**Hacettepe Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi**
Hacettepe University Journal of Economics and Administrative Sciences
https://dergipark.org.tr/tr/pub/huniibf
**ISSN:1301-8752 E-ISSN:1309-6338**

**Başvuru Tarihi / Submission Date: 29/06/2022**
**Kabul Tarihi / Acceptance Date: 07/01/2023**

**DOI:10.17065/huniibf.1137805**
**2023, 41 (2), 251-270**

*Araştırma Makalesi / Research Article*

# Transmission Mechanism between Consumer and Producer Prices in Fragile Five Countries: Threshold Cointegration and Error Correction

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## Abstract

This study focuses on examining the interrelationship between consumer and producer prices within the framework of the fragile five within the scope of asymmetric models. Considering the 2010:M1-2021:M8 period, TAR and M-TAR cointegration and error correction models were used in the study. The results of the analysis indicated that there was no asymmetrical relationship between CPI and PPI for Brazil and India, while it pointed to an asymmetric long-term relationship for South Africa, Indonesia, and Turkey. According to the asymmetric error correction estimation results, while no long-term asymmetric causality relationship could be found for Indonesia, South Africa and Turkey, it was determined for the short-term. According to this, there is a causal relationship from PPI to CPI for Indonesia, from CPI to PPI for South Africa, and bidirectional causality for Turkey. The differences in the transmission mechanism between the price indices of the fragile five countries reveal the differences in the internal dynamics of the countries.

***Keywords:*** *Inflation, Consumer Prices, Producer Prices, Threshold Cointegration, Threshold Error Correction.*

# Kırılgan Beşli Ülkelerde Tüketici ve Üretici Fiyatları Arasındaki Aktarım Mekanizması: Eşik Eşbütünleşme ve Hata Düzeltme

## Öz

Bu çalışmada tüketici ve üretici fiyatlar arasındaki akaktarım mekanizması, asimetrik modeller çerçevesinde ve kırılgan beşli ülkeler kapsamında incelenmiştir. Çalışmada 2010:M1-2021:M8 dönemi dikkate alınarak TAR ve M-TAR eşbütünleşme ve hata düzeltme modelleri kullanılmıştır. Analiz sonuçları Brezilya ve Hindistan için TÜFE ile ÜFE arasında asimetrik bir ilişki olmadığını gösterirken, Güney Afrika, Endonezya ve Türkiye için uzun dönemli asimetrik bir ilişkiye işaret etmiştir. Asimetrik hata düzeltme tahmin sonuçlarına göre Endonezya, Güney Afrika ve Türkiye için uzun dönemli asimetrik nedensellik ilişkisi bulunmazken, kısa dönemde nedensellik ilişkisi tespit edilmiştir. Kırılgan beşli ülkelere ilişkin fiyat endeksleri arasındaki aktarım mekanizmasının farklı işlemesi, ülkelerin iç dinamiklerinin farklılığını ortaya koymaktadır.

***Anahtar Kelimeler:*** *Enflasyon, Tüketici Fiyatları, Üretici fiyatları, Eşik Eşbütünleşme, Eşik Hata Düzeltme.*

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**Atıf/Cite as:** Mert, N. (2023). Transmission mechanism between consumer and producer prices in fragile five countries: Threshold cointegration and error correction. *Hacettepe Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 41 (2), 251-270.

## INTRODUCTION

The primary objective of monetary policy, which is one of the most frequently used economic policy tools in the fight against economic problems that have arisen in recent years, is price stability, which is accepted by both economists and monetary authorities. That is, the focus of attention of monetary policy is the steps to solve the inflationary trend. As a result of the closure processes experienced after the global epidemic, countries have implemented expansionary monetary policies against the risk of recession in the economy. The increase in the monetary base at a speed that has never been experienced before in history has brought along the concerns that the high inflation experiences in the past will re-emerge. In such a period and environment where the economies are extremely fragile, policy authorities should pay more attention than ever to the nature of the problem and the origin of the problem in the steps to be taken against inflationary pressures.

The important factor behind the inflationary process in emerging economies is the monetary policy followed by the FED and the pressure on exchange rates created by capital outflows. While nominal exchange rates are expected to appreciate due to the abundance of liquidity in developing countries, especially due to the expansionary monetary policies implemented by the FED, the abundance of liquidity may cause high inflation and the real exchange rate may lose value (Kangal, 2021). On the other hand, while the exchange rate is effective on inflation through the cost channel, fluctuations in the exchange rate may affect the total demand both in the short and long term (Uslu, 2012). Since the exchange rate can directly affect the prices of imported goods and the direction of expenditures, it may have an impact on inflation (Landry, 2005). Excessive increases above the growth in the monetary base of countries pose a risk of consumer inflation by increasing consumption. This situation indirectly pumps producer inflation due to the increasing demand for products in the market. The fact that the US Federal Reserve (FED) started to reduce its bond purchases at the end of 2013 adversely affected many developing countries and the national currencies of these countries depreciated significantly against the US dollar. In this process, the sharp depreciation in the exchange rate increased the costs of production and led to a significant increase in producer inflation. It is an inevitable fact that deviations in producer inflation will reflect on consumer inflation and lead to deviations in targeted inflation (Yıldırım, 2015). Therefore, the direction and extent of the pass-through of producer and consumer prices on each other is of great importance for policy authorities.

The high financial needs of foreign-dependent countries make the economies of those countries more fragile externally. In the report published by Morgan Stanley in 2013, five countries including Brazil, Indonesia, South Africa, India, and Turkey were named as the "Fragile Five". The grouping of the fragile five, on the other hand, was formed after the US Federal Reserve's (FED) statement that it would reduce its bond purchases. When the World Bank development indicators of the fragile five countries are examined, it is observed that all of the countries have increased their monetary bases proportionally more than the FED. This is to reduce the value of the national currencies of the countries against other stable currencies that are accepted and demanded all over the world. In this context, it has been observed that all national currencies of the countries subject to the study have depreciated against the USD (World Bank, World Development Indicators).

This study investigated the transmission mechanism between consumer and producer prices within the framework of nonlinear models and fragile five countries, taking into account

the lack of literature. The sections of the study continue as follows. Following the introduction, the second section consists of the theoretical framework and literature on the subject, the method used in the study is mentioned in the third section, and the dataset and empirical findings are reported in the fourth part. The study is concluded with the fifth section.

## 1. REVIEW OF THE THEORETICAL FRAMEWORK AND LITERATURE

While the consumer price index (CPI), which is frequently used in the measurement of inflation, measures the changes in the prices of the goods and services purchased by the households, the producer price index (PPI) measures the changes in the prices of the goods made by the domestic producers. When the PPI and CPI baskets are analyzed, while domestically produced intermediate goods are in the PPI basket, they are not in the CPI basket, and imported final goods are in the CPI basket but not in the PPI basket. Also, following practice in most OECD countries, services including housing rental, transport and telecommunications, health and education are excluded from the PPI index but included in the CPI index. Although central banks usually set their inflation targets according to CPI, the existing literature has continued to research and make policy recommendations for many years, whether CPI or PPI is more appropriate in setting inflation targets (Wei & Xie, 2018). In the relevant literature, three different hypotheses regarding the transmission mechanism between consumer and producer prices are mentioned.

$H_1$: $The\ supply-side\ approach\ is\ valid\ (PPI \rightarrow CPI)$.

Inflation may occur as an effect on producer prices depending on the change in input costs, and then on consumer prices with a spillover effect in the production chain. According to this approach, which is described as supply-side or cost-push within the framework of the New Keynesian view, the transmission mechanism operates from producer prices to consumer prices. Because all firms are dominated by households, distortions associated with PPI inflation also decrease household welfare (Wei & Xie, 2018). According to Clark (1995), the trend of producer prices should give an idea about the future trend of consumer prices, provided that CPI and PPI take place in the production chain. Changes in raw material prices must pass into intermediate and final goods prices and ultimately consumer prices. Considering the aforementioned indirect successive link between price indices, the production chain view can be tested by estimation methods to see if consumer prices are effective in explaining producer prices. In particular, it can be stated that CPI inflation responds significantly to imbalance errors in respect to the long-term pass-through between price indices. When producer prices experience a shock, the CPI temporarily rises in the long run until consumer and producer price levels are in equilibrium. (Sidaoui et al., 2009).

The literature on the subject has concentrated on studies investigating the relationship between related variables within the framework of linear causality analysis. Most of these studies (Alemu, 2012; Erdem & Yamak, 2014; Ghazali, et al., 2008; Li, et al., 2019; Saraç & Karagöz, 2010; Sidaoui, et al., 2009; Tiwari, et al., 2013; Yıldırım, 2015) have found that the direction of causality is from PPI to CPI. Ghazali et al. (2008) found a long-term relationship between consumer and producer prices for the Malaysian economy, and also revealed that there is a unidirectional causality relationship from producer prices to consumer prices. Sidaoui et al. (2009) examined the long- and short-term effects of the producer price index on consumer prices. According to the in-sample and out-of-sample causality analysis within the scope of error correction model it was concluded that it would be beneficial to use information about PPI in

CPI inflation forecasts for Mexico. When producer prices are subject to a shock, CPI inflation for a while rises until consumer price levels adjust to their long-run relationship with producer prices. In their study Saraç and Karagöz (2010), found that there is only one-way causality from PPI to CPI in both the long and short run for Turkey. They explained that the imbalance in the short-term could not be eliminated in the long-term by the fact that the effects of cost shocks on the CPI were permanent.

Alemu (2012) study is one another rare study that investigates the asymmetrical relationship between variables. For South Africa, he found a dynamic unidirectional causal relationship from producer to consumer inflation and when the asymmetric relationship was examined, it was revealed that consumer prices increase faster than they fall. In another study investigating the time-frequency relationship between variables for Romania using a continuous wavelet transform approach, Tiwari et al. (2013) reported that inflation based on PPI was ahead between 1991-1993 and 2004-2010 and PPI-based inflation fell behind in the 1993-1994 and 1995-1999 periods. Based on these results, they provided strong evidence that cyclical and non-cyclical effects from variables were not observed. Erdem & Yamak (2014), using Kalman Filter analysis, obtained elasticity values for each period, examined the degree of pass-through between indices, the possibility of the relationship between indices to change over time, and they found that there was a decline in the pass-through from the producer price index to the consumer price index in Turkey for the period of 2003-2012. Li et al. (2019) found a long-term relationship and the short-term fluctuations in their study, in which they examined the effect of the industrial producers' price index on the consumer price index with the VEC model for China.

$H_2$: $The\ demand-side\ approach\ is\ valid\ (CPI \rightarrow PPI)$.

On the other hand, the New Classical view described the situation as demand-side or demand-pull inflation, which occurs when demand shocks for different reasons increase consumer prices, and subsequently the demand for inputs and input costs. Tarı et al. (2012) investigated the relationship between price indices with the frequency domain approach, which reveals long- and short-term causality, unlike traditional causality tests. While the authors found a causal relationship from producer prices to consumer prices in the 1987:1-1993:4 period in the short run, they found that the causality relationship between the related variables was from CPI to PPI in the long run.

In some of the studies (Cerquera-Losada et al., 2018; Khan et al., 2018; Yin & Jia, 2013) on various countries in the literature, different findings for countries have been reached. Yin & Jia (2013) examined the asymmetric relationship between the variables for 10 countries, while no cointegration relationship could be found for almost all countries according to the linear cointegration test, but considering the asymmetric fit, there was a cointegration relationship in Pakistan, Indonesia, Denmark, Japan, Spain, Canada, and Uruguay. In their study of 10 CEE countries, Khan et al. (2018) found that PPI had a significant effect on CPI for Latvia, Lithuania, Romania, Slovakia, and Slovenia. On the other hand, there is a causality relationship from CPI to PPI only for Hungary. Khan et al. (2018) also tested the effects of CPI and PPI on each other with SGMM analysis using a large number of macroeconomic variables and they revealed that CPI and PPI have positive and statistically significant effects on each other. In another study for six South African countries Cerquera-Losada et al. (2018) found a long-term relationship between the two indices for Brazil, Uruguay and Peru, but not for Ecuador, Colombia, and Paraguay. In addition to these, the results of the causality test revealed a bidirectional causality between CPI and PPI for Peru, and a unidirectional causality from CPI to PPI for Paraguay. For Brazil, Colombia,

Ecuador and Uruguay, no prove was found to provide a causal relationship between these variables.

$$H_3: The\ bidirectional\ transmission\ mechanism\ is\ valid. (CPI \leftrightarrow PPI).$$

Another view frequently encountered in the literature is that there is a bidirectional transmission mechanism between price indices. Clark (1995), in his study investigating whether there is a transmission mechanism from PPI to CPI, argues that the relationship between price indices is weak; he concluded that PPI changes sometimes help to predict CPI changes, but cannot do this systematically, and stated that recent increases in some producer price indices do not by themselves mean higher CPI inflation. Shahbaz et al. (2009) revealed that there is a bidirectional causality relationship between consumer and producer inflation for Pakistan, but stronger from producer to consumer. In addition, a long-term relationship between the two variables was found for Pakistan, which is a small developing economy. Tiwari and Shahbaz (2013), static and dynamic causality between price indices is analyzed in the context of India. The outcomes of the analysis showed that there is bidirectional causality between the related variables in both the long and short run. When the coefficients related to WPI and CPI are compared, they concluded that the effect of WPI on CPI is less than the effect of CPI on WPI. Su et al. (2016) used the bootstrap-rolling window technique to examine the causality for Slovakia, to overcome the problem of structural variation in data. They emphasized that traditional causality methods could not define the relationship between the full sample and sub-sample and were deficient in detecting time variation, and stated that the bootstrap rolling window method overcame these problems. The analyses showed that there is a bidirectional causality relationship, supporting the neoclassical profit maximising model. Examining the relationship in terms of determining the dominant pricing approach in an economy, Topuz et al. (2018) found a bidirectional causality relationship between the two variables for both Turkey and England. Producer prices are comparatively more essential on the consumer prices in both countries.

Considering the sub-items of consumer prices and producer prices, studies (Abdioğlu & Korkmaz, Anggraeni & Irawan, 2018; 2012; Jongwanich et al., 2019; Koçak, 2021; Öner, 2018) examining the relationship between them and contributing to the literature were also encountered. Abdioğlu and Korkmaz (2012), investigated the relations between the relevant sectors in terms of price pass-through by determining the sub-sectors in which CPI and PPI contain almost the same mutually, as well as their general levels for Turkey. It has been determined that there is a long-term association between consumer and producer prices in terms of clothing, health and education-communication-culture sub-indices. In the study of Atuk et al. (2013), in which they focused on the reasons for the differentiation between inflation rates, the pass-through relationship between the two indices was investigated. As a result of the estimations made using two different price definitions, general and core, it is seen that the pass-through is partial in the short run, even when the main items that distort the relationship between indices are excluded. However, the short-term pass-through in the core goods group, which is a narrowly defined price indicator, is estimated to be approximately twice that of the CPI.

Examining the relationship inflation rates and sub-inflation items of PPI and CPI, Öner (2018) concluded that when compared to PPI, sub-inflation items triggered CPI inflation more seriously. The common items in which the causality relationship is determined with the CPI and PPI inflation rates are entertainment and culture, furniture, household appliances and home care, and health sub-inflation items. Anggraeni and Irawan (2018) found a one-way causality

relationship from PPI to CPI in general and from CPI inflation to PPI inflation in the clothing group for Indonesia. Jongwanich, et al. (2019), was found that in countries where oil use is intense, government intervention is limited in energy and energy-related sectors, and energy efficiency is low, the degree of reflection of oil prices on consumer prices is higher; exchange rate pass-through to producer prices is higher than consumer prices; and again, it was concluded that the pass across of the exchange rate to consumer prices is more than that of producer prices.

In addition to these, Oyeleke and Ojedira (2018), who tested the long- and short-term relationship between CPI and PPI for the Nigerian economy, concluded that there is no short- and long-term relationship between the two indicators as of the examined period.

While there is strong evidence for the existence of causality between PPI and CPI, the direction of the relationship differs in terms of the economy or the period studied. The follow-up of the relationship between CPI and PPI is of vital importance in the analysis of the inflation process faced by the economy and in choosing a policy that will minimize uncertainty.

## 2. METHODOLOGY

The time series properties of the series were investigated by the Kapetanios, Shin and Snell (KSS, 2003), Philips-Perron (PP, 1988), and Augmented Dickey Fuller (ADF,1979) unit root tests.[1] In the literature, the transmission mechanism between consumer and producer prices has generally been examined with the scope of linear models and it has been found that inconsistent results have been obtained. Therefore, in this study, the long-term relationship between the relevant variables was examined using the threshold cointegration method.

Threshold cointegration phenomenon was introduced to the literature by Balke and Fomby (1997). Balke and Fomby (1997), who stated that the movement towards long-term equilibrium will not exist in every period and that the adjustment to be made will give more effective results in case the deviation from the equilibrium surpass a critical threshold, emphasized that the agents can take more effective steps to bring the system to equilibrium. Rather than trying to determine if there is asymmetry, recent studies have sought to identify a particular type of asymmetry. Enders and Granger (1998) described a class of models that can be used as the basis for unit root tests in the presence of asymmetric correction and can capture fundamental aspects of any "deep" motion in a sequence. Lows will be more persistent than highs if the autoregressive decrease is rapid when the variable is above the trend and is slow when the variable is below the trend. In addition, they described the momentum threshold autoregressive (MTAR) model, which allows a variable to exhibit a significant autoregressive decay according to its positive and negative changes. The momentum model is able to capture the probability of "sharp" movements in a series asymmetrically (Enders & Granger, 1998). In spite of that the Engle–Granger (1987) and Johansen (1996) tests, which implicitly assumed a linear adjustment mechanism, Enders and Siklos (2001) generalized the threshold autoregressive (TAR) and momentum TAR (M-TAR) tests for unit roots to a multivariate context. The symmetric long-run equilibrium relationship with the ordinary least squares (OLS) method begins with the estimation of the following model.

$$CPI_t = \beta_0 + \beta_1 PPI_t + \beta_2 EXC_t + \mu_t \quad (1a)$$

$$PPI_t = \beta_0 + \beta_3 CPI_t + \beta_4 EXC_t + \mu_t \quad (1b)$$

In equations (1a) and (1b), $\beta_i$ are the estimation parameters, and $\mu_t$ is the disturbance term that can be serially correlated. After the estimation of the long-run equilibrium model, the focus is on the OLS estimation of $\rho$ in the regression equation.

$$\Delta\mu_t = \rho\mu_{t-1} + \varepsilon_t \quad (2)$$

In equation (2) $\varepsilon_t$ is a white noise disturbance. Equation (1a) and (1b) are a dynamic model such that its pull is proportional to $|\mu_t|$. Granger's representation theorem reassures of that $\rho \neq 0$, (1a or 1b), and (2) together have an error-correcting representation of the variables in the equation. However, if the adjustment is asymmetrical, then these cointegration tests and, accordingly, error correction results are incorrectly specified. In this case, Enders and Siklos (2001) suggested in their study to use the TAR model, which allows nonlinear asymmetric corrections, to determine the cointegration relationship.

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \varepsilon_t \quad (4)$$

$$I_t = \begin{cases} 0, & \mu_{t-1} < \tau \\ 1, & \mu_{t-1} \geq \tau \end{cases} \quad (5)$$

where $I_t$ is the Heaviside indicator function; $\tau$ is the unknown threshold value; $\varepsilon_t$ represents represents a set of *iid* random variables with constant variance and zero mean. Also, when $j < t$ and $t$ is the value of the threshold, $\varepsilon_t$ is independent of $\mu_j$. In the TAR model, the null hypothesis of no cointegration is tested with $\rho_1 = \rho_2 = 0$, while the null hypothesis of symmetrical fit is tested with $\rho_1 = \rho_2$. Assuming the existence of asymmetrical relationship and ($\rho$1>$\rho$2), the model exhibits more reductions for positive (changes) errors, that is, the rate of adjustment is faster in increments than in decreases. Given that the indicator variable in equation (5) rely on the price imbalance $\mu_{t-1}$ in the previous period, the TAR model captures the response of the price imbalance to positive and negative deviations from the threshold. If $\mu_{t-1}$ is below the threshold, it represents the negative stage of price imbalance and the adjustment is at $\rho_2\mu_{t-1}$, if $\mu_{t-1}$ is above the threshold describing the positive phase of price imbalance, the adjustment is $\rho_1\mu_{t-1}$. Although equations (1a), (4) and (5) are consistent with an extensive diversity of error correction models, and given the existence of a single cointegration vector (1a), the error correction model for $CPI_t$ variable can be written as follows.

$$\Delta CPI_t = \rho_{1,i}I_t\mu_{t-1} + \rho_{2,i}(1 - I_t)\mu_{t-1} + \sum_{i=1}^{k}\beta_i\Delta PPI_{t-i} + \sum_{i=1}^{k}\alpha_i\Delta EXC_{t-i} + \sum_{i=1}^{k}\gamma_i\Delta CPI_{t-i} + \nu_{it} \quad (6)$$

In (6), there is no requirement that $\rho_{1,1} = \rho_{1,2}$ or $\rho_{2,1} = \rho_{2,2}$, since the adjustment speeds for $\Delta CPI_t$ can be different, with $\rho_{1,i}$ and $\rho_{2,i}$ being the speed of the adjustment coefficients of $\Delta CPI_t$. In order to achieve the dynamic adjustment of $\Delta\mu_t$ towards the long-term equilibrium value and to allow the errors to approach a white noise process, equation (4) is specified as follows:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \sum_{i=1}^{p-1}\gamma_i\Delta\mu_{t-1} + \varepsilon_t \quad (7)$$

(7) allows the lagged changes of $\Delta\mu_t$ to show asymmetrical adjustment. The coefficients of the lagged asymmetric error correction terms represent the long-term adjustment returning to equilibrium. While the magnitude of each depends on whether $\gamma_i$ is positive or negative, one feature of equation (7) is that it retains its equivalence to the Engle-Granger specification if $\rho_1 = \rho_2$.

Caner and Hansen (1998), Enders and Granger (1998) have proposed an alternative model where the threshold depends on the change of the previous period in $\mu_{t-1}$. The alternative rule introduced by adjusting the Heaviside indicator is as follows.

$$M_t = \begin{cases} 0, & \Delta\mu_{t-1} < \tau \\ 1, & \Delta\mu_{t-1} \geq \tau \end{cases} \quad (8)$$

Models constructed using (1a/1b), (4), and (8) are referred to as momentum threshold autoregressive (M-TAR) models, since the $\mu_t$ series exhibits more "momentum" in one direction. The $M_t$ indicator allows it to be used in a dynamic model enriched with lagged changes in $\Delta\mu_t$. The M-TAR adjustment is useful when correcting for large changes in a series (Enders & Siklos, 2001:167-168). The ($|\rho_1| > |\rho_2|$), in the MTAR model suggests that the rate of adjustment is faster as the prices increase than as the prices decrease. In the light of this information, the different effects of the positive and negative stages of price deviation on each other can be examined under the TAR and M-TAR models.

## 3. DATA ANALYSIS and EMPIRICAL RESULTS

The entity and direction of the transmission mechanism between consumer and producer prices was investigated within the scope of the non-linear model in a comparative manner within the framework of fragile five countries (Brazil, India, Indonesia, South Africa, Turkey). Information on the series used in the experimental analysis is given in Table 1.

**Table 1: Variable Definitions**

| | Notation | Period | Source |
|---|---|---|---|
| Consumer Price Index (2015=100) | LCPI | 2010: M1-2021:M8 | OECD Database |
| Producer Price Index | LPPI | | OECD Database |
| Exchange Rate (Domestic Currency per U.S. Dollar) | LEXC | | International Financial Statistics (IFS) |

Notes: The natural logarithms of series were taken.

While examining the relationship between producer (LPPI) and consumer (LCPI) price indices with nonlinear models, the exchange rate (LEXC) series is included in the models as an exogenous variable. The rise in the real effective exchange rate, which is one of the main indicators of fragility to crises and shocks, causes inflation and the current account deficit to increase.

Before testing the asymmetric relationship between consumer and producer prices for fragile five countries, whether the series is stationary or not was investigated with the traditional unit root tests ADF and PP, and then with the KSS unit root test, which is based on the assumption that the series are non-linear.

**Table 2: Traditional Tests of Unit Roots**

| | | | LCPI | LPPI | LEXC | ΔLCPI | ΔLPPI | ΔLEXC |
|---|---|---|---|---|---|---|---|---|
| Brazil | ADF | Constant | -0.9167 (1) | 2.3623 (1) | -0.4047 (0) | -6.7554 (0)[a] | -4.1969 (1)[a] | -12.1283 (0)[a] |
| | | Constant & Trend | -1.1676 (1) | 1.1146 (1) | -2.8518 (0) | -6.7816 (0)[a] | -4.5413 (1)[a] | -12.0950 (0)[a] |
| | PP | Constant | -1.0577 [8] | 2.2780 [7] | -0.3835 [1] | -7.1217 [6][a] | -6.2947 [5][a] | -12.1291 [1][a] |
| | | Constant & Trend | -1.2263 [8] | 1.3731 [7] | -2.9243 [4] | -7.1447 [6][a] | -6.7275 [5][a] | -12.0957 [1][a] |
| India | ADF | Constant | -2.2029 (0) | -6.2947 [5][a] | -1.3326 (0) | -9.6658 (0)[a] | -6.7432 (0)[a] | -11.7929 (0)[a] |
| | | Constant & Trend | -1.3259 (0) | -2.3968 (1) | -2.2843 (0) | -9.9753 (0)[a] | -6.7567 (0)[a] | -11.7787 (0)[a] |
| | PP | Constant | -2.1295 [12] | -1.7327 [4] | -1.2717 [14] | -9.6696 [10][a] | -6.9698 [10][a] | -12.4327 [14][a] |
| | | Constant & Trend | -1.3620 [11] | -2.2660 [4] | -2.2231 [7] | -9.9016 [19][a] | -6.9591 [10][a] | -12.6216 [14][a] |
| Indonesia | ADF | Constant | -3.7428 (2)[a] | -2.3271 (1) | -0.9962 (0) | 8.6197 (0)[a] | -15.6157 (0)[a] | 12.5032 (0)[a] |
| | | Constant & Trend | 0.4355 (2) | -0.0590 (1) | -1.7918 (0) | -8.9784 (1)[a] | -16.0574 (0)[a] | -12.4708 (0)[a] |
| | PP | Constant | -3.7513 [1][a] | -2.0055 [3] | -0.9774 [1] | -8.5254 [3][a] | -14.9978 [6][a] | -12.5068 [1][a] |
| | | Constant & Trend | 0.4999 [3] | -0.4462 [3] | -1.6467 [3] | -9.3515 [4][a] | -15.4442 [5][a] | -12.4747 [1][a] |
| S. Africa | ADF | Constant | -1.2823 (1) | -1.0210 (2) | -1.2860 (0)[a] | -8.7323 (0)[a] | -8.5483 (1)[a] | -13.2948 (0)[a] |
| | | Constant & Trend | -0.8053 (1) | -1.9390 (2) | -2.0229 (0) | -8.8336 (0)[a] | -8.5836 (1)[a] | -13.2735 (0)[a] |
| | PP | Constant | -1.4036 [3] | -0.8506 [15] | -1.2206 [7] | -8.5623 [6][a] | --8.3017 [26][a] | -13.3645 [6][a] |
| | | Constant & Trend | -0.5097 [2] | -1.8599 [11] | -1.9360 [3] | -8.5788 [8][a] | -9.3916 [29][a] | -13.3746 [7][a] |
| Turkey | ADF | Constant | 3.7062 (2) | 2.6814 (2) | 0.5013 (0) | -8.2680 (0)[a] | -5.8284 (1)[a] | -11.0150 (0)[a] |
| | | Constant & Trend | -0.1539 (2) | 0.3088 (2) | -2.7115 (0) | -9.0288 (1)[a] | -6.5402 (1)[a] | -11.0741 (0)[a] |
| | PP | Constant | 3.6977 [3] | 3.0728 [5] | 1.6565 [17] | -8.3450 [1][a] | -4.8434 [6][a] | -11.8393 [15][a] |
| | | Constant & Trend | -0.0898 [3] | 0.5528 [5] | -2.4996 [9] | -8.9135 [6][a] | -5.2754 [8][a] | -14.6930 [19][a] |

The optimal lags determined according to the Schwarz Information Criteria are in brackets. Bandwith bands (Newey-West) are in square brackets. a<0.01

The findings in Table 2 show that the LCPI, LPPI and LEXC series are stationary at first differences for all five countries according to traditional unit root tests. The KSS (2003) nonlinear unit root test was also used to determine whether the mean and variances of the series changed over time in terms of the examined periods. KSS (2003) test is a STAR type unit root test with exponential transition function and smooth transition between regimes.

**Table 3: Nonlinear Unit Root Test (KSS (2003) Test)**

| | | | LCPI | LPPI | LEXC |
|---|---|---|---|---|---|
| Brazil | Level | Constant | 0.499 (3) | 0.682 (2) | -0.914 (0) |
| | | Constant/Trend | -1.179 (1) | -0.277 (2) | -2.032 (0) |
| | First Dif. | Constant | -7.015[a] (0) | -2.690[b] (1) | -4.740[a] (2) |
| | | Constant/Trend | -7.304[a] (0) | -2.787[c] (1) | -4.821[a] (2) |
| India | Level | Constant | 0.424 (10) | 0.228 (1) | -1.682 (0) |
| | | Constant/Trend | -1.475 (0) | -1.520 (1) | -2.993[c] (0) |
| | First Dif. | Constant | -8.562[a] (0) | -5.453[a] (0) | -5.274[a] (2) |
| | | Constant/Trend | -7.819[a] (0) | -5.319[a] (0) | -5.232[a] (2) |
| Indonesia | Level | Constant | -0.428 (4) | -0.933 (3) | -1.624 (0) |
| | | Constant/Trend | 0.153 (1) | 0.411 (1) | -2.277 (0) |
| | First Dif. | Constant | -8.389[a] (0) | -5.961[a] (3) | -4.479[a] (3) |
| | | Constant/Trend | -8.580[a] (0) | -6.203[a] (3) | -4i472[a] (3) |
| S. Africa | Level | Constant | -0.174 (5) | -0.116 (1) | -1.866 (0) |
| | | Constant/Trend | -1.027 (1) | -1.672 (2) | -1.647 (0) |
| | First Dif. | Constant | -1.231[b] (4) | -5.350[a] (0) | -5.214[a] (1) |
| | | Constant/Trend | -2.391[a] (2) | -5.332[a] (0) | -5.131[a] (1) |
| Turkey | Level | Constant | 0.914 (3) | 1.854 (1) | 0.587 (0) |
| | | Constant/Trend | 0.588 (1) | 0.670 (2) | -4.684[a] (1) |
| | First Dif. | Constant | -3.719[a] (2) | -6.608[a] (1) | -5.028[a] (3) |
| | | Constant/Trend | -3.886[a] (2) | -6.856[a] (1) | -4.987[a] (3) |

Critical values belong to Otero and Smith (2017). Optimal lags determined according to Schwarz Information Criteria are presented in brackets. a<0.01, b<0.05 and c<0.10.

According to the results of the KSS (2003) unit root test presented in Table 3, the null hypothesis, stating that the series contains a unit root, could not be rejected, at levels. When all tests are examined together, the LPPI, LCPI and LEXC series of five countries were considered stationary at their first difference.

**Table 4: EG, TAR and MTAR Results/ Brazil**

| | Engel-Granger | Threshold | Momentum |
|---|---|---|---|
| $\rho_1$ | -0.0577 (-2.1775) | -0.0302 (-0.9010) | -0.1065[b] (-2.3970) |
| $\rho_2$ | - | -0.1146[b] (-2.3388) | -0.0248 (-0.6952) |
| Optimal lag | 0 | 2 | 2 |
| $\rho_1 = \rho_2 = 0$ | - | 3.0970 | 3.1010 |
| $\rho_1 = \rho_2$ | - | 2.0613 | 2.0690 |
| $\tau$ | - | -0.0618 | 0.0046 |
| Q(4) | 0.885 | 0.836 | 0.960 |
| Q(8) | 0.372 | 0.341 | 0.510 |
| Q(12) | 0.621 | 0.541 | 0.774 |

The coefficients t statistics are presented in brackets. Engle-Yoo table critical values are 4.22, 3.62 and 3.32 for 1%, 5% and 10%, respectively. Critical values for $\rho_1 = \rho_2 = 0$ are based on Enders and Siklos (2001). a<0.01, b<0.05 and c<0.10

In Table 4, the findings of the Engel-Granger, TAR and M-TAR models created for Brazil are reported. According to the TAR and M-TAR estimation results in models where LPPI and LCPI variables are considered as endogenous and EXC variable as exogenous variables, there is no cointegration relationship ($\rho_1 = \rho_2 = 0$ and $\rho_1 = \rho_2$) between the relevant variables for Brazil.

**Table 5: EG, TAR and MTAR Results/ India**

| | Engel-Granger | Threshold | Momentum |
|---|---|---|---|
| $\rho_1$ | -0.0977 (-2.6633) | -0.0503 (-0.9076) | -0.1732[a] (-2.8746) |
| $\rho_2$ | - | -0.1421[a] (-2.7060) | -0.0476 (-0.9497) |
| Optimal lag | 0 | 2 | 2 |
| $\rho_1 = \rho_2 = 0$ | - | 3.9720 | 4.5446 |
| $\rho_1 = \rho_2$ | - | 1.5106 | 2.6032[c] |
| $\tau$ | - | -0.0443 | 0.0058 |
| Q(4) | 0.486 | 0.564 | 0.487 |
| Q(8) | 0.641 | 0.800 | 0.720 |
| Q(12) | 0.361 | 0.463 | 0.383 |

The coefficients t statistics are presented in brackets. Engle-Yoo table critical values are 4.22, 3.62 and 3.32 for 1%, 5% and 10%, respectively. Critical values for $\rho_1 = \rho_2 = 0$ are based on Enders and Siklos (2001). a<0.01, b<0.05 and c<0.10

Findings for India are similar to those for Brazil and are given in Table 5. The null hypothesis ($\rho_1 = \rho_2 = 0$) suggesting that there is no cointegration relationship according to the TAR and M-TAR models could not be rejected. There is no long run relationship between consumer and producer prices for India.

**Table 6: EG, TAR and MTAR Results/ Indonesia**

| | Engel-Granger | Threshold | Momentum |
|---|---|---|---|
| $\rho_1$ | -0.1600[a] (-3.6376) | -0.1016[c] (-1.6697) | -0.1094[b] (-2.3124) |
| $\rho_2$ | - | -0.1599[a] (-2.7143) | -0.4722[a] (-4.8200) |
| Optimal lag | 3 | 2 | 4 |
| $\rho_1 = \rho_2 = 0$ | - | 4.8836 | 13.0198[a] |
| $\rho_1 = \rho_2$ | - | 0.4947 | 12.4381[a] |
| $\tau$ | - | 0.0077 | -0.0033 |
| Q(4) | 0.999 | 0.287 | 0.649 |
| Q(8) | 0.994 | 0.596 | 0.890 |
| Q(12) | 0.396 | 0.139 | 0.405 |

The coefficients t statistics are presented in brackets. Engle-Yoo table critical values are 4.22, 3.62 and 3.32 for 1%, 5% and 10%, respectively. Critical values for $\rho_1 = \rho_2 = 0$ are based on Enders and Siklos (2001). a<0.01, b<0.05 and c<0.10

When we examine the findings for Indonesia in Table 6, there is not any long-term relationship between the variables according to the TAR model, while there is threshold cointegration with asymmetric adjustment mechanism between the variables according to the results of the M-TAR model. The point estimates for $\rho_1$, $\rho_2$, and $\tau$ were calculated as -0.1094, -0.4722, and -0. 0033 respectively. This suggests to us that it has faster convergence for the negative than for the positive discrepancies from long-run equilibrium ($|\rho_1| < |\rho_2|$). Forecasts show that for Indonesia, discrepancies in the long-term equilibrium resulting from long-term increases ($\Delta\mu_{t-1} < -0.0033$) are resolved relatively quickly, but other changes are largely persistent.

**Table 7: TAR and MTAR Error-Correction Model / Indonesia**

| | Adjustment coefficients MTAR | | Wald F-Stat. | Direction |
|---|---|---|---|---|
| | $\rho_1$ | $\rho_2$ | | |
| CPI | -0.0168 (-0.5457) | -0.1219[a] (-2.7166) | 1.0834 (0.6657) | - |
| PPI | 0.1105[c] (1.7437) | 0.3996 (1.3985) | 3.0952[b] (1.0323) | CPI→PPI |

The coefficients t statistics are presented in brackets. a<0.01, b<0.05, c<0.10. Findings regarding the EXC used as an exogenous variable were not reported.

After the determination of the cointegration relationship, the error correction model based on the M-TAR model was calculated and the outcomes are presented in Table 7. In Indonesia, the coefficient of adjustment in the CPI and PPI equations are significant only when ($\Delta\mu_{t-1} < -0.0033$) and ($\Delta\mu_{t-1} \geq -0.0033$), respectively. When the Wald test results of the equations are examined, while the null hypothesis that there is no Granger causality from CPI to PPI is rejected, the null hypothesis that there is no Granger causality from PPI to CPI cannot be rejected in Indonesia, which means that there is a one-way short-run causality from CPI to PPI. In addition, when the error correction parameters are examined, it is noteworthy that the negative equilibrium errors ($|\rho_2|$). are larger than the positive equilibrium errors ($|\rho_1|$). Thus, producer prices may adjust faster to negative deviations from the equilibrium. As a result, empirical evidence can point to the demand-side approach ($H_2$ hypothesis is accepted) and help policymakers in these countries to forecast the producer inflation rate in the future.

**Table 8: EG, TAR and MTAR Results/ S. Africa**

| | Engel-Granger | Threshold | Momentum |
|---|---|---|---|
| $\rho_1$ | -0.1903[a] (-3.4186) | -0.2724[a] (-4.3858) | -0.1696[a] (-3.3294) |
| $\rho_2$ | - | -0.0519 (-0.6932) | -0.3384[b] (-2.2094) |
| Optimal lag | 3 | 1 | 1 |
| $\rho_1 = \rho_2 = 0$ | - | 9.7636[a] | 7.4634[b] |
| $\rho_1 = \rho_2$ | - | 5.3199[a] | 1.1452 |
| $\tau$ | - | -0.0069 | -0.0028 |
| Q(4) | 0.927 | 0.574 | 0.465 |
| Q(8) | 0.590 | 0.322 | 0.308 |
| Q(12) | 0.315 | 0.199 | 0.228 |

The coefficients t statistics are presented in brackets. Engle-Yoo table critical values are 4.22, 3.62 and 3.32 for 1%, 5% and 10%, respectively. Critical values for $\rho_1 = \rho_2 = 0$ are based on Enders and Siklos (2001). a<0.01, b<0.05 and c<0.10

The estimation findings of South Africa are given in Table 8. The findings reject the null hypothesis ($\rho_1 = \rho_2 = 0$), which suggests that there is no cointegration relationship between the variables for the models. TAR model suggests that the variables are cointegrated and that the adjustment mechanism is asymmetric ($\rho_1 \neq \rho_2$). The adjustment parameters ($\rho_1$ and $\rho_2$) were estimated as -0.2724 and 0.0519, respectively, as statistically significant. Contrary to Indonesia, South Africa seems to converge faster for positive rather than negative discrepancies from the long-run equilibrium ($|\rho_1| > |\rho_2|$).

**Table 9: TAR and MTAR Error-Correction Model/ S. Africa**

| | Adjustment coefficients TAR | | Wald F Stat. | Direction |
|---|---|---|---|---|
| | $\rho_1$ | $\rho_2$ | | |
| CPI | -0.1750[a] | 0.0728 | 8.5879[a] | PPI→CPI |
| | (-3.3831) | (1.2193) | 0.3702 | |
| PPI | 0.1154 | 0.1549 | 2.1504 | |
| | (1.1826) | (1.5070) | 0.6053 | |
| | Adjustment coefficients MTAR | | Wald F Stat. | Direction |
| | $\rho_1$ | $\rho_2$ | | |
| CPI | -0.0674 | -0.0400 | 6.8033[a] | PPI→CPI |
| | (-1.5267) | (-0.5188) | 0.3466 | |
| PPI | 0.1109 | 0.4057[b] | 1.8773 | |
| | (1.4904) | (2.1902) | 0.8629 | |

The coefficients t statistics are presented in brackets. a<0.01, b<0.05. Findings regarding the EXC used as an exogenous variable were not reported.

The findings of the TAR-ECM and MTAR-ECM models for South Africa are given in Table 9. According to the TAR-ECM model, the adjustment coefficient in the CPI equation is significant when ($\Delta\mu_{t-1} \geq -0.0069$). According to the results of causality analysis based on the TAR model, the direction of causality is from producer prices to consumer prices. When the adjustment coefficients obtained from the MTAR-ECM model were examined, the adjustment coefficient in the PPI equation was found to be significant only when ($\Delta\mu_{t-1} < -0.0028$). Similar to the TAR model, according to the MTAR-ECM model, the direction of short-run causality for South Africa is unidirectional, from PPI to CPI. Estimates of error correction parameters of positive equilibrium errors ($|\rho_1|$) are greater in absolute value than negative equilibrium errors ($|\rho_2|$). CPI may adjust more quickly to positive deviations from equilibrium and this result indicates to us that the $H_1$ hypothesis, which states that the supply-side approach is valid for South Africa, is accepted.

**Table 10: EG, TAR and MTAR Results/ Turkey**

| | Engel-Granger | Threshold | Momentum |
|---|---|---|---|
| $\rho_1$ | -0.1341[a] (-3.1538) | -0.0528 (-0.8842) | -0.1129[b] (-2.1590) |
| $\rho_2$ | - | -0.2837[a] (-4.3503) | -0.3172[a] (-3.2126) |
| Optimal lag | 0 | 2 | 2 |
| $\rho_1 = \rho_2 = 0$ | - | 9.6238[a] | 7.4590[a] |
| $\rho_1 = \rho_2$ | - | 7.3426[a] | 3.3539[a] |
| $\tau$ | - | -0.0298 | -0.0148 |
| Q(4) | 0.142 | 0.962 | 0.883 |
| Q(8) | 0.281 | 0.944 | 0.820 |
| Q(12) | 0.387 | 0.935 | 0.871 |

The coefficients t statistics are presented in brackets. Engle-Yoo table critical values are 4.22, 3.62 and 3.32 for 1%, 5% and 10%, respectively. Critical values for $\rho_1 = \rho_2 = 0$ are based on Enders and Siklos (2001). a<0.01, b<0.05 and c<0.10

According to the findings presented in Table 10, a cointegration relationship was found between price variables according to both TAR and M-TAR models for Turkey, and this relationship is asymmetrical. For the TAR model, the adjustment parameters were estimated as -0.0528 and -0.2837, while for the M-TAR model, they were estimated as -0.1129 and -0.3172. These values indicate that negative discrepancies from long-run equilibrium converge faster than positive discrepancies, similar to Indonesia.

**Table 11: TAR and MTAR Error-Correction Model/ Turkey**

| | Adjustment coefficients TAR | | Wald F Stat. | Direction |
|---|---|---|---|---|
| | $\rho_1$ | $\rho_2$ | | |
| CPI | 0.0034 | -0.0424 | 10.1260[a] | PPI→CPI |
| | (0.1466) | (-1.5143) | 3.0997[c] | EXC→CPI |
| PPI | -0.0123 | 0.0938[b] | 5.2245[b] | CPI→PPI |
| | (-0.2653) | (2.2858) | 71.5000[a] | EXC→PPI |
| | Adjustment coefficients MTAR | | Wald F Stat. | Direction |
| | $\rho_1$ | $\rho_2$ | | |
| CPI | 0.0093 | -0.1247[b] | 7.4415[a] | PPI→CPI |
| | (0.5662) | (-2.2848) | 2.9207[c] | EXC→CPI |
| PPI | 0.0598[a] | -0.0520 | 7.1420[a] | CPI→PPI |
| | (2.6163) | (-0.9484) | 23.7186[a] | EXC→PPI |

The coefficients t statistics are presented in brackets. a<0.01, b<0.05, c<0.10. Findings regarding the EXC used as an exogenous variable were not reported.

Finally, the estimation results of TAR-ECM and MTAR-ECM equations for Turkey are reported in Table 11. According to the findings obtained from the TAR-ECM model, the adjustment coefficient in the PPI equations is significant ($\Delta\mu_{t-1} < -0.0298$). When the findings obtained from the MTAR-ECM results presented in Table 10 are examined, the adjustment coefficient in the CPI equation is significant when ($\Delta\mu_{t-1} < -0.0148$) and the adjustment coefficient in the PPI equation is significant when ($\Delta\mu_{t-1} \geq -0.0148$). In addition, according to the Wald tests results obtained from the TAR-ECM and MTAR-ECM equations, there is a bidirectional causality relationship between consumer and producer prices, accordingly, the $H_3$ hypothesis is valid. When the asymmetric error correction coefficients obtained from MTAR-ECM model are examined, producer prices may adjust faster to positive deviations from equilibrium ($|\rho_1| > |\rho_2|$); consumer prices, on the other hand, may adapt faster to negative deviations from the equilibrium ($|\rho_1| < |\rho_2|$).

## 4. CONCLUSION

The fragility of developing countries to global conditions varies according to their financial structure and financial openness. Especially countries with weak fiscal positions and high current account deficits are more vulnerable to global shocks. In other words, emerging markets are more vulnerable to financial shocks due to the fact that their economic systems are not yet sufficiently developed and that they are under the influence of developed countries. Inflation, exchange rate and current account deficit make the fragile structures of these countries more fragile.

Increasing money supply around the world can cause abundant liquidity flow to emerging economies, and creates demand for the goods exported by these countries. On the other hand, the global disruptions in supply chains and the increase in the prices of various products, especially commodities used as intermediate goods, led to inflationary effects in these countries. The fact remains that the increase in money supply created by the US and Euro Central banks may cause inflation in other countries. In addition, with the spillover effect, increases in inflation in any country can lead to an increase in inflation in other countries such as especially in fragile economies. The emergence of inflation differs depending on the economic structure of the fragile five as supply and/or demand side. Although the relationship between producer and consumer prices is generally examined within the framework of linear models in the literature, it was investigated the asymmetric relationship for fragile five between these variables in this study. The findings showed that there is an asymmetrical relationship between consumer and producer prices for Indonesia, South Africa and Turkey. The direction of causality is from consumer prices to producer prices for Indonesia and it was determined that negative deviations in consumer prices brought producer prices into equilibrium faster than positive deviations. In other words, it has been observed that producer prices are more sensitive to decreases in consumer prices. Therefore, contrary to the studies in the literature (Anggraeni & Irawan, 2018; Yin & Jia, 2013), in the analyzed period, it is seen that the consumer prices increased in the first stage against the increasing demand due to the limited supply in Indonesia and the producer prices increased due to the producer input demand. In South Africa, the direction of causality is determined from producer prices to consumer prices. Similar to the findings of Alemu (2012), we can say that the supply-side approach is valid in South Africa, and that changes in raw material prices affect the prices of intermediate and final products, which ultimately affect consumer prices. When the asymmetric relationship is examined, it is seen that positive deviations in producer prices bring consumer prices to equilibrium faster. For South

Africa, it can be said that while consumers determine their spending trends, they are more sensitive to producer price increases and adjust their consumption behavior accordingly. Among the studies conducted for Turkey, it supports the studies (Abdioğlu & Korkmaz, 2012; Koçak, 2021; Topuz et al., 2018) claiming that there is a bidirectional relationship between consumer prices and producer prices. It has been observed that negative deviations in producer prices in Turkey bring consumer prices to equilibrium faster. When the other side of asymmetric short-run causality is examined, it has been determined that producer prices react faster to positive deviations in consumer prices. Increases in consumer prices in Turkey are directly reflected in production costs, making producer prices more sensitive. Finally, under the asymmetric effect, no relationship was found between the variables mentioned for Brazil (as in Cerquera-Losada et al., 2018) and India. Different results have been obtained regarding the transmission mechanism between consumer and producer prices in fragile five countries. The difference in the internal dynamics of the five countries causes the difference in the price pass-through of the countries as of the examined period. This finding may help policy makers to predict future prices and give more importance to the asymmetric transmission mechanism between CPI and PPI.

## FOOTNOTES

[1] For more details see Kapetanios, Shin & Snell (2003), Phillips & Perron (1988), and Dickey & Fuller (1979).

## AUTHOR STATEMENT

### Statement of Research and Publication Ethics

This study has been prepared in accordance with scientific research and publication ethics.

### Author Contributions

Contribution rate (100%)

### Conflict of Interest

There is no conflict of interest for the authors or third parties arising from the study.

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