Regime 1 smoothed (P [Regime 1] Smoothed), respectively. Table 3 reveals the regime classifications.

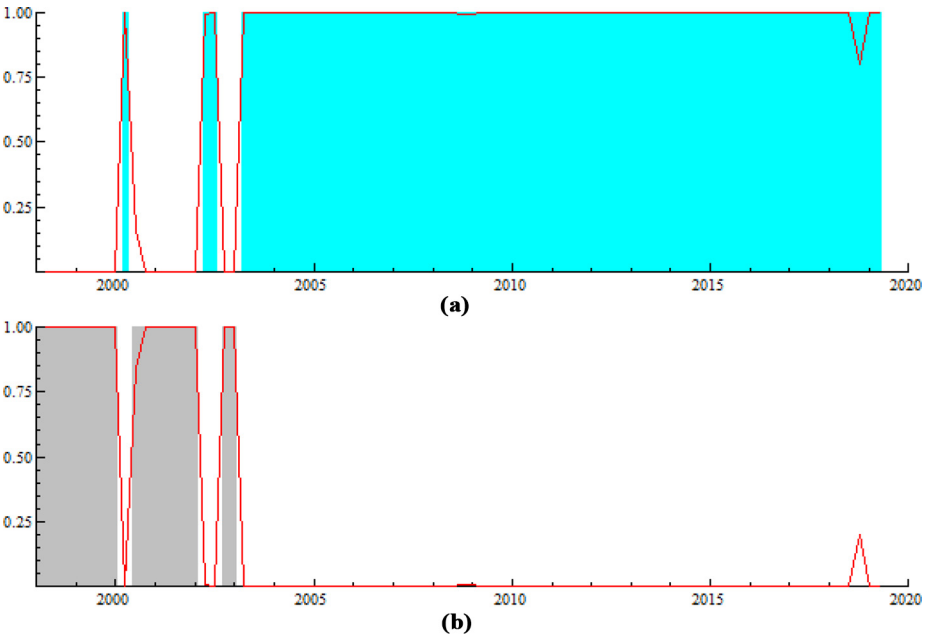

Figure 2.
(a) P [Regime 0] Smoothed, (b) P [Regime 1] Smoothed

Regime classification of Regime 0 based on smoothed probabilities refers to periods 2000(2) – 2000(2), 2000(2) – 2002(3) and 2003(2) – 2019(2), respectively. Regime classification of Regime 1 based on smoothed probabilities corresponds to periods 1998(2) – 2000(1), 2000(3) – 2002(1) and 2002(4) – 2003(1), respectively. Regime 0 classification covers a total of 68 quarters (80.00% of observations) with an average duration of 22.67 quarters whereas Regime 1 classification includes a total of 17 quarters (20.00% of observations) with an average duration of 5.67 quarters. The average probability of Regime 0 classification is 0.99766. The average probability of Regime 1 classification is equal to 0.99233.

What might be the empirical facts underpinning the output of Markov regime classification?

The period 1998(2)–2000(1), which is captured by Regime 1 classification, indicates the Turkish economic crises of 1999. The crises of 1991, 1994 and 1998, which led to serious weaknesses in the Turkish economy, triggered the 1999 crisis. Before 1999, the high public debts (approximately 40%), budget deficits (approximately 12%), real interest rates (approximately 70%) and inflation (approximately 80%) along with the external conjuncture (Asian, Mexican and Russian crises) brought about severe uncertainty environment by decreasing the confidence level in the Turkish Lira and thus increased exchange rates (Brinke, 2013). On the other side, high inflation and increasing uncertainties led savings owners to purchase short-term investment instruments. Besides, syndicated loans from the European Banking System had caused maturity mismatches in the financial accounts of the banks. So, the problem of repayment in banks happened. After the 1999 crisis, Turkish authorities decided to implement a decisive fighting program entitled "Transition to Strong Economy Program" against inflation in 2000. Following this program, interest rates went down faster than expected, the inflation rate slowed down, demand for domestic products increased, and eventually, the exchange rate diminished (CBRT, 2000).

The period 2000(3) – 2002(1), which is captured by Regime 1 classification refers to the Turkish financial crises of 2000 November and 2001 February. The interest rates on overnight borrowing in the interbank market in November 2000 approximately tripled. The rates jumped from 37% to 110.8% on average, to the highest 210% (Uygur, 2001). All these conditions required the devaluation of February 2000 and increased the exchange rates (CBRT, 2002).

The February 2001 crisis resulted in a considerable depreciation of the Turkish Lira, caused private investors to postpone the planned investment expenditures and gave rise to recession in Turkish GDP. The investment expenditures and hence GDP in the Turkish economy reduced by 5.7% and 30%, respectively (Macove, 2009). The high-country risk premium deepened the uncertainty in the environment and shaken the confidence in the Turkish lira, and the exchange rates moved upwards constantly. With the impact of fiscal

Regime 0	Quarters	Average probability
2000(2) – 2000(2)	1	1.000
2002(2) – 2002(3)	2	0.996
2003(2) – 2019(2)	65	0.997
Total: 68 quarters (80.00%) with an average duration of 22.67 quarters		
Regime 1	Quarters	Average probability
1998(2) – 2000(1)	8	1.000
2000(3) – 2002(1)	7	0.977
2002(4) – 2003(1)	2	1.000
Total: 17 quarters (20.00%) with an average duration of 5.67 quarters		

Table 3.
Regime classification based on smoothed probabilities

discipline and structural reforms in 2000, interest rates decreased, and an increase in the exchange rate slowed down (CBRT, 2002).

The period 2000(2)–2000(2), which is captured by Regime 0 classification refers to the exchange-rate-based stabilization program supported by an IMF stand-by agreement, which was launched in early 2000, to fight against inflation (CBRT, 2001). Following this program, interest rates started to fall due to the measures taken for fiscal discipline, increases in capital inflows, a decline in risk premiums and the exchange rate anchor (Brinke, 2013). This decline in the interest rates led to a slowdown in the inflation rates and hence domestic demand-led economic growth. As a matter of fact, in February 2000, the interest rate, CPI and PPI were approximately 42%, 69% and 67%, respectively (Uygur, 2001). Additionally, in the first quarter of 2000, the GDP growth rate was approximately 5.4% (TSI, 2021). This recovery caused the current account deficit as a percentage of GDP to jump to 4.8% by increasing the demand for imported goods. On the other hand, the inflation rate went down slower than expected, the rate of increase in prices was higher than the rate of increase in exchange rates, and eventually, the Turkish Lira appreciated against foreign currency units.

The period 2000(2) – 2002(3), which has been monitored by Regime 0 classifications, refers to both financial crises and a strong program against the crises. The program was also called "Strengthening the Turkish Economy-Turkey's Transition Program" which had been implemented due to the worsening economic conditions before the 2000s, and consequently, positive recoveries in interest rates, inflation rates and exchange rates were experienced.

The period 2002 (4) – 2003(1), which has been observed by Regime 1 classifications, depicts the effects of the transition program. By the end of 2002, consumer price inflation (29.7%) and wholesale price inflation (30.8%) dropped to the lowest level for the last 20 years and 16 years, respectively. These realizations increased the credibility of the program in terms of macroeconomic policies applied and structural reforms. This situation led to a decrease in inflation expectations and became the determinant of success in the fight against inflation. However, domestic demand remained at a level that did not affect inflation. Besides, the existence of a floating exchange rate regime reduced the degree and velocity of the exchange rate PT to the prices. On the other side, maintaining a monetary policy that focused on price stability within the scope of the transition program had also positive impacts on various macroeconomic indicators such as economic growth and employment. The macroeconomic effects, that appeared in 2002 (4), continued in 2003 (1) similarly (CBRT, 2002, 2003).

The period 2003(2)–2019(2), which is pointed out also by Regime 0 classification shows most likely the association between the Turkish economy and the global crisis in 2008, and the implements to avoid or mitigate the effects of the crisis. The various measures (foreign currency reserve requirement ratios, maturity extension in foreign exchange deposit transactions, etc.) had been taken by following monetary policy in Turkey. As a result of these measures, the process of normalization in the economy was initiated in 2010 (CBRT, 2010). The authorities aimed at:

- preventing overvaluation of exchange rates in 2011;
- conducting tight monetary policies as a result of the increase in inflation in 2015;
- implementing the policies to reduce inflation due to increases in food and oil prices in 2015;
- following tight monetary policy to stabilize foreign exchange liquidity and support financial stability; and

- eventually, expanding the monetary policy instruments because of the exchange rate volatility and volatile domestic price level in 2018 (CRBT, 2019).

4. Robustness checking

This paper has conducted robustness testing using different transition parameters of Econ-Uncertainty and GDP_g in MSM4. Table 4 reveals the output of MSM4 through different transition variables. The MSM4 column depicts the final output of Table 1 among four different MS models which corresponds to the last column values of the table. The purpose of re-plotting this column is to compare this column output with other column outputs. MSM4 follows the transition variable of Geo-Risk. The selection of the transition variable as Geo-Risk is based on the hypothetical assumption of causality from geopolitical risk to supply shocks and to prices. This assumption assumes a high correlation between geopolitical risk and price level although in the literature there exist a limited number of papers regarding the linkages between geopolitics and commodity prices and/or between geopolitical risk and markets (Murray, 2020; EIA, 2014: Foresight, 2019). Among these few studies, for instance, Hoque and Zaidi (2019, 2020) find positive and negative impacts of geopolitical risk on stock market performance in different countries.

This work has conducted robustness testing following different transition parameters. In Table 4, MSM4b and MSM4c columns follow the transition variables of economic uncertainty and GDP growth, respectively. In MSM4, MSM4b and MSM4c, all estimated coefficients, (except IP_g), in terms of magnitude, sign and significance during regimes 0 and 1 are similar (close) to each other. The estimated IP_g coefficients of MSM4, MSM4b and MSM4c are negative but the significance levels of IP_g of MSM4, MSM4b and MSM4c are (0.049) (0.140) and (0.072), respectively.

The bottom part of the table yields transition variables with transition matrix parameters. Under transition variables, b1 depicts the probability of staying at Regime 0 (p00) and b2 denotes the probability of switching from Regime 1 to Regime 0 (p01). 1st, 2nd and 3rd rows represent the corresponding coefficients, *t*-values (in brackets) and t-prob values (in parentheses), respectively. Besides the transition matrix parameters, one can also examine the transition matrix probabilities. To save space, however, the table does not reveal matrix probabilities. AIC and SC denote the Akaike info criterion and Schwarz criterion, respectively. The lower the AIC and SC, the better the model fits data. Considering also the lowest log sigma value of MSM4 among three MS models, one can decide that MSM4 fits data better.

Overall, one can indicate that the MSM4 model from Table 4 (hence from Table 1) is appropriate to explore the effects of Geo-Risk factors on CPI_g in Turkey, and following Hoque and Zaidi (2020) one can state that MSM4 estimations are free from specification error issues.

This work has also considered using some global factors such as global geopolitical risk index (GPR), WUI and World oil prices. To this end, MSM5, MSM6 and MSM7 models included additionally GPR, WUI and World oil price growth, respectively, to the MSM4 model. Overall; this paper might reveal that the regime shifts predictions of CPI_g in MSM4 can be considered more efficient and consistent among other MS predictions [7]. We also compared the outputs of MS models and the outputs from regressions with normal distributions with different functions and/or quantile regressions at different quantiles, one might state that, although distributions and quantiles matter, any regression function might fail to capture the effects of independent variables on ERPT without estimating the outputs from different regimes/states [8].

Variables	MSM4	MSM4b	MSM4c
Constant	0.0325443	0.032636	0.032139
(Regime 0)	[4.489]	[4.011]	[4.017]
	(0.000)	(0.000)	(0.000)
Constant	0.0727235	0.068107	0.062584
(Regime 1)	[5.00]	[5.031]	[4.682]
	(0.000)	(0.000)	(0.000)
Exchange_g	0.0960139	0.099122	0.103745
(Regime 0)	[3.67]	[3.380]	[3.534]
	(0.000)	(0.000)	(0.000)
Exchange_g	0.154087	0.161975	0.184271
(Regime 1)	[4.40]	[4.506]	[5.468]
	(0.000)	(0.000)	0.000
GDP_g	0.00230061	0.002179	0.002329
(Regime 0)	[3.04]	[2.619]	[2.602]
	(0.003)	(0.008)	(0.009)
GDP_g	0.00897510	0.009752	0.010832
(Regime 1)	[6.28]	[7.416]	[9.609]
	(0.000)	(0.000)	(0.000)
IP_g	−0.132315	−0.131376	−0.137707
(Regime 0)	[−2.00]	[−1.474]	[−1.793]
	(0.049)	(0.140)	(0.072)
IP_g	−0.101737	−0.061522	−0.041661
(Regime 1)	[−0.911]	[−0.571]	[−0.407]
	(0.365)	(0.567)	(0.683)
Econ-Uncertainty	0.00102752	0.000837	0.055207
(Regime 0)	[0.091]	[0.066]	[0.055]
	(0.927)	(0.9467)	(0.956)
Econ-Uncertainty	0.0855484	0.093576	0.092562
(Regime 1)	[3.50]	[3.735]	[3.774]
	(0.001)	(0.000)	(0.002)
Geo-Risk	−0.000117223	−0.000117	−0.000118
(Regime 0)	–[1.77]	[−1.741]	[−1.758]
	(0.082)	(0.082)	(0.078)
Geo-Risk	−0.000123795	−0.000133	−0.000140
(Regime 1)	[−1.20]	[−1.417]	[−1.484]
	(0.235)	(0.156)	(0.137)
Log Sigma	−4.244732	−4.270023	−4.270560
	[−48.889]	[−45.563]	[−48.807]
	(0.000)	(0.000)	(0.000)
b1	Transition Variable:	Transition Variable: Econ_Unc.	TransitionVariable:
b2	Geo-Risk	3.400850	GDP_g
	0.017204	[1.540]	0.181593
	[2.152]	(0.123)	[1.299]
	(0.031)	–12.45265	(0.193)
	–0.029640	[−3.551]	–1.042940
	[−4.161]	(0.000)	[−3.799]
	(0.000)		(0.000)
AIC	−4.906979	−4.837105	−4.639346 –4.208290
SC	–4.475923	–4.406049	

Table 4.
MS Models for CPI growth (1998:Q1–2019:Q2) with different transition variables

Notes: The dependent variable is CPI growth. The independent variables are given in the first column. The values in brackets are *t*-values and the *t* prob. values are given in parentheses

5. Conclusion and discussion

This paper aims at estimating the nonlinear models in which the basic determinants of domestic prices in Turkey are predicted through MSMs.

Therefore, to identify well the nonlinear PT model in Turkey, this paper considers the variables of CPI growth, USD Exchange rate growth, Gross Domestic Product growth, Industrial production index growth, Economic uncertainty and Geopolitical Risk Index for Turkey.

The paper eventually estimates the possible potential structural breaks (regime shifts) available in the models and observes the regime shifts in constant term and in parameters of independent variables of four MSMS to explain the PT in Turkey.

Among others, the 4th Markov regime-switching model (MSM4) is found best according to the goodness of fit statistics. In MSM4, the exchange rate has a positive and significant effect on the CPI at Regime 0. A similar significant positive impact appears also at Regime 1. Therefore, both at Regime 0 (low volatile period), and, at Regime 1 (high volatile period), an increase in exchange rates leads to an increase in the CPI in Turkey.

In MSM4, GDP growth and economic uncertainty seem to have also positive impacts on the CPI at both regimes. An expansion in expenditures at commodity and service markets (GDP by expenditure) brings about an increase in the price level. An increase in economic uncertainty might result in a switch of loanable funds from domestic investment areas to foreign investment areas which can, in turn, cause an increase in interest rates of available loanable funds in Turkey. The higher interest rates can amplify production costs, hence, raise the cost of inflation. The economic uncertainty, however, is significant only at Regime 1 while GDP growth is significant at both regimes. Regime 1 corresponds to high inflation or a highly volatile period. Thus, one can claim that Markov regime-switching model 4 captured the significant influences of GDP on consumer prices at both stable (low volatile) periods and high volatile periods of the price movements. On the other hand, the MSM4 model captured the significant impact of economic uncertainty on consumer prices during less stable (high volatile) periods of price level fluctuations. Additionally, the impact of both variables on the CPI was determined to be higher at Regime 1.

Industrial production growth and geopolitical risk have significant negative impacts on the CPI during Regime 0. The industrial production index, which is a proxy for the real production side of the economy, has a negative association with price levels, as is expected. The aggregated demand for commodities and services might shrink due to geopolitical risk and hence, the risk can lower the CPI. Both variables captured the variance of CPI during less volatile (less inflation) period rather than high volatile (unstable) period.

Briefly, an increase in the exchange rate causes an increase in the CPI. This situation refers to the validity of the PT effect. The analyses' results are supported by the papers available in the literature such as the papers of Bailliu and Fujii (2004), Junior (2007), Lin and Wu (2012), Mujica and Saens (2015), Tümtürk (2017) and Campos (2019). After all, if GDP growth and economic uncertainty increase, consumer prices move upward. One can notice also from the estimations that economic uncertainty has more effect on consumer prices than GDP growth at Regime 1.

The Turkish economy, discussed in this research, has a fragile structure as a developing country since she has not yet completed the industrialization process, and frequently and considerably responds to internal and external shocks due to her terms of trade, uncertainties and risk(s).

This statement has two main remarks exhibiting that:

(1) the CPI movements of a developing country might be significantly sensitive to economic uncertainty and geopolitical risks; and

(2) the realized responses might further boost the uncertainty and risks by high volatility in exchange rates and price level.

These remarks are consistent with seminal works such as Krol (2014), Kido (2016), Beckmann and Czudaj (2017) and Liming *et al.* (2019).

This paper finally suggests that policymakers should keep track of phases/regimes (contraction and expansion) of business cycles closely to reach more favorable terms of trade and price targets.

Potential future work(s) can investigate the PT effect model in Turkey and/or in other developing or developed countries by using financial and/or political uncertainties as well as economic uncertainty and geopolitical risk. Such future researches can consider as well the Markov regime-switching vector autoregression models, or dynamic MSMs, or time-series/panel structural vector autoregression models to confirm/disconfirm the output of this paper.

This paper might suggest that future works consider as well the moderator effects of economic uncertainty and geopolitical risk on ERPT through time domain and frequency domain estimations (e.g. with discrete or continuous wavelet analyses) to observe the influences of economic uncertainty and geopolitical risk on ERPT at a different time and frequency intervals of the sampled data. Or, future works might follow time series or panel structural VAR, or, panel data quantile regressions to observe the effects of economic uncertainty and geopolitical risk on ERPT at 10th, 25th, 50th,75th and 90th quantiles with and without fixed effects.

5.1 Data availability statement

Data were derived from public domain resources. The data that support the findings of this study are available in Baker *et al.* (2011), FRED (2019a, 2019b, 2019c, 2019d) and Caldara and Iacoviello (2019a, 2019b). The authors included citations for available data in their reference section.

Notes

1. Interested reader can reach the relevant review literature through the link given in Appendix 1.
2. *The Boston Globe, Chicago Tribune, The Daily Telegraph, Financial Times, The Globe and Mail, The Guardian, Los Angeles Times, The New York Times, The Times, The Wall Street Journal* and *The Washington Post*.
3. We considered also the International Trade (Net trade) for Turkey in MSMs. Since we obtained insignificant *t* statistics with *prob*. values of greater than 0.25, we decided to conduct MSMs without the International Trade variable.
4. IP_g of MSM2 has the *prob*. value of 0.102 during regime 0. It can be considered significant at 15% level.
5. Or, stable period, low inflation period, low volatility period or less volatile inflation period.
6. Or, an unstable period, high inflation period or high volatile period.
7. Although we did not give the estimated outputs to save space, one can reach the relevant estimated outputs through the link given in Appendix 2.
8. We did not give the estimated outputs to save space. One can reach the relevant estimated outputs through the link given in Appendix 3.

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Appendix 1

http://iibf.erciyes.edu.tr/workingpapers/fbilgili/fbilgili_Appendix_A.pdf

Appendix 2

http://iibf.erciyes.edu.tr/workingpapers/fbilgili/fbilgili_Appendix_B.pdf

Appendix 3

http://iibf.erciyes.edu.tr/workingpapers/fbilgili/fbilgili_Appendix_C.pdf

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