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Asymmetric Interest Rate Pass-Through in Türkiye: The Role of Global Financial Crisis

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Türkiye'de Asimetrik Faiz Oranı Geçişkenliği: Küresel Finansal Krizin Rolü

Öz

Bu çalışmanın amacı, Türkiye'de para politikası faizinin bankaların kredi ve mevduat faizlerine geçişkenliğini sorgulamaktır. Çalışmada 2002 Ocak ve 2019 Ekim dönemini kapsayan veri seti ile doğrusal olmayan gecikmesi dağıtılmış otoregresif (NARDL) modeli kullanılmaktadır. Finansal kriz öncesi dönem için uzun dönemde kredi faizleri genellikle yukarı yönlü katılıklara sahipken, bu katılıklar finansal kriz sonrası dönem için aşağı yönlü ve kısa döneme dönüşmektedir. Bu sonuçlar, kriz öncesinde bankaların parasal sıkılaştırma dönemlerinde kredi faizlerini daha yavaş ayarladıklarını, parasal genişleme dönemlerinde ise bankaların tepkilerinin daha hızlı olduğunu ima etmektedir. Ancak kriz sonrasında para politikası sıkılaştırması dönemlerinde bankaların kredi faizleri parasal genişleme dönemlerine göre daha hızlı tepki vermektedir.

Anahtar Kelimeler: Asimetriler, fiyat katılıkları, küresel finansal kriz, Türkiye, NARDL

JEL Kodları: E43, E52, E58

Asymmetric Interest Rate Pass-Through in Türkiye: The Role of Global Financial Crisis

Abstract

The aim of this paper is to investigate the monetary policy rate pass-through to banks' loan and deposit rates in Turkey. We employ the nonlinear autoregressive distributed lag (NARDL) model with the data set covering the period from January 2002 to October 2019. The loan rates generally have upward rigidities in the long run before the financial crisis, but these rigidities turn into downward and short-run after the financial crisis. These results imply that banks adjusted their loan rates more slowly during monetary tightening periods in the pre-crisis period, while banks' responses are faster during monetary easing periods. However, in the post-crisis period, banks' loan rates react faster during monetary policy tightening than monetary easing periods.

Keywords: Asymmetries, price rigidities, global financial crisis, Turkey, NARDL

JEL Codes: E43, E52, E58

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1. Introduction

The vast majority of modern central banks rely on short-term interest rates during monetary policy implementation and try to stimulate the price level expectations of economic actors, portfolio balance decisions, and spending decisions such as consumption and investment, which determine economic activity. It is expected that this mechanism works roughly with changes in policy rates, which affect banks' liquidity costs and thus transition to other market rates such as loan and deposit rates. This monetary policy transmission mechanism, known as the interest rate channel, is one of the primary and most important mechanisms for monetary policymakers. However, the changes in policy rates should be transmitted to banks' loan and deposit rates rapidly and completely for an effective interest rate transmission mechanism and hence monetary policy. For this reason, the information about the size and speed at which the policy rate is transferred to the market rates is essential for policymakers to implement an effective monetary policy. Besides, this information may affect price stability, and it also contributes to the policies towards sustaining financial stability by affecting the level of profitability of banks through banks' interest margins and the stability of the banking sector as a whole.

Although the interest rate transmission process from policy rate to banks' retail rates is mostly assumed to be complete in the policy pillar of the issue, the empirical evidence claims that the interest rates pass-through may not be complete, and it differs in the long-run and short-run. Many factors can affect the adjustment process of retail interest rates during policy rate changes. Moreover, the speed and size of this adjustment process may not be equal up and down. The potential reasons for this asymmetric adjustment process are mainly discussed in the Berger and Hannan (1989), Hannan and Berger (1991), Neumark and Sharpe (1992), Lowe and Rohling (1992), Hannan and Liang (1993), Shaffer (1994), Cottarelli and Kourelis (1994), and Scholnick (1999) . Firstly, the condition that the price is equal to marginal cost under perfect competition assumptions may mean that interest rate pass-through is complete, but the difference between price and marginal cost may cause an asymmetric and incomplete pass-through effect as the industry moves away from perfect competition. The high adjustment cost of banks may delay this pass-through effect up or down. Furthermore, increases in asymmetric information problems in financial markets may cause banks to slow down loan rate increases in order not to attract riskier customers. The factors affecting bank customer relations and the passive behavior of customers can change the adjustment process of banks' interest rates separately for the loan and deposit interest rates.

Despite its crucial role in determining the effectiveness of the monetary policy, the pass-through from policy rate to deposit and loan rates is surprisingly under-studied for Turkey. The vast majority of previous studies, which take account of asymmetries in the relationship between the policy rate and banks' loan and deposit rates, investigate the existence of either short-term or long-term asymmetries, and almost all results show that there are noticeable differences between countries. Turkey is not an exception in this case. This study particularly has attempted to answer several questions concerning the relationship between the policy rate and bank deposit and loan rates for Turkey. What is the relationship between banks' deposit or loan rates and the central bank's policy rate? If if there is such a significant relationship, is this relationship symmetric or asymmetric? Do these asymmetries appear in the short run or the long run? In other words, are these asymmetries temporary or permanent? What is the role of the financial crisis and changing financial conditions in the adjustment process banks' loan and deposit rates?

Previously published studies on the interest rate pass-through in Turkey including Özdemir (2009), Aydın (2010), Yıldırım (2012), Yüksel ve Özcan (2013), and Siklar et al. (2016) differs from this study in several aspects. Firstly, Aydın (2010) and Siklar et al. (2016) performs its analysis within the framework of linear models and does not take into account asymmetries. Özdemir (2009) examines the period only before the global financial crisis. Yıldırım (2012) and Yüksel and Özcan (2013) use TAR and M-TAR models. This study relies on the nonlinear ARDL (NARDL) framework to examine both long and short-term asymmetric relationships. In addition, the data set covers a broader period from January 2002 to October 2019, and the analyzes are repeated for two sub-periods in order to observe whether there is a change in the interest rate pass-through before and after the financial crisis. While the findings do not indicate an asymmetric cointegration relationship between deposit rates and policy rates, they suggest that bank loan rates follow an asymmetric adjustment process both in the long and short-run in Turkey. The loan rates mostly have upward rigidities in the long run before the financial crisis, but these rigidities are downward and short-run after the financial crisis.

The remaining part of the paper proceeds as follows: The second section includes theoretical discussions on the causes of potential asymmetries that may arise between the monetary policy interest rate and banks' retail interest rates. The third section presents summaries of empirical studies that especially take account of asymmetries during the examination of this relationship. The fourth section describes the data and NARDL methodology. In the fifth section, findings based on model estimations are presented, while the findings of the study are discussed in the sixth section. The seventh and final chapter is devoted to the conclusion and policy recommendations.

2. Theoretical Discussions on Asymmetric Interest Rate Adjustments

A wide variety of theoretical explanations have been proposed to explain the price stickiness in goods markets. Many of the theories explaining price stickiness in the good market have been adapted to financial markets (see Hannan and Liang (1991), Hannan and Berger (1991), Klemperer (1987), Fried and Howitt (1980), Rotemberg and Saloner (1987)). The theories explaining interest rate stickiness in the banking sector are commonly based on market structure and consumer behaviors. The theories of market structure attempt to explain interest rate asymmetries with arguments such as lack of competition and market concentration. The imperfect competition model of the banking sector discussed in Freixas and Rochet (1997) give the banking sector's optimal loan and deposit rates as functions of the interbank rate and the intermediation margins. This model also helps to demonstrate bank behavior under perfect competition. The model takes the form of perfect competition as the number of banks approaches infinity, and the optimal loan and deposit interest rates, which maximize the profit of banks, are realized when the loan and deposit intermediation margins (differences between the interbank money market interest rate and the bank's loan and deposit interest rates) are equal their marginal costs. However, as the number of banks decreases, the banking market has an oligopolistic structure. In monopoly conditions, loan intermediation margin increases while deposit intermediation margin decreases. Therefore, under the imperfect competition, the bank’s loan and deposit rates do not react simultaneously to the changes in the money market interest rate, but they follow an adjustment path that reflects adjustment costs. In case of positive shocks in the monetary policy rate, loan interest rates are adjusted faster, while deposit rates exhibit upward rigidity. On the contrary, loan interest rates are expected to exhibit downward rigidity when the policy rate decreases.

Similar to the framework described above, when market concentration is considered as an important indicator of market power, Berger and Hannan (1989), Hannan and Berger (1991) and Neumark and Sharpe (1992) emphasize that banks tend to adjust more slowly their deposits during policy rate increases in highly concentrated markets. On the other hand, they react to decreases in policy rates by lowering deposit rates faster. Similarly, the banks with more market power guarantee downward rigidity of loan rates during funding costs reductions. However, Shaffer (1994) states that the relationship between concentration and market power is uncertain and that competitive results may also be observed in concentrated markets. The structure of the banking sector in Turkey is a very interesting example in this regard. The top 10 banks by asset size in the banking sector constitute more than 90% of the sector. There is evidence that the competitive structure is monopolistic competition in this highly concentrated market (see Sekmen et al. (2014)). Hannan and Berger (1991), Neumark and Sharpe (1992), and Cottarelli and Kourelis (1994) also discuss that a bank's motivation to change loan and deposit rates depends on the cost of adjustment. The banks may not respond to small fluctuations in policy rate as long as the cost of adjustment of retail interest rates is high. The cost of this adjustment is likely higher due to the relationship between banks and consumers and collusive price arrangements, especially in the case of imperfect competition. It may be extremely costly to give up collusive price arrangements in less competitive and highly concentrated markets. Therefore, banks operating in such a market are likely to exhibit downward rigidities in loan interest rates and upward rigidities in deposit interest rates.

Another branch of the theories that try to explain asymmetric behaviors in loan and deposit interest rates is based on consumer behaviors, including customer reaction hypothesis, consumer sophistication, and search and switching costs. As stated earlier, the level of the relationship of banks with customers appears as a cost element in the process of adjustment of interest rates. According to the customer reaction hypothesis, customers may react negatively to unstable interest rate fluctuations or unfavorable interest rate changes for them (see Scholnick (1999), Lim (2001)). In this case, adjustments in loan and deposit rates may lead to customer losses of banks. In this environment, banks may be reluctant to adjust loan and deposit rates in response to policy rate changes if the adjustment cost is too high. The customer reaction hypothesis reveals that the asymmetries that occur during the adjustment of interest rates are due to upward rigidity in loan rates and downward rigidity in deposit rates. This result, which has the opposite implications of imperfect competition and market concentration hypotheses is more likely to emerge, especially in a more competitive environment.

When we approach the customer reaction hypothesis from a different perspective, it can be seen that there are costs that determine customer behavior similar to the costs that affect bank behavior. The negative customer reaction can be valid only if these costs are low. Search and switching costs may be another reason for the retail interest rate rigidity. Klemperer's (1987) model points out that even small switching costs reduce the elasticity of demand faced by firms. The search and switching costs typically include the costs, such as information about the loan interest of different banks, filling out the forms required to become a bank customer, or obtaining documents required for the acceptance of a loan request. When the model is adapted in the banking market, these costs, which involve a large amount of information collection costs, may prevent customers from changing banks despite the more advantageous interest rates in the market. Lowe and Rohling (1992) state that search and switching costs may be more critical in the banking market than in other markets since banks may need more information and time to analyze customers' risk structures. However, it can be assumed that

the rapid developments in information, communication, and financial technologies significantly reduce these search and switching costs. Therefore, these costs may not have significant effects on the motivation of consumers to change banks.

Another explanation for consumer behavior is made by Rosen (2002) by dividing consumers into two groups: sophisticated and unsophisticated. The unsophisticated consumers are assumed to only know the past and current interest rates of their banks, while sophisticated consumers are assumed to be familiar with all market interest rates. The customers may be less likely to change banks in markets with less sophisticated customers; thus, banks can lead to asymmetries by adjusting interest rates to their advantage. On the other hand, Scholnick (1999) points out that the proportion of sophisticated customers is related to the level of search and switching costs. The high costs may lead to an increase in the ratio of unsophisticated customers by reducing sophisticated customers' efforts to obtain information and by transforming them to unsophisticated customers. Ultimately, increases in the search and switching costs, as well as the proportion of unsophisticated customers, can lead to downward rigidity in loan rates and upward rigidity in deposit rates by providing market power to banks.

It is well known that asymmetric information creates problems in financial markets such as adverse selection and moral hazard. Stiglitz and Weiss (1981), in their well-known model of the relationship between interest rates and asymmetric information costs, assume that firms have more information about the risk of their projects than banks and that banks will have difficulty in comparing the risks of projects. There are two types of borrowers in the model. While the probability of default of the first borrower group is zero, the probability of default of the second group is positive, and this rate increases with the increase in the loan interest rates of the banks. When banks increase their loan interest rates, the expected return of less risk-free investment projects will decrease more, and the safer projects will give up the loan demand first. In this case, the projects only with higher risk can continue to demand the loans due to higher expected returns, and the ratio of risk-free borrowers in loan demanders decreases while the ratio of risky borrowers increases. Increases in the ratio of risky borrowers will increase the probability of adverse selection of banks.

Additionally, increases in loan interest rates may lead to a moral hazard problem since borrowers can choose riskier projects. Consequently, when the policy rate increases, the cost of raising loan rates can be offset by the cost of attracting risky customers, and banks may be reluctant to raise loan rates. Therefore, the model predicts that the upward adjustment of loan interest rates is slow.

In summary, the theories related to imperfect competition, market power or market concentration, collusive price adjustments, and search and switching costs argue that loan and deposit interest rates lead to asymmetries by exhibiting downward and upward rigidity, respectively. The negative customer reaction hypothesis states that contrary to the aforementioned theories, downward rigidity in deposit rates and upward rigidity loan rates will occur. Theories of adverse selection problems based on asymmetric information suggest that loan rates exhibit upward rigidity, similar to the negative customer reaction hypothesis. The loan rates react more slowly to policy rate decreases when the loan rates have downward rigidity. In this case, a contractionary monetary policy has a greater impact on loan rates than an expansionary monetary policy. Conversely, if deposit interest rates are adjusted slowly by banks due to upward rigidity, deposit interest rates will be more affected during monetary easing periods than monetary tightening periods.

3. Empirical Literature Review

The previous section provides a wide variety of theoretical explanations for interest rate asymmetries based on imperfect competition, market concentration, adjustment cost, degree of consumer sophistication, search and switching costs, negative customer reactions, asymmetric information and adverse selection. This section provides an overview of the empirical studies on asymmetric interest rate adjustment. The majority of these studies prefer asymmetric threshold autoregressive (TAR) and momentum threshold autoregressive (MTAR) and error correction model proposed by Enders and Siklos (2001) as methods. In the vast majority of studies investigating asymmetries, the interest rate pass-through is found slow and incomplete. Besides, the behaviors of banks are presented as the primary reason due to the imperfect competitive structure of the banking sector, while they also draw attention to issues such as transparency, credibility, and good communication of monetary policy as factors affecting the size of asymmetries. However, empirical evidence remains inconclusive. The adjustment process of loan and deposit interest rates shows significant differences according to the country, sample, and interest rate types.

Lim (2001) examines the asymmetric adjustments of the three Australian Banks' interest rates against monetary policy. The findings of the study conclude that interest rate adjustments are not asymmetric in the short run, but it is asymmetric in the long run during the negative and positive shocks in monetary policy. Adjustment of banks' deposit and loan interest rates is faster in monetary easing periods but slower in monetary tightening periods. Valadkhani and Anwar (2012), who examined the effects of the Australian central bank interest rate on mortgage loan rates for the period after 1989, find that this effect is asymmetric. The effect of increases in monetary policy interest rates on mortgage loan rates is greater than the effect of decreases.

Bondt (2005) investigates the pass-through effect of overnight official interest rates at the European Union level to long-term market interest rates, that is, banks' deposit and loan rates. The findings reveal that the pass-through of the official interest rate to market interest rates is not complete for maturities up to 3 months but complete for the longer term. Fifty percent of the transition of money market interest rates to the bank deposit and loan rates is realized immediately. This finding related to the faster interest rate pass-through is supported after the transition to the European Union. Kleimeier and Sander (2006) that examine the interest rate pass-through in the European Union banking market differentiate from other studies by analyzing the response of deposit and loan rates to anticipated and unanticipated monetary policy shocks. In the study, which is assumed that interest rates in the futures market for Austria, Belgium, Finland, Germany, France, Ireland, Italy, Netherlands, Portugal, and Spain represent the anticipated monetary policy interest rate, it is determined that the adjustment in loan rates is faster than the adjustment in deposit rates. They also emphasize the importance of well-communicated monetary policy and competitive policies for a faster and more homogeneous adjustment process and monetary policy effectiveness. Similarly, Belke, Beckmann, and Verheyen (2013) analyze the pass-through effect of money market interest rates on different loan rates for the post-transition period to the European Union for 12 European Monetary Union countries. The analyzes between EONIA (Euro OverNight Index Average) and the loan rates of 12 countries reveal that the short-run adjustment process of loan rates differs significantly between loan types and countries, and the interest rate pass-through is incomplete in most cases, so the long-run adjustment process is asymmetric.

Gambacorta and Iannotti (2007) investigate the interest rate pass-through between policy interest rate and bank interest rates in Italy during the period of 1985-2002 using an asymmetric error correction model. The evidence indicates that the adjustment is asymmetric in the short run. Additionally, it is suggested that during periods of monetary expansion policies, loan interest rates adjust more rapidly compared to deposit interest rates.

Payne (2006) examines the effect of the federal fund rate on 30-years traditional mortgage loan rates, and he shows that the interest rate pass-through is not complete in the USA. However, the long-run adjustment process of interest rate seems to be symmetric rather than asymmetric. In another study for the USA, Payne and Waters (2008) examine the long-run pass-through effect of the federal fund rate to the prime rate, which is applied to loans extended by large banks to customers with the highest credibility. The findings support that the adjustment process of loan rates is asymmetric and exhibits upward rigidities. It is stated that such upward rigidity supports negative customer reaction and adverse selection hypotheses. On the other hand, it is observed that the interest rate pass-through effect is stronger in periods of increasing competition in the banking sector and during a more transparent monetary policy. Estimates based on the theoretical model developed by Roelands (2012), which tries to explain the asymmetric interest rate pass-through effect with the concepts of capital structure and liquidity adequacy, reveals that banks in the USA adjust their loan rates less than the changes in federal funds rate when capital adequacies determined by regulatory authorities are binding. In addition, banks, if capital regulations are binding, increase their loan rates faster than unrestricted banks after a decrease in capital ratio. Apergis and Cooray (2015), which examine the relationship between interest rates of central banks of the USA, UK, and Australia and loan and deposit rates of selected banks at the bank level, provide on the evidence of the existence of asymmetries. When the sample is divided into two sub-periods, before and after the global financial crisis, an asymmetric interest rate pass-through effect is only supported for Australia.

Wang and Lee (2009) investigate the effect of money market interest rates on loan and deposit rates and also on interest rate volatility in 9 Asian countries other than the USA. While it is determined that the pass-through effect in USA deposit interest rates is complete, the relationship between deposit rates and money market interest rates in 5 Asian countries is determined asymmetric. The asymmetric relationship with loan rates exists only in three Asian countries. It is stated that the adjustment process of deposit rates has upward rigidities in 5 of the countries that have an asymmetric relationship in the short run, whereas there are downward rigidities in loan rates in three countries. It is also stated that the collusive price arrangements hypothesis is supported for some countries. In another study parallel to this study, Wang and Thi (2010) question the effect of money market interest rates and interest rate volatility on banks' retail interest rates for Taiwan and Hong Kong. It is determined that the interest rate pass-through in both markets is not complete, and the relationship between the two interest rates is asymmetric. These asymmetries exhibit upward rigidities in deposit rates and downward rigidities in loan rates in the short run. Again, these findings highlight that it supports the collusive price arrangements hypothesis between banks. On the other hand, Haughton and Iglesias (2012) repeat the methods used in the study of Wang and Lee (2009) for the Caribbean countries and compare the results with the USA and Asia. They find that the interest rate pass-through in loan rates is complete Trinidad Tobago and St. Lucia, while this effect is not complete for other countries. Only three of the six countries, Jamaica, Guyana, and St. Lucia, have an asymmetric cointegration relationship for both loan and deposit rates. In

these countries where an asymmetric relationship is detected, the loan rates show rigidity in the upward adjustment process, whereas this process exhibits downward rigidity in deposit rates.

Turning to emerging markets, Fadiran and Ezeoha (2012) compare the transmission mechanism of money market interest rates for the periods before and after the transition to South Africa's repo system. According to short and long-run analysis results, the pass-through effect of money market interest rates is not complete in the short run. In addition, the adjustment process of deposit rates is symmetric and includes upward rigidities, while the adjustment process of loan rates is asymmetric and includes downward rigidities. Their results also support the collusive price arrangements hypothesis between banks. In a similar study for Southern Arfica, Matemilola, Bany-Ariffin, and Muhtar (2015) examine the long-run the asymmetric effect of money market interest rates on banks' loan rates. According to the findings, South African banks only adjust their loan rates significantly during the downward movement of money market interest rate, but this adjustment process has upward rigidity and therefore provides evidence supporting the negative customer reaction hypothesis. Karagiannis, Panagopoulos, and Vlamis (2011) find no evidence that the adjustment process of banks' interest rates is asymmetric for Greece, while loan rates for Slovenia and Bulgaria exhibit negative asymmetries in response to changes in monetary policy rates. Becker, Osborn and Yıldırım (2012) examine the effect of the official interest rates in the UK on money market rates and then pass-through from money market rates to mortgage rates in two stages. The findings show that there are significant asymmetries in both transmission stages. Sznajderska (2013) investigating possible interest rate asymmetries for Poland reveals that the effect of interbank money market rates on the deposit and loan rates of different maturities and amounts is asymmetric in both the short and long run. The level of competition in the banking sector and the increases in the credibility of the central bank strengthen the adjustment process of interest rates in Poland. The study by Crespo-Cuaresma and Reininger (2004) examines interest rate pass-through in the Czech Republic, Hungary, and Poland using the ARDL method. The results highlight differences among the countries. While there is no pass-through for any interest rate in Poland, deviations from pass-through are observed for various interest rates in the Czech Republic and Hungary. In the case of policy changes, it is concluded that bank interest rates exhibit more symmetric responses. Víquez and Monge (2008) examine the interest rate pass-through for the Costa Rica economy during the period of 1996-2007. They use a nonlinear asymmetric vector error correction model and obtain evidence supporting the full pass-through hypothesis in the long run. It is suggested that there is no evidence of asymmetric responses of retail interest rates to movements in policy interest rates. Jamilov and Égert (2014) investigating the interest rate pass-through effect for the Caucasus economies, Azerbaijan, Georgia, Kazakhstan, Russia, and Armenia, mentions that the interest rate pass-through is systematically incomplete and slow. While they underline that the findings are heterogeneous among countries, they argue low competition in the banking sector and macroeconomic instabilities as the cause of these asymmetries. Tai, Sek, and Har (2012) use the SUR method to examine the interest rate transmission mechanism for seven Asian countries, including Indonesia, the Philippines, Hong Kong, Korea, Malaysia, Singapore, and Thailand. The analysis results indicate that the transmission from money market interest rates to deposit and lending interest rates is slow. Additionally, while there is no significant difference between deposit and lending interest rate pass-through, the pass-through in deposits is higher compared to lending interest rates. Tang, Puah and Liew (2015) conclude that the effect of policy rate on loan and

deposit rates is not complete for Malaysia. They also stated that this effect is found to be asymmetric for loan rates, while the adjustment process in both loan and deposit rates has downward rigidities. Hussain and Nahar (2016) examine the interest rate pass-through mechanism among the discount rate, deposit interest rate, and lending interest rate for Malaysia using asymmetric threshold autoregression (TAR) and momentum analysis. The evidence indicates an asymmetric threshold cointegration relationship between two interest rates. On the other hand, there is only a symmetric cointegration relationship between lending and discount rates. The authors, who also investigate the impact of the 2008-2009 global financial crisis, state that there was no significant change in the speed and magnitude of the pass-through of different interest rates during this period.

Finally, we review the studies that investigate the interest rate pass-through effect from policy rate to loan and deposit rates of banks in Turkey. It is noteworthy that this relationship is not adequately questioned in terms of asymmetries. Firstly, Ozdemir (2009) explores the potential asymmetric relationship between money market rate and retail rates of banks using symmetric and asymmetric error correction method. The estimation results show that the adjustment process of retail rates is complete in the long run, but in the short run, the deposit rate is more rigid compared to the loan rate. Aydın (2010) compares the speed of the adjustment process for housing, cash, and vehicle loan rates against the CBRT monetary policy interest rates. Analyzes with data at the bank level reveal results in favor of the central bank's control of credit markets through short-run interest rates, especially in the post-2001 crisis period. On the other hand, the sensitivity of loan types to short-term policy rates is ranked, from highest to lowest, as housing, cash, automobile, and corporate loans, respectively. Yıldırım (2012) also examines the effect of policy rate on transport, housing, and corporate loan rates. Unlike Aydın (2010), the study which takes asymmetries into account determines that the all retail loan rates response to policy rate asymmetrically. Banks respond more rapidly to increases in monetary policy rates, while they respond to decreases more slowly, and it is emphasized that the decreases in interest rates for each loan type are quite different during the decreases in monetary policy rates. Yüksel and Özcan (2013) evaluate potential asymmetries for the period from 2001 to 2011. The results of the asymmetric threshold cointegration test address that the pass-through from monetary policy rates to loan rates is complete, and therefore no asymmetrical relationship is encountered. While the cointegration relationship cannot be determined between the policy rate and deposit rates, it is emphasized that the symmetric adjustment speed and size of these interest rates did not change during the financial crisis.

4. Data and Methodology

In this section, we introduce the data, methodology, and the information related to the Turkish banking.

4.1. Data

The data set used in the study consists of monthly data covering the period of January 2002 and October 2019. In some parts of this period, the CBRT used different interest rates as a policy rate during the implementation of the interest rate corridor. The CBRT's overnight lending rate (ONLR) in the interbank market is used to represent the policy rate. The weighted

average interest rates applied by the commercial banks to deposits[2] and loans are used to represent retail interest rates. These loan types consist of personal finance (PFLR), vehicle (VLR), housing (HLR), commercial (COMLR), and consumer loans (CONLR), respectively. The use of weighted average interest rates can be useful for testing the impact of market concentration and reasons such as collusive price arrangement on asymmetries since this interest rate mostly reflects the behavior of the banks that dominate the sector. According to the asset size, the ten largest commercial banks constitute more than 90% of the banking sector in Turkey. The high concentration level may have an impact on the response of weighted average interest rates to policy rate changes. All of this data set is obtained from the CBRT's electronic data distribution system (EVDS).

4.2. NARDL Model

In order to empirically investigate whether the central bank's policy rate pass-through has an asymmetric effect on banks' loan and deposit rates, we use the NARDL model proposed by Shin et al. (2014). NARDL model has some important advantages in modeling the cointegration relationship. Firstly, it provides flexibility in modeling the cointegration relationship by relaxing the assumption that the time series are integrated at the same level. It also allows the distinction between linear and nonlinear cointegration and enables to determine the short and long run asymmetries. Suppose that represents banks' weighted average loan and deposit rates, and i^p, is central bank policy rate, asymmetric long-run equilibrium relationship within the framework of the NARDL is shown as follows:

$$i = \beta^+ i^{p+}_t + \beta^- i^{p-}_t + u_t \quad (1)$$

where u_t, is the error process with constant and zero average, which represents deviations from the long term equilibrium levels. We can define ${i^p}_t$, as ${i^p}_t = {i^p}_0 + i^{p+}_t + {i^p}^-_t$, and it represents the process of partial sums of positive and negative changes in ${i^p}_t$. The decomposition of the partial sums of positive and negative changes can be expressed as follows, respectively:

$$i^{p+}_t = \sum_{j=1}^{t} \Delta i^{p+}_j = \sum_{j=1}^{t} \max\left(\Delta {i^p}_j, 0\right) \quad (2)$$

$$i^{p-}_t = \sum_{j=1}^{t} \Delta i^{p-}_j = \sum_{j=1}^{t} \min\left(\Delta {i^p}_j, 0\right) \quad (3)$$

Shin et al. (2014) obtain the NARDL (*p, q*) model by associating the linear ARDL (*p, q*) model with long-run asymmetric effects:

$$\Delta i_t = \mu + \rho i_{t-1} + \theta^+ i^{p+}_{t-1} + \theta^- i^{p-}_{t-1} + \sum_{j=1}^{p-1} \alpha_j \Delta i_{t-j} + \sum_{j=0}^{q-1} (\varphi^+_j \Delta i^{p+}_{t-j} + \varphi^-_j \Delta i^{p-}_{t-j}) + \varepsilon_t \quad (4)$$

The long-run positive and negative coefficients, $\beta^+ = -\theta^+/\rho$ and $\beta^- = -\theta^-/\rho$, can be calculated concerning asymmetries based on the equation (4). *p* and *q* show the number of lags of exogenous variables and the dependent variable within the autoregressive of distributed lag model. The null hypothesis of a long-run symmetric relationship, $\beta^+ = \beta^-$, can be tested with the Wald test. The φ^+_j and φ^-_j coefficients represent the short-run adjustment process of

[2] Although the relationship between the CBRT policy rate and both loan and deposit rates was examined at the beginning of the study. Similar to Yüksel & Özcan (2013), we could not find any cointegration relationship between the policy rate and deposit rates (one-month maturity, three-month maturity, six-month maturity, one-year maturity, and over-year maturity) for whole and sub-periods. These results are not reported here, but available upon request.

banks' loan and deposit rates after positive and negative changes in the monetary policy interest rate. Once more, we can test the null hypothesis of the short-run symmetry, $\varphi_j^+ = \varphi_j^-$ ($j = 0,1,2 \ldots., q-1$) for these coefficients.

If the null hypothesis cannot be rejected after the test of symmetric relations in the long and short run, the equation (4) above turns into the traditional error correction model. However, in cases where only one of them cannot be rejected after long or short-run symmetry tests, the equations showing short and long-run asymmetric relationships are as follows, respectively.

$$\Delta i_t = \mu + \rho i_{t-1} + \theta {i^p}_{t-1} + \sum_{j=1}^{p-1} \alpha_j \Delta i_{t-j} + \sum_{j=0}^{q-1} (\varphi_j^+ \Delta {i^p}^+_{t-j} + \varphi_j^- \Delta {i^p}^-_{t-j}) + \varepsilon_t \quad (5)$$

$$\Delta i_t = \mu + \rho i_{t-1} + \theta^+ {i^p}^+_{t-1} + \theta^- {i^p}^-_{t-1} + \sum_{j=1}^{p-1} \alpha_j \Delta i_{t-j} + \sum_{j=0}^{q-1} \varphi_j \Delta {i^p}_{t-j} + \varepsilon_t \quad (6)$$

After determining an asymmetric relationship, both short and long term relationships can be determined by the NARDL model. The long-run response of banks' loan and deposit rates to positive and negative shocks in the monetary policy interest rate can be calculated with asymmetric dynamic multipliers as follows:

$m_h^+ = \sum_{j=0}^{h} \frac{\partial i_{t+j}}{\partial {i^p}_t^+}$ ve $m_h^- = \sum_{j=0}^{h} \frac{\partial i_{t+j}}{\partial {i^p}_t^-}$ $\quad h = 0,1,2 \ldots$

where $h \to \infty$, represents $m_h^+ \to \beta^+$ ve $m_h^- \to \beta^-$. After a shock affecting the system, the dynamic adjustment process can be observed between the system variables from the initial equilibrium level to the new equilibrium by using estimated dynamic multipliers.

5. Model Estimations

One of the pre-condition to estimate the nonlinear ARDL model is that none of the series of variables is stationary at I(2) level. In order to investigate this pre-condition, the previously introduced series are examined with Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. The results of the unit root tests for the whole sample are given in Table 1. Table 1 demonstrates that all of the variables are stationary at I(0) or I(1) level.

Table 1: Unit Root Tests for Whole Period

Interest Rates	Levels				First Difference			
	Constant		Constant & Trend		Constant		Constant & Trend	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
ONLR	-2.87**	-4.04***	-2.29	-2.78	-5.64***	-13.01***	-5.87***	-13.32***
PFLR	-3.91***	-5.06***	-3.34*	-4.26***	-9.50***	-8.14***	-9.74***	-8.18***
VLR	-2.96**	-4.05***	-2.72	-3.40*	-10.00***	-10.94***	-10.22***	-10.95***
HLR	-3.59***	-2.99**	-3.23*	-2.46	-9.77***	-9.50***	-9.95***	-9.50***
COMLR	-3.14**	-4.30***	-2.66	-3.44**	-4.93***	-9.99***	-5.18***	-10.31***
CONLR	-3.85***	-4.69***	-3.35*	-4.01***	-9.34***	-7.59***	-9.55***	-7.53***

Note: The values demontrate t statistics for ADF and PP tests. ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively.

Table 2: Unit Root Tests for Pre-Crisis Period

Interest Rates	Levels				First Difference			
	Constant		Constant & Trend		Constant		Constant & Trend	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
ONLR	-3.22**	-3.05**	-1.44	-1.19	-6.66***	-6.86***	-7.56***	-7.60***
PFLR	-2.82*	-4.16***	-2.92	-2.91	-6.27***	-5.39***	-6.67***	-5.67***
VLR	-2.29	-2.80*	-1.78	-2.17	-6.61***	-7.34***	-6.89***	-7.43***
HLR	-2.27	-1.75	-1.70	-1.11	-6.52***	-6.59***	-6.77***	-6.74***
COMLR	-3.54***	-3.60***	-1.87	-1.87	-7.81***	-7.85***	-8.59***	-8.59***
CONLR	-2.68*	-3.80***	-2.83	-2.44	-5.85***	-5.31***	-6.20***	-5.61***

Note: The values demontrate t statistics for ADF and PP tests. ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively.

Table 3: Unit Root Tests for Post-Crisis Period

Interest Rates	Levels				First Difference			
	Constant		Constant & Trend		Constant		Constant & Trend	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
ONLR	-2.69*	-2.25	-3.26*	-2.83	-4.13***	-11.03***	-4.11***	-11.13***
PFLR	-2.72*	-2.02	-3.53**	-2.57	-6.93***	-5.70***	-6.95***	-5.69***
VLR	-2.41	-1.87	-2.97	-2.25	-6.98***	-6.86***	-6.96***	-6.83***
HLR	-3.38**	-2.54	-3.68**	-2.70	-7.83***	-6.25***	-7.87***	-6.18***
COMLR	-2.73*	-1.80	-3.94**	-2.72	-6.06***	-6.24***	-6.13***	-6.22***
CONLR	-2.72*	-2.26	-3.65**	-2.57	-7.56***	-4.73***	-7.60***	-4.66***

Note: The values demontrate t statistics for ADF and PP tests. ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively.

The policymaker has implemented comprehensive reforms under the strong economy transition program after the severe crisis in Turkey's economy in 2001. An important part of these reforms covers the regulations regarding the central banking and banking sector. In addition to the Banking Regulation and Supervision Board (BRSA) established to increase the monitoring and supervision of the banking sector, the regulations on the main aim of the Central Bank of Turkey Republic (CBRT) and the monetary policy practices in the central bank law take place on the top. After this date, the CBRT adopted price stability as the primary objective and started to implement the implicit inflation targeting regime in 2003 and fully-fledged inflation targeting regimes in 2006. In order to ensure price stability, the inflation targeting regime largely relies on policymakers that have a long-term perspective, as well as features of the central bank, such as independence, transparency, and accountability. However, the global financial crisis led to a revision in the goals and practices of the CBRT, while the developments for the effective inflation-targeting regime have just started in Turkey. The highlight on financial stability in 2010 as well as price stability, which is the main objective of the CBRT, has led the CBRT to monitor financial markets and especially banks more carefully. In recent years, especially in parallel with the developments in communication tools, there has been noticeable progress in the CBRT's transparency, communication, and forward guidance policies. All these developments may have led to changes in the CBRT policy rate pass-through to banks' loan and deposit rates and, thus, the effectiveness of the monetary policy. Therefore, analyzes are repeated for two sub-periods to observe whether there is a significant change in the interest rate pass-through effect before and after 2008. Table 2 and Table 3 demonstrate the unit root test results for the series before and after the 2008 global financial crisis, respectively. Here again, it is seen that all of the series are stationary at I(0) or I(1) level.

Although the results of traditional unit root tests confirm that none of the variables are I(2), the findings regarding the stationary levels of dependent variables are complex. Another precondition to estimate a non-linear ARDL model is that the dependent variable should not be stationary at the I(0) level. To determine whether this condition is satisfied, in addition to traditional unit root tests, we rely on unit root test considering structural breaks by Zivot and Andrews (1992) and non-linear unit root test by Kapetanios and Shin (2008). The results of these tests are presented in Table 4 and Table 5, respectively. Both test results confirm, at the 5% significance level, that all dependent variables have a unit root, thus verifying that none of the dependent variables are I(0). Weak evidence in favor of stationarity is observed only for two dependent variables here. In Table 4, the commercial loans variable appears stationary at the 10% significance level in the pre-crisis period and in the trended model, while in Table 5, the hypothesis that personal finance loans have a unit root in the post-crisis period can be rejected at the 10% significance level. However, considering other tests and different specifications in the tests, the findings suggest that in these two cases, the dependent variables are not stationary at the I(0) level.

Table 4: Zivot and Andrews (1992) Unit Root Tests

Interest Rates	Intercept			Trend			Intercept&Trend		
	t-statistics								
ONLR	-2.76 (179)			-3.097 (36)			-2.889 (36)		
PFLR	-3.730 (84)			-3.790 (99)			-3.792 (109)		
VLR	-3.194 (180)			-3.761 (38)			-3.679 (37)		
HLR	-3.353 (35)			-3.684 (38)			-3.777 (35)		
COMLR	-3.201 (84)			-3.596 (94)			-3.660 (37)		
CONLR	-3.764 (84)			-3.819 (101)			-3.821 (109)		
Critical Values	1%	5%	10%	1%	5%	10%	1%	5%	10%
	-5.34	-4.80	-4.58	-4.93	-4.42	-4.11	-5.57	-5.08	-4.82
	t-statistics								
ONLR	-4.628* (18)			-3.191 (23)			-4.665 (18)		
PFLR	-4.218 (22)			-3.722 (39)			-4.465 (22)		
VLR	-4.317 (20)			-3.487 (40)			-4.287 (20)		
HLR	-3.236 (17)			-3.224 (42)			-3.498 (37)		
COMLR	-4.147 (23)			-4.314* (42)			-4.707 (20)		
CONLR	-4.570 (21)			-3.884 (41)			-4.461 (21)		
Critical Values	1%	5%	10%	1%	5%	10%	1%	5%	10%
	-5.34	-4.80	-4.58	-4.93	-4.42	-4.11	-5.57	-5.08	-4.82
	t-statistics								
ONLR	-5.209** (114)			-4.334* (105)			-4.353 (92)		
PFLR	-4.318 (112)			-3.656 (76)			-3.740 (51)		
VLR	-3.986 (112)			-3.451 (22)			-3.351 (23)		
HLR	-4.535 (112)			-3.845 (74)			-3.854 (50)		
COMLR	-4.572 (114)			-4.008 (72)			-4.097 (114)		
CONLR	-4.534 (112)			-3.814 (76)			-3.843 (51)		
Critical Values	1%	5%	10%	1%	5%	10%	1%	5%	10%
	-5.34	-4.80	-4.58	-4.93	-4.42	-4.11	-5.57	-5.08	-4.82

Note: The values demontrate test statistics for ZA test. ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively. The values in parentheses indicate observations for structural break.

Table 5: Kapetanios and Shin (2008) Unit Root Tests

	Whole Period			Pre-Crisis Period			Post-Crisis Period		
Interest Rates	KS statistics								
ONLR	-0.760 (3)			-0.596 (3)			-1.692 (3)		
PFLR	-0.307 (3)			-0.120 (3)			-2.210* (7)		
VLR	-0.532 (3)			-0.427 (2)			-1.782 (2)		
HLR	-0.643 (14)			-0.451 (7)			-1.102 (11)		
COMLR	-0.523 (10)			-0.359 (6)			-1.302 (10)		
CONLR	-0.358 (2)			-0.141 (2)			-1.183 (10		
Critical Values	1%	5%	10%	1%	5%	10%	1%	5%	10%
	-2.663	-2.059	-1.780	-3.036	-2.381	-2.074	-2.703	-2.211	-1.826

Note: The values demontrate test statistics for KS test. ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively. The values in parentheses represent appropriate lag lengths based on AIC.

Table 6: Bound Test Results for the Nonlinear ARDL Models

	Dependent Variables				
	Personal Finance Loan Rate	Vehicle Loan Rate	Housing Loan Rate	Commercial Credit Rate	Consumer Loan Rate
Whole Sample					
F_{PSS}	6.879	4.989	6.389	4.445	7.243
Pre-Crisis Period					
F_{PSS}	5.427	5.140	3.174	4.535	3.866
Post-Crisis Period					
F_{PSS}	7.580	3.853	9.629	7.348	8.193

Note: The 10 % critical value of the F_{PSS} test obtained by Pesaran et al. (2001) is 4.14 for k = 2.

After testing the above preconditions, the non-linear ARDL model can now be estimated for the whole sample and sub-samples. Firstly, Table 6 demonstrates the cointegration statistics based on the bound test for the NARDL model. According to F statistics, only three models do not reject the null hypothesis of no cointegration relationship. When considering the whole sample, an asymmetric cointegration relationship is accepted between all loan rates and policy rates. In the pre-crisis period, an asymmetric cointegration relationship cannot be detected between housing and consumer loan rates and policy rate, while the asymmetric relationship between vehicle loans and policy rate disappears after the crisis. Therefore, it is concluded that the asymmetric modeling of the relationship between policy rates and loan rates is appropriate in most cases here. Table 7, Table 8, and Table 9 demonstrate the nonlinear ARDL estimation results for the whole period, pre-crisis and post-crisis periods, respectively. According to diagnostic tests, autocorrelation and heteroskedasticity are rejected at 5% significance level in the majority of the models. Therefore, our estimates are consistent in terms of diagnostics.

Table 7: Baseline Nonlinear ARDL Model Estimation Results for Whole Period

Variables	Dependent Variables				
	Personal Finance Loan Rate *(p=3, q=4)*	Vehicle Loan Rate *(p=4, q=4)*	Housing Loan Rate *(p=3, q=4)*	Commercial Loan Rate *(p=4, q=4)*	Consumer Loan Rate *(p=3, q=4)*
i^{p}_{t-1}	-0.142***	-0.132***	-0.139***	-0.099***	-0.154***
	[0.036]	[0.042]	[0.035]	[0.032]	[0.037]
i^{p+}_{t-1}	0.097***	0.106***	0.090***	0.066**	0.117***
	[0.036]	[0.040]	[0.029]	[0.033]	[0.037]
i^{p-}_{t-1}	0.112***	0.105***	0.107***	0.071***	0.121***
	[0.032]	[0.032]	[0.028]	[0.026]	[0.032]
Δi^{p}_{t-1}	0.345***	0.240***	0.401***	0.224***	0.411***
	[0.065]	[0.074]	[0.065]	[0.067]	[0.065]
Δi^{p}_{t-2}	-0.235***	-0.222***	-0.233***	-0.179***	-0.215***
	[0.065]	[0.070]	[0.069]	[0.068]	[0.068]
Δi^{p}_{t-3}		0.119**		0.152**	
		[0.059]		[0.062]	
Δi^{p+}_{t}	0.440***	0.463***	0.196***	0.484***	0.283***
	[0.083]	[0.084]	[0.073]	[0.074]	[0.083]
Δi^{p+}_{t-1}	0.285***	0.221**	0.357***	0.101	0.397***
	[0.088]	[0.091]	[0.076]	[0.080]	[0.086]
Δi^{p+}_{t-2}	0.204**	0.082	0.035	0.237***	0.140
	[0.089]	[0.091]	[0.079]	[0.080]	[0.088]
Δi^{p+}_{t-3}	0.290***	0.191**	0.338***	0.086	0.294***
	[0.088]	[0.092]	[0.082]	[0.083]	[0.091]
Δi^{p-}_{t}	-0.053	0.135	0.012	0.176*	0.003
	[0.115]	[0.118]	[0.101]	[0.101]	[0.117]
Δi^{p-}_{t-1}	0.627***	0.735***	0.660***	0.385***	0.667***
	[0.110]	[0.115]	[0.095]	[0.097]	[0.112]
Δi^{p-}_{t-2}	0.104	0.054	-0.234**	-0.063	-0.018
	[0.118]	[0.128]	[0.110]	[0.106]	[0.122]
Δi^{p-}_{t-3}	-0.145	-0.178	-0.019	0.001	-0.168
	[0.113]	[0.124]	[0.110]	[0.106]	[0.117]
Constant	8.158***	7.214***	7.306***	4.976***	8.507***
	[2.172]	[2.136]	[1.824]	[1.716]	[2.094]
	Long Run Coefficients				
L_{ON^+}	0.684***	0.806***	0.650***	0.667***	0.756***
L_{ON^-}	-0.787***	-0.800***	-0.769***	-0.717***	-0.785***
	Asymmetry Statistics				
$W_{LR,\ ON}$	1.624	0.004	2.842*	0.213	0.160
$W_{SR,\ ON}$	6.794***	0.599	5.006**	3.015*	5.793**
	Model Diagnostics				
Adj. R-square	0.540	0.507	0.553	0.453	0.571
χ^2_{SC}	51.81	39.37	35.95	37.14	44.71
	(0.10)	(0.498)	(0.653)	(0.599)	(0.280)
χ^2_{HET}	0.205	0.538	3.338	0.065	2.793
	(0.65)	(0.463)	(0.067)	(0.797)	(0.094)

Note: ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively. The optimal lag length (p, q) for all models is based on the Akaike information criterion (AIC), Hannan-Quinn information criterion (HQIC), and Schwarz information criterion (SIC). L_{ON^+} and L_{ON^-}, denote the long-run coefficients associated with positive and negative changes in the CBRT policy rate. $W_{LR,\ ON}$, and $W_{SR,\ ON}$, denote the Wald test for long-run and short-run symmetry restrictions, respectively. χ^2_{SC} and χ^2_{HET}, denote Breusch Godfrey LM test for serial correlation and White heteroscedasticity test, respectively.

Table 5 demonstrates the estimation results of the nonlinear ARDL model for the whole sample. The long-run positive and negative coefficients are all statistically significant. This result implies that all of the loan rates increase in response to positive shocks in the policy rate and decrease in response to negative shocks. The positive and negative long-run coefficients are very close to each other for all loan rates. In parallel with this finding, Wald tests are unable to reject the null hypothesis of long-run symmetry except for housing loan rate, whereas, in the short run, Wald tests are able to reject the null hypothesis of the short-run symmetry except for vehicle loan rate.

Table 8: Nonlinear ARDL Model Estimation Results for Pre-Crisis Period

Variables	Dependent Variables				
	Personal Finance Loan Rate *(p=3, q=2)*	Vehicle Loan Rate *(p=4, q=2)*	Housing Loan Rate *(p=4, q=2)*	Commercial Loan Rate *(p=4, q=2)*	Consumer Loan Rate *(p=3, q=2)*
i^{p}_{t-1}	-0.354***	-0.381***	-0.196***	-0.325***	-0.300***
	[0.088]	[0.111]	[0.073]	[0.089]	[0.089]
i^{p+}_{t-1}	0.099	0.166**	0.113	0.076	0.153*
	[0.068]	[0.081]	[0.069]	[0.049]	[0.084]
i^{p-}_{t-1}	0.304***	0.310***	0.179***	0.244***	0.263***
	[0.077]	[0.084]	[0.060]	[0.067]	[0.078]
Δi^{p}_{t-1}	0.334***	0.274***	0.227**	0.067	0.309***
	[0.083]	[0.101]	[0.097]	[0.084]	[0.088]
Δi^{p}_{t-2}	-0.153*	-0.160*	-0.147	-0.173**	-0.115
	[0.085]	[0.090]	[0.097]	[0.074]	[0.089]
Δi^{p}_{t-3}		0.223**	0.061	0.273***	
		[0.084]	[0.089]	[0.077]	
Δi^{p+}_{t}	0.310	0.486**	0.426*	0.248	0.415*
	[0.219]	[0.242]	[0.217]	[0.167]	[0.236]
Δi^{p+}_{t-1}	0.664***	0.544**	0.472**	0.262	0.647***
	[0.222]	[0.252]	[0.221]	[0.164]	[0.242]
Δi^{p-}_{t}	-0.053	0.016	0.022	0.003	0.026
	[0.146]	[0.190]	[0.163]	[0.116]	[0.162]
Δi^{p-}_{t-1}	0.475***	0.523**	0.610***	0.227*	0.545***
	[0.173]	[0.197]	[0.153]	[0.134]	[0.189]
Constant	21.662***	20.823***	11.323***	16.999***	17.659***
	[5.430]	[5.791]	[3.969]	[4.693]	[5.204]
	Long Run Coefficients				
L_{ON^+}	0.278	0.435**	0.576*	0.233	0.509**
L_{ON^-}	-0.859***	-0.814***	-0.911***	-0.751***	-0.887***
	Asymmetry Statistics				
$W_{LR,\ ON}$	13.25***	5.246**	1.27	14.72***	3.236*
$W_{SR,\ ON}$	2.214	1.413	0.529	1.057	1.501
	Model Diagnostics				
Adj. R Square	0.603	0.563	0.497	0.523	0.584
χ^2_{SC}	41.68	29.26	24.44	50.66	38.19
	(0.237)	(0.779)	(0.928)	(0.053)	(0.370)
χ^2_{HET}	0.024	0.003	0.000	2.984	0.412
	(0.874)	(0.951)	(0.997)	(0.084)	(0.520)

Note: ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively. The optimal lag length (p, q) for all models is based on the Akaike information criterion (AIC), Hannan-Quinn information criterion (HQIC), and Schwarz information criterion (SIC). L_{ON^+} and L_{ON^-}, denote the long-run coefficients associated with positive and negative changes in the CBRT policy rate. $W_{LR,\ ON}$, and $W_{SR,\ ON}$, denote the Wald test for long-run and short-run symmetry restrictions, respectively. χ^2_{SC} and χ^2_{HET}, denote Breusch Godfrey LM test for serial correlation and White heteroscedasticity test, respectively.

Table 6 demonstrates the estimation results of the pre-crisis period model. Although the asymmetric cointegration relationship cannot be determined for housing and consumer loans, statistically significant long-run and short-run coefficients are detected. Besides, it is determined that vehicle loans respond positively and significantly to positive changes in the policy rate in the long run while all loan rates respond negatively and significant to negative changes in the policy rate in the long-run. When long-run positive and negative coefficients are compared, it is seen that negative coefficients are considerably larger than positive coefficients. Furthermore, in the pre-crisis period, while long-run asymmetries appear between policy rates and loan rates, the existence of a symmetric relationship between these variables cannot be denied in the short run.

The findings of the post-crisis period are presented in Table 7. All long-run negative coefficients, which are statistically significant in the pre-crisis period, turn into insignificant in the post-crisis period. While the findings related to the existence of an asymmetric relationship between vehicle loans and the policy rate in the pre-crisis period disappear in the post-crisis period, on the contrary, asymmetric cointegration relationship and significant long-run coefficients are estimated for the consumer loans in the post-crisis period. The long-run coefficients of consumer and commercial loans become significant in the post-crisis period. Asymmetry statistics show that only commercial loan rates respond asymmetrically to policy rate changes in the long run. On the other hand, when the policy rate changes, the symmetric adjustment process for personal finance, housing, and consumer loans is rejected in the short term.

Table 9: Nonlinear ARDL Model Estimation Results for the Post-Crisis Period

Variables	Dependent Variables				
	Personal Finance Loan Rate *(p=3, q=4)*	Vehicle Loan Rate *(p=2, q=4)*	Housing Loan Rate *(p=3, q=4)*	Commercial Loan Rate *(p=2, q=4)*	Consumer Loan Rate *(p=3, q=4)*
i^{p}_{t-1}	-0.135***	-0.096**	-0.117***	-0.136***	-0.122***
	[0.040]	[0.037]	[0.036]	[0.033]	[0.037]
i^{p+}_{t-1}	0.055	0.044	0.026	0.066**	0.047
	[0.042]	[0.038]	[0.032]	[0.032]	[0.040]
i^{p-}_{t-1}	0.045	0.034	0.021	0.017	0.034
	[0.045]	[0.040]	[0.038]	[0.033]	[0.043]
Δi^{p}_{t-1}	0.499***	0.304***	0.597***	0.405***	0.640***
	[0.082]	[0.087]	[0.070]	[0.085]	[0.076]
Δi^{p}_{t-2}	-0.227**		-0.393***		-0.356***
	[0.089]		[0.079]		[0.085]
Δi^{p+}_{t}	0.385***	0.346***	0.104*	0.462***	0.162**
	[0.077]	[0.072]	[0.055]	[0.069]	[0.068]
Δi^{p+}_{t-1}	0.157*	0.130	0.367***	-0.058	0.349***
	[0.085]	[0.080]	[0.059]	[0.082]	[0.072]
Δi^{p+}_{t-2}	0.248***	0.037	0.041	0.229***	0.180**
	[0.086]	[0.072]	[0.063]	[0.067]	[0.074]
Δi^{p+}_{t-3}	0.344***	0.293***	0.498***	0.176**	0.401***
	[0.083]	[0.073]	[0.067]	[0.072]	[0.078]
Δi^{p-}_{t}	0.039	0.149	-0.185	0.574***	-0.027
	[0.195]	[0.173]	[0.146]	[0.166]	[0.176]
Δi^{p-}_{t-1}	0.339*	0.590***	0.846***	0.346**	0.511***
	[0.177]	[0.166]	[0.129]	[0.164]	[0.159]
Δi^{p-}_{t-2}	-0.011	-0.061	-0.429**	-0.490**	-0.176
	[0.212]	[0.205]	[0.166]	[0.196]	[0.193]

Δi^{p}_{t-3}	-0.004	-0.083	-0.130	0.060	-0.059
	[0.206]	[0.184]	[0.171]	[0.174]	[0.193]
Constant	2.547**	1.622*	1.495*	1.689**	2.005**
	[1.048]	[0.853]	[0.827]	[0.668]	[0.938]
			Long Run Coefficients		
L_{ON^+}	0.405*	0.465*	0.222	0.485***	0.387*
L_{ON^-}	-0.335	-0.357	-0.175	-0.125	-0.277
			Asymmetry Statistics		
$W_{LR,\ ON}$	0.278	0.385	0.165	9.217***	0.688
$W_{SR,\ ON}$	5.853**	0.481	15.95***	1.219	8.993***
			Model Diagnostics		
Adj. R Square	0.581	0.526	0.735	0.621	0.679
χ^2_{SC}	30.88	53.36	19.87	24.30	29.24
	(0.849)	(0.076)	(0.996)	(0.976)	(0.895)
χ^2_{HET}	3.487	0.413	41.88	0.066	3.353
	(0.061)	(0.520)	(0.000)	(0.796)	(0.067)

Note: ***, **, and * indicate statistical significance level at 1%, 5% and 10%, respectively. The optimal lag length (p, q) for all models is based on the Akaike information criterion (AIC), Hannan-Quinn information criterion (HQIC), and Schwarz information criterion (SIC). L_{ON^+} and L_{ON^-}, denote the long-run coefficients associated with positive and negative changes in the CBRT policy rate. $W_{LR,\ ON}$, and $W_{SR,\ ON}$, denote the Wald test for long-run and short-run symmetry restrictions, respectively. χ^2_{SC} and χ^2_{HET}, denote Breusch Godfrey LM test for serial correlation and White heteroscedasticity test, respectively.

Figure 1, Figure 2, and Figure 3 show the response of banks' loan rates to positive and negative shocks in monetary policy through dynamic multipliers based on nonlinear ARDL model estimates for the whole period, pre-crisis and post-crisis periods, respectively. The dynamic multipliers based on 1000 bootstrapped and 95% confidence intervals reveal more clearly the time-varying behavior of asymmetries and in which direction the loan rates are adjusted faster or slower. The first thing to notice here is that the findings of the whole period behave similarly to the post-crisis period. The asymmetries, which are high in the short run in both periods, lose their effect in the long run and approach to zero. The asymmetries in the short term for the whole period begin to decrease after 3-4 months at the latest and disappear entirely in the maximum tenth month. In the post-crisis period, the asymmetries in the adjustment process, which is almost similar in terms of duration, are more dominant than the whole period. In both periods, the loan rates are more rigid downwards than upwards in the short run. The significant asymmetries in the pre-crisis period, which began to appear in the short run, become apparent in the fifth period and continue in the long run. On the contrary to the pre-crisis period, it is concluded that loan rates are more rigid upwards than downwards in the long run.

Figure 1: Dynamic Multipliers for Whole Period Model

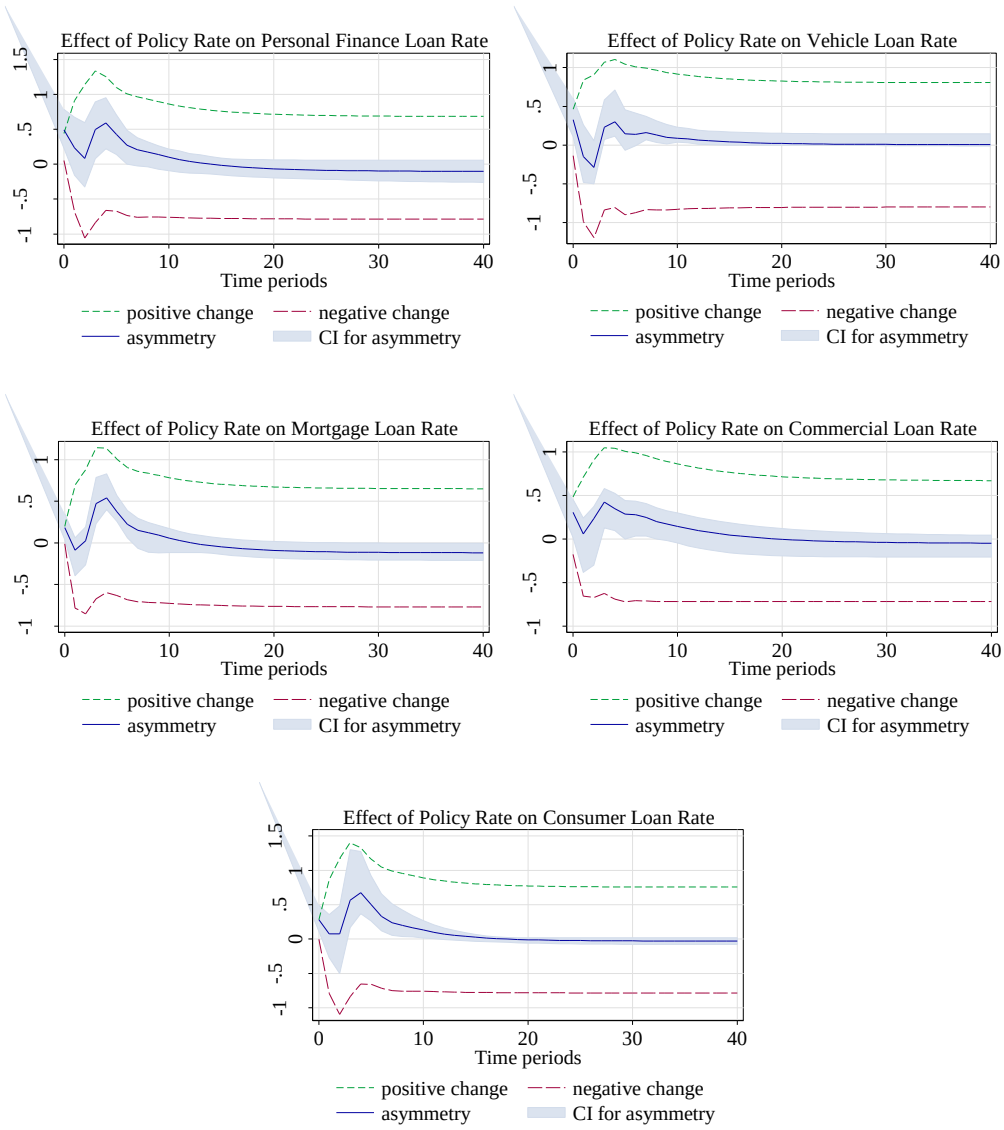


Figure 2: Dynamic Multipliers for Pre-Crisis Period Model

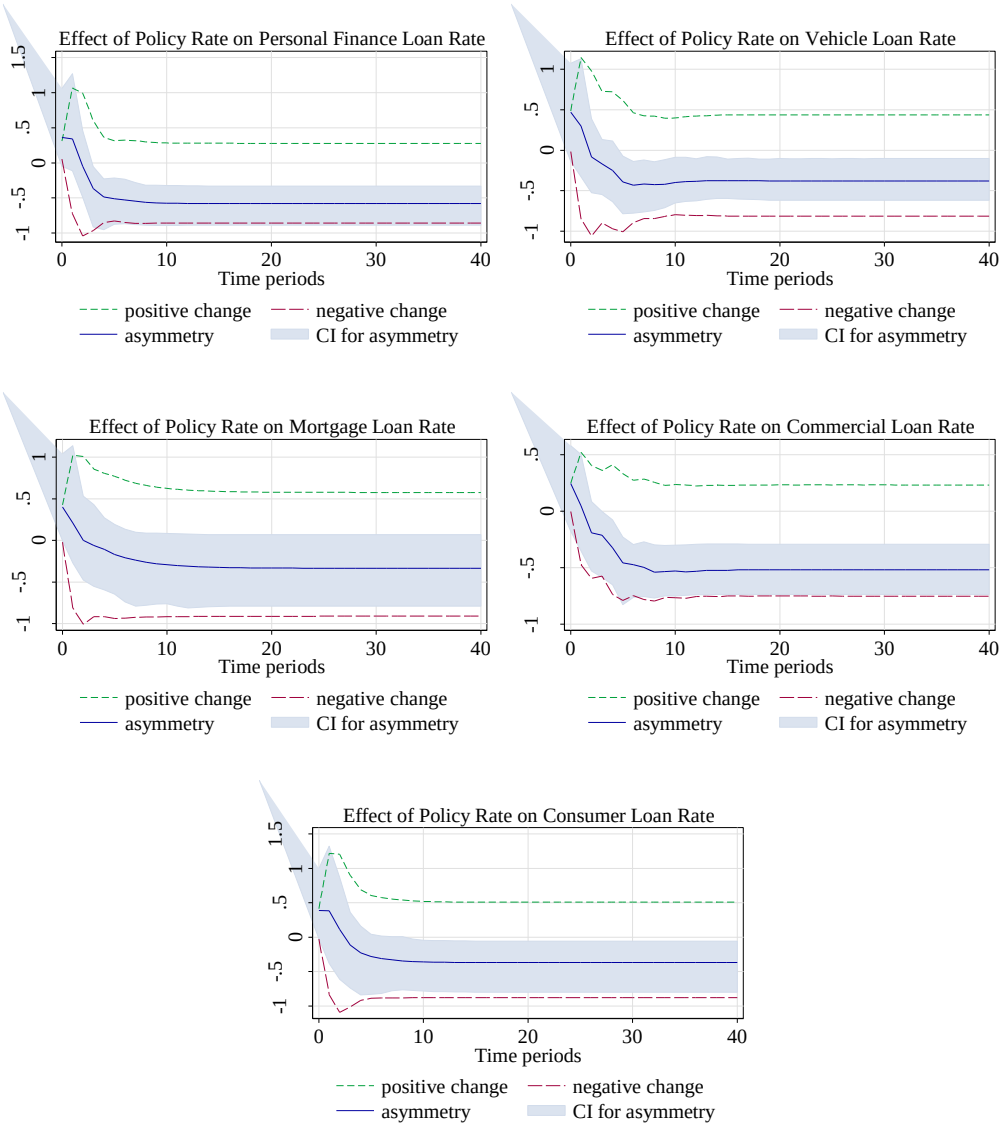
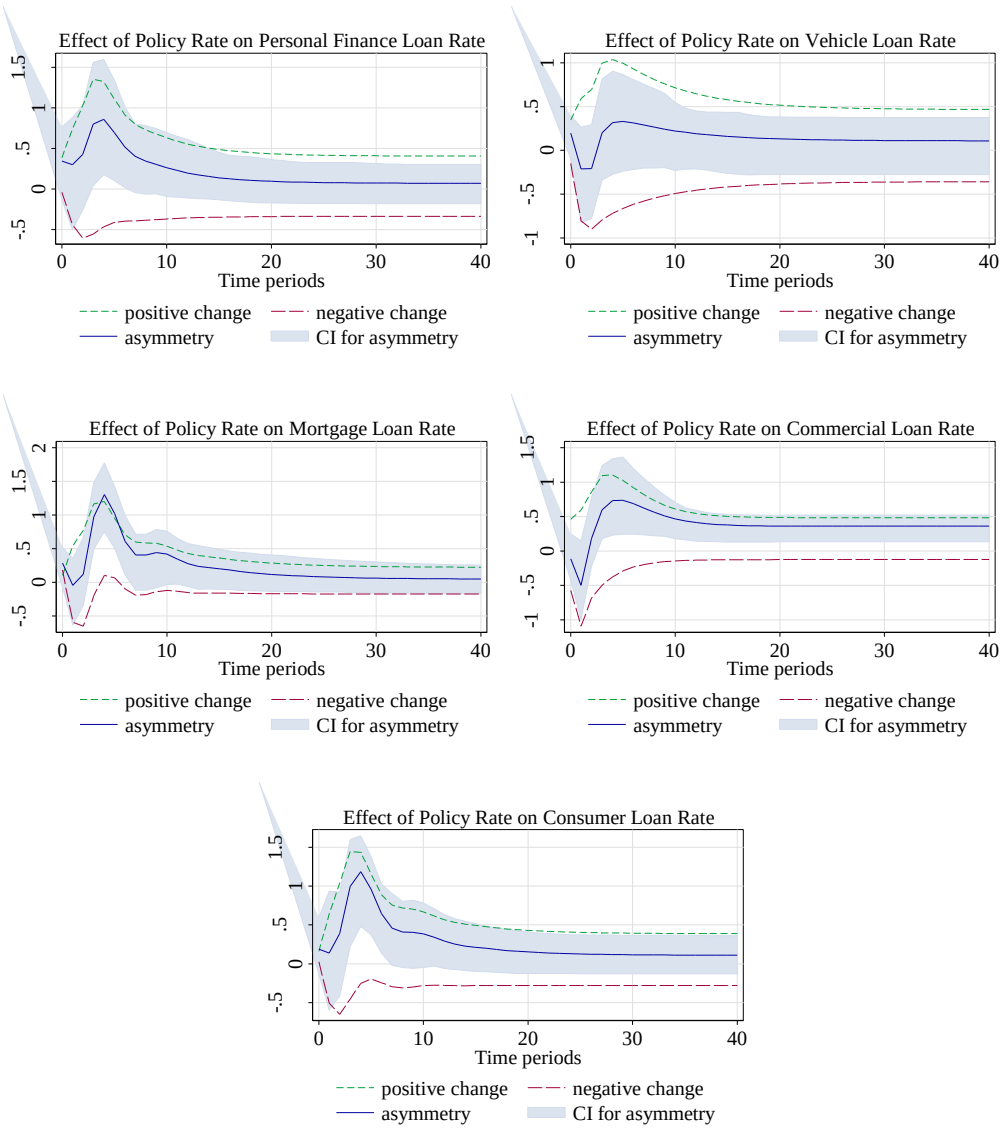


Figure 3: Dynamic Multipliers for Post-Crisis Period Model



6. Discussion

The findings based on data from the whole period confirm that there is a long-run relationship between the CBRT policy rate and bank loan rates. This long-run relationship is symmetric for most interest rates. In the short run, this relationship turns into asymmetric except for vehicle loans. However, when we divide the sample into two sub-periods, there is evidence that there may be significant changes in banks' loan rate behaviors in case of the policy rate changes of the central bank after the global financial crisis. Although the long-run relationship continues to be supported mainly before the crisis, especially after the crisis, the

relationship between negative shocks in monetary policy and bank loan rates disappears. In addition, long-run responses to negative shocks in policy rates are significantly larger than positive shocks before the crisis, while these negative responses converge each other after the crisis. This result implies that banks respond to a decrease in policy rate more than the increases before the crisis. In other words, it can be concluded that loan rates in this period are more rigid upwards in the long run. The 2001 crisis triggered the bankruptcy of many banks and great losses for customers in Turkey. Afterward, the confidence of the households in the banking sector has decreased significantly, and the reuse of the banking sector has been gradually realized. The upward rigidity of banks' loan rates in this period may be due to the effort to acquire new customers and not to lose existing customers. These developments, in parallel with the findings of the study, support the negative customer reaction hypothesis. In addition, it may be consistent to consider that asymmetric information problems increase after the 2001 banking crisis and that banks adjust their loan rates upwards slowly as well as credit rationing in order not to attract riskier customers. In the period of 2001-2008, some foreign banks entered the Turkish banking sector by purchasing a domestic bank or by making direct investments. These developments may have caused the banking sector to have a more competitive structure and a temporary decrease in market concentration. Therefore, in parallel with this development in the Turkish banking sector, our findings on upward rigidities in loan rates support the opposite of the collusive price arrangement hypothesis. Moreover, excess liquidity opportunities in the global markets in this period may have significantly reduced the cost of alternative fund sources of banks in the long run, thereby reducing the sensitivity of loan rates to increases in the policy rate.

The adjustment process of loan rates is not complete in any period, and it can be concluded that the negative adjustment process slows down, but the positive adjustment process accelerates in the long run after the financial crisis. However, although all long-run negative coefficients are negative after the financial crisis, they are statistically insignificant. In the post-crisis period, there is no significant relationship between the tightening of monetary policy and the decline in banks' loan rates. Similarly, although the adjustment process of bank loans has asymmetric patterns in both periods, this asymmetric adjustment appears only in the long term before the financial crisis but in the short term after the financial crisis. As mentioned earlier, these results show that the post-crisis period exhibits closer behaviors with findings from the entire period. The loan rates are more rigid downwards in the short run in both periods. The fact that downward rigidity of loan rates in the short run and the long-run relationship between negative shocks in policy rates and decreases in loan rates disappear after the financial crisis may be related to the transformations in the competitive structure of the banking sector in Turkey. Sekmen et al. (2015) find that the banking sector does not have a perfect competitive structure in Turkey. They emphasize that the market structure of the Turkish banking sector is closer to monopolistic competition. In addition, the decrease in the average number of banks in these twenty years and the fact that fewer banks gradually constitute a larger part of the sector can be interpreted as an increase in market concentration and market power of banks. These circumstances may have created an environment for banks to exhibit a collusive price arrangement in the post-crisis period. Furthermore, global liquidity conditions, which started to tighten, especially with the FED policies after 2013, may have caused an increase in the cost of alternative fund sources of banks, making loan rates more sensitive to policy rate increases.

When these findings related to asymmetries are evaluated more specifically in terms of loan types, the vehicle loan rates are unrelated to the policy rates in post-crisis periods or symmetric in the whole period except for the long-run asymmetric response in the pre-crisis period. The considerable changes have been experienced in vehicle sales with loans in the last ten years. It is observed that vehicle purchase transactions via loans are slowly shifting from banks to financial companies that are independent or a subsidiary of banks. This process, which is carried out through vehicle dealers in agreement with financial companies, can affect the potential of conventional vehicle loans. Such financial developments as substitutes may affect the interest elasticity of the vehicle loan demand and cause to break the relationship between the policy rate and the vehicle loan rates. It would be appropriate to observe the opposite effect of personal finance and consumer loans. Because of the macro-prudential measures that increased after 2010, some restrictions were made on the use of credit cards and sales by installments, especially in durable consumer goods such as electronics, furniture, and white goods. These policies may cause the banks to display asymmetric pricing behaviors in the short term in the face of increasing credit demand by causing consumers to change the financing methods from credit cards to personal finance and consumer loans in the financing of such needs. Lastly, commercial loan rates follow the asymmetric adjustment process in both periods in the long run, while housing loans are only asymmetric in the short run after the financial crisis.

7. Concluding Remarks

Understanding the adjustment process of banks' loan and deposit rates is extremely important for monetary policymakers. In this process, the direction and severity of the banks' reaction in loan and deposit rates contribute to how the policy rate should be calibrated. Incomplete or inaccurate information about this process may cause ineffectiveness of monetary policy and thus uncertainty in output and price fluctuations.

In this study, the nonlinear ARDL framework is applied to understand how the banks adjust the deposit and loan rates when the policy rate changes. The empirical analysis, for the period 2002:01-2019:10 and two sub-periods, reveals that the adjustment process of bank loan rates in Turkey exhibits significant asymmetric patterns both in the long and short run. The loan rates generally have upward rigidities in the long run before the financial crisis. These rigidities are downward and in the short-run after the financial crisis. The findings covering the entire period are parallel to the findings in the post-crisis period. These results imply that banks adjusted their loan rates more slowly during monetary tightening periods in the pre-crisis period, while banks' responses are faster during monetary easing periods. However, in the post-crisis period, banks' loan rates react faster during monetary policy tightening than monetary easing periods.

While almost all previous studies have concluded that this relationship is asymmetric, the adjustment process exhibits different behaviors after positive and negative shocks. Our results are consistent with these findings. The findings obtained for whole period and post-crisis period indicate that the adjustment process is downward rigid, similar to the studies of Valadkhani and Anwar (2012), Wang and Lee (2009), Wang and Thi (2010), Fadiran and Ezeoha (2012), Tang, Puah, and Liew (2015), and Yıldırım (2012). The pre-crisis period findings, on the other hand, display upward rigidities in line with the studies of Gambacorta and Iannotti (2007), Payne and Waters (2008), Wang and Lee (2009), Haughton and Iglesias (2012), Matemilola, Bany-Ariffin, and Muhtar (2015). In contrast to our findings, studies by Kleimeier and Sander (2006), Gambacorta and Iannotti (2007), Wang and Lee (2009), Fadiran and Ezeoha (2012),

Haughton and Iglesias (2012), Tai, Sek, and Har (2012), Tang, Puah, and Liew (2015), Hussain and Nahar (2016), and Ozdemir (2009) identify asymmetries in both loan and deposit interest rates, indicating that the two types of interest rates do not adjust at the same speed. While Yüksel and Özcan (2013) state that there is no asymmetric relationship for Turkey, Hussain and Nahar (2016) cannot identify a difference for both pre and post-global crisis periods. This study reveals opposite results.

The results of the study correspond to different theoretical explanations. While the findings based on pre-crisis period point out to the fact that the banking sector has a more competitive structure, While the findings related to the pre-crisis period point out that the banking sector has a more competitive structure, it can be concluded that changes in the market structure after the crisis cause changes in the interest rate adjustment process. As a result of increases in anti-competitive practices, interest rate responses are likely to be even more asymmetric.

In recent years, particularly after the transfer of state banks to the established asset fund, the loan rate decreases have occurred due to political concerns, especially housing interests. Although these interest rate decisions of state banks seem to be acting simultaneously with policy rates, they may not fully reflect the impact of the policy rate and industry's cost conditions, and thus the response of interest rates can be expected to be even more asymmetric in the future periods. On the other hand, in periods of financial instability when the asymmetric information problem may be higher, the behavior of interest rates is in line with theoretical expectations. A well-functioning and stable financial structure can be seen as a prerequisite for the complete and symmetric interest rate pass-through.

The last decade is a period when financial development and deepening have accelerated in Turkey. Financial innovations and financial product diversity enabled the acceleration of the integration of economic actors to the financial system, particularly banks, and the relationship between them becomes more multifaceted in Turkey. Also, the widespread use of information communication tools in financial markets in this period may have reduced asymmetries by decreasing the cost of obtaining information, causing the rate of more sophisticated customers to increase gradually. On the other hand, individuals have to engage with the financial system since the first stages of their lives. Tighter bank and customer relationships may lead to an increase in transaction costs, such as search and switching, while banks may also have trade-off short and long-run goals to avoid losing their loyal customers. All these developments bring a different set of balancing effects in each of the loan and deposit rates. Turkey's financial development is still at an early stage, but it has a rapidly changing social and economic structure thanks to the rapidly spreading technology. Therefore, analyzing the changes that cause asymmetries, particularly bank and consumer behavior at the micro-level, can fill the gap in this field.

These results indicate that the effectiveness of monetary policy is largely dependent on the interest rate pass-through mechanism. Policymakers should dynamically design measures to reduce frictions that impede this transmission mechanism. In this context, it is necessary to more closely monitor and regulate the levels of competition and concentration in the banking sector

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