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Linear and Nonlinear Dynamics of Housing Price in Turkey*

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Abstract

Housing sector have an important size in economic activities of Turkey. This sector could absorb an important size of skilled and unskilled unemployed. Furthermore, decreasing rents would cause an increase in household savings because of lightening their basic expenditures. Therefore, having knowledge about the dynamics of housing prices is very crucial for economic policymakers. In this paper, the dynamics between house prices and macroeconomic variables including inflation, interest rate, unemployment and real domestic product are studied. Despite the well-known fact that macroeconomic variables possess asymmetric and nonlinear features, many studies about the dynamics of housing prices has been tested only within a linear framework. Therefore, in this paper non-linear autoregressive distributed lag (NARDL) model is used to explore asymmetrical relations in the long-run. Despite to most researches in this field, the effect of interest rate found with a negative sign. Negative effect of both nominal interest rate and inflation on housing prices alongside of greater impact of inflation in comparison with nominal interest rate, would cause the long-run coefficient of real interest rate be positive. Forethought can explain of the positive relation of the unemployment rate and housing prices.

Keywords: housing price, Turkey, linear and nonlinear methods
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1. Introduction

The housing sector represents an important element of economic activity in Turkey, *i.a.* because it is capable of absorbing a large number of skilled and unskilled unemployed people. Overall, the construction industry is the sixth largest economic sector in Turkey on the basis of the value it adds to GDP, and it employs 7.4% of the entire Turkish workforce (Erol and Unal 2015). Moreover, were the housing sector to be characterized by lower rents, the effect would be for household saving to increase, given the reduced burden of basic expenditure.

It is *i.a.* for the above reasons that a knowledge of the dynamics of housing prices can prove crucial for economic policymakers. A house satisfies a basic physical need of the human being, and is thus a very attractive good for householders. Actual ownership of a house relieves householders of the need to pay rent, thereby making the saving of money more achievable. According to Hutchison (1994) by purchasing a house, a buyer is able to obtain an attractive and positive return.

All of this ensures that the housing sector cannot be studied in the same way as other sectors offering goods and services. Alongside the direct and indirect utilitarian value, a home also provides economic returns for those who own one.

The housing sector in Turkey has a few distinctive characteristics, not least the rapid growth in the size of the market ongoing during the period the work described here was being carried out. Figure 1 shows the general situation in the housing sector, making it clear that prices are not decreasing. Indeed, the rate of increase in the housing price index exceeds the inflation rate, and has also exceeded the nominal interest rate for a long time now. The latter fact is relevant given the assumption that the cost of having a new house will be financed by banking system credits, with interest paid therefore acknowledged as a cost associated with having a new house. Where growth in the HPI is greater than the nominal interest rate, the housing sector should be more attractive to investors than the depositing of money in the banking system. The return to be gained in the housing sector is likely to be greater than that from a banking deposit account, and all the more so if rents are taken into account. Thus, analysed overall, the Turkish housing sector compares favourably with saving on deposit in the country's banking system, offering better guarantees and little or no risk, and in general emerging as attractive. Riskless assets are in particular sought out by shareholders or financial investors when recession or depression in economic activity threatens. If the housing sector becomes riskless and also offers returns high in comparison with other riskless assets, then any expectation of depression will increase the demand for, and the prices of, houses.

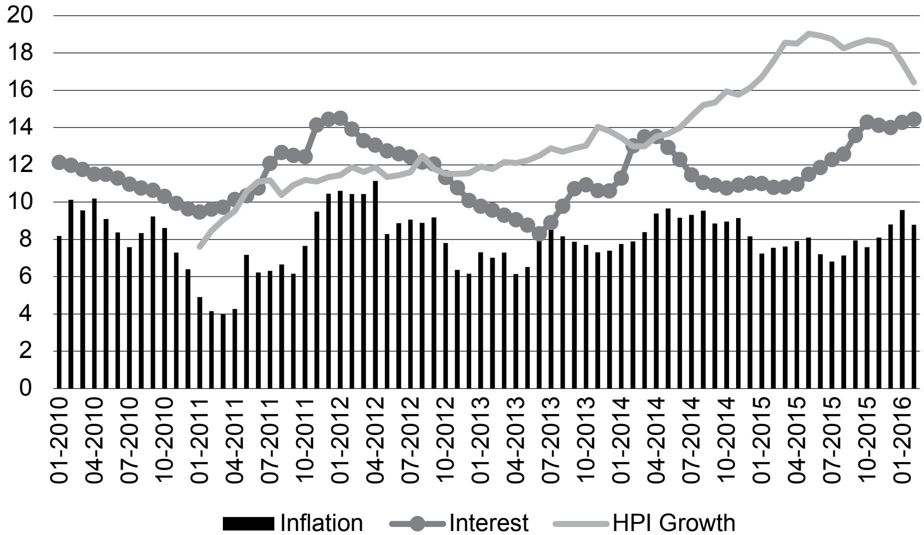

Figure 1. Interest rate, inflation and HPI growth rate in Turkey

Source: author's own elaboration.

House prices are capable of affecting macroeconomic variables, such as inflation, interest rates, unemployment and real domestic product. On the other hand, house prices may themselves be affected by macroeconomic variables. The relationship between house prices and macroeconomic movements is thus a bilateral one. Abate (2016) showed that fluctuations in house prices have a negative and significant effect on the main macroeconomic variables.

However, despite the well-known fact that such macroeconomic variables possess asymmetric and nonlinear features, many studies of the dynamics of housing prices have been tested within a linear framework only. In a famous remark, Keynes (1936, 314) noted that "the substitution of a downward for an upward tendency often takes place suddenly and violently, whereas there is, as a rule, no such sharp turning point when an upward is substituted for a downward tendency". After Shin *et al.* (2014), we can assume that "the nonlinearity of many macroeconomic variables and processes has long been recognized and nonlinearity is endemic within the social sciences and that asymmetry is fundamental to the human condition". Furthermore, Kahneman and Tversky (1979), as well as Shiller (1993; 2005) suggested nonlinear approaches for economic models.

The work detailed in this paper has thus used a non-linear autoregressive distributed lag (NARDL) model to explore asymmetrical relations over the longer term. A contribution is thus made to a growing literature, through the provision of additional evidence in the context of the housing market of Turkey, through an application of new methods and variables that has seemed suitable for this research.

The remainder of this paper is organised as follows. Section 2 offers a review of relevant literature, while Section 3 describes the model and econometric method. Section 4 then analyses the empirical results, before the last section presents key conclusions from the work.

2. Literature review

There are a wide range of studies concerning the relationship between the housing sector and macroeconomic variables. A thorough review of the literature on this was carried out by Leung (2004). In turn, the role played by construction in development and economic growth has *inter alia* been studied by Wells (1985), Green (1997), Lean (2001), Anaman and Osei-Amponsah (2007), Tse and Ganesan (1997), Yiu *et al.* (2004), Lopes, J. *et al.* (2002), Lopes, Jorge *et al.* (2011), Ramachandra *et al.* (2013), Jackman (2010), Alonso Nuez *et al.* (2015), Fereidouni *et al.* (2014), Antonakakis and Floros (2016) and Yunus (2016). Among many relevant studies of the Turkish housing sector that have been conducted, reference might for example be made to Sertkaya (2016), Öztürk and Fıtöz (2009), and Erol and Unal (2015). Feldstein (1992) indicated that rising inflation curbs the incentive people feel to invest in real estate, with this in turn limiting the demand forhousing.

On the other hand, Kearl (1979) argued that inflation causes nominal housing payments to rise, which implies reduced demand for housing. Building activity is stimulated by higher employment growth (Smith and Tesarek 1991; Sternlieb and Hughes 1997), while Hartzel *et al.* (1993) argued that certain regional employment characteristics play a significant role in investors' decisions, and thus, in the determination of housing prices. Finally, Giussani *et al.* (1992) found a significant impact on housing prices of GNP changes (and thus employment).

Theoretical background to the use of various determinants of house prices is to be found in Gallin (2006), Timmermann (1995), and Poterba (1984). Himmelberg *et al.* (2005) used their own calculations on the costs of owning housing in relation to 46 Metropolitan Statistical Areas (MSAs), arguing that the high price-to-income and price-to-rent ratios observed in recent years were explained by shifts in real long-term interest rates, meaning that there was no bubble on the U.S. housing market. Smith and Smith (2006) suggested that house prices were below their fundamental value derived from house rents where prices and rents were taken from a sample of matched single-family homes. However, Case and Shiller (2003) were more in favour of the existence of a speculative bubble on some regional U.S. housing markets, in line with the results of a survey of consumer attitudes towards housing. Gallin (2006) and Mikhed and Zemčík (2007) employed panel data for the U.S. MSAs to analyze house prices. The former study used income and the latter rent as the only fundamental factor. Both studies employed panel data stationarity tests to find that house-price dynamics could not be explained by either of the two variables.

In consequence, the above studies are followed in deriving housing prices as a function of underlying economic factors in both present value and structural housing models, with the link between them illustrated explicitly.

Moreover, in case of Turkey there are many studies exploring such issues as the effects of income on Turkey's housing sector (see Solak and Kabadayi 2016). Their paper regards the most significant factor affecting housing demand as income levels in Turkey and income elasticity as regards housing greater than one.

Apergis *et al.* (2015) found a bidirectional relationship between income and housing prices, while Chen *et al.* (2007) used VECM and a co-integration method to check for the long-run relationship between house prices and income levels. Holly *et al.* (2010) used the panel-data method to investigate the relationship between housing prices and income in the U.S. In line with their results, real housing prices can be seen to have been rising in line with fundamentals. In contrast, evidence from univariate and panel unit root and co-integration tests allowed Mikhed and Zemčík (2009) to conclude that there was indeed a housing-price bubble in the U.S. prior to 2006. Gallin (2006) in turn rejected any long-run relationship between the main macroeconomic variables and housing prices. He asserted that relevant literature was likely spurious, with the associated error-correction modelsto be seen as possibly inappropriate. However, Nyakabawo *et al.* (2015) imply that, while real house prices lead real GDP per capita, significant feedbacks generally also exist from real GDP per capita to real house prices.

Meen (2002) carried out a time-series analysis using UK and US data, finding that house pricing behaviour has been differentiated over time in the two countries, at both the national and sub-national levels.

The relationship between housing price and income explains the effects of macroeconomic conditions on the housing sector. In this regard, Tiwari *et al.* (1999) found a positive if flexible relationship between income and housing prices in Mumbai, India. Income of individuals is a factor of importance to the housing sector, though the long–term effects of income should not be measured by reference to present income. Rather, unemployment rates may represent the economic situation in the long run, with usage of this measure potentially giving better results. In the context of demand rule, it is expected that a declining unemployment rate could be associated with housing prices being pushed upwards. However, some studies have obtained results that are the reverse of this. For example, Çankaya (2013) found a negative relationship between employment and housing prices, which could therefore be reinterpreted as a positive relationship between housing prices and the rate of unemployment. Lebe and Akbaş (2014) obtained similar results for the relationship between agricultural employment and housing prices. Interest rates could also represent the general situation on the financial market, and could determine householders' abilities where the purchase of a house is concerned. Higher interest rates would be expected to exert a negative impact on the demand for housing. The relationship between interest rates and housing prices founded in traditional economic theory should be negative, but again some research has found an inverse relationship defying such expectations. For example, Öztürk and Fitöz (2009) found a positive relationship between housing prices and interest rates in Turkey. As nominal interest rates are not sufficient to explain housing price changes (Harris 1989), real interest rates should be taken account of in models, as opposed to nominal ones.

3. Model specifications

House prices could be affected by numerous variables, be these macroeconomic, or psychological or sociological. Abbott and De Vita (2011) determined that the location and siting of housing can affect prices. From the general point of view, all microvariables should be removed from any model, leaving only the macroeconomic. Income level is seen to be the most important determinant of housing demand (Lebe and Akbaş 2014).

Gallin (2006), Bahmani-Oskooee and Ghodsi (2016) used a given household's income level and mortgage rate as an independent variable to be set against house price as the dependent variable. Schnure (2005) in turn used unemployment rateas an independent variable, concluding that a 1% increase in this leads to a 1% reduction in housing prices.

A housing price index after Apergis (2003) is used as a dependent variable, and interest rates, unemployment rates and economic growth rates are defined as independent variables. This model was tested by VECM and the results interpreted by Apergis (2003).

$$\mathrm{HPI} = f(\mathrm{INT}, \mathrm{UEM}, \mathrm{GIND}) \tag{1}$$

Here house price index, unemployment rate and economic growth rate are represented by INT, UEM and GIND respectively. This model shows the relationship between these variables over the longer term, as described in equation no (1). The model does not include the inflation rate, which may be the most important determinant of housing price, so in this paper it was the real interest rate that was made use of in the model, rather than the nominal interest rate. The real interest rate can be shown as a housing-demand financing price. Coşkun (2015) showed that real interest rate has a significant impact on the demand for housing in Turkey. In turn, McQuinn and O'Reilly (2008), Ibrahim and Law (2014), and Tang and Tan (2015) all found a negative long-term relationship between interest rates and housing prices. In turn, Panagiotidis and Printzis (2015) established that the relationship between housing prices and interest rates differs in the long term, as opposed to the short. We expect that any increase in real interest rates would give rise to reduced demand for housing, and therefore a decrease in housing prices as well. However a real interest rate calculation may lead to an adverse point.

The standard Fisher equation for a nominal interest rate is $1 + i = (1 + r)(1 + \pi)$; where r is the real interest rate, i the nominal interest rate and the rate of inflation. This equation could be rewritten as $i = r + \pi$ where $r\pi$ is small and of negligible value. The real interest rate in our model is obtained by subtracting the inflation rate from the nominal interest rate. The real interest rate can thus be said to include the nominal interest rate and inflation rate at the same time. The real interest rate may thus have a positive effect on housing prices when the impact of inflation is greater than the nominal interest rate. Contradictory effects of these variables could determine the effect of real interest rate on housing price. In other words, if the impact of inflation on housing prices is stronger than that of the nominal interest rate, the relationship between real interest rate and housing prices will assume a positive direction.

Unemployment rate is the main variable in this model, and can be used as a proxy for the macroeconomic situation in the country. When the number of unemployed people increases, employed people and investors can interpret this situation as a pessimistic alert regarding the economic future. An increased unemployment rate has two opposing effects on the housing sector. The first involves a reduction in numbers of potential customers and in effective demand for real estate, while the second is rather a signal effect capable of showing the economic situation anticipated for the nearest future. The signal effect could affect the prediction as regards future prices of houses. The housing sector has become a secure investment instrument against economic fluctuations, but this has the effect that any destructive expectation regarding economic activity can cause an increase in expected housing prices. This case will lead investors to invest more in the housing sector when an economic downturn is expected in the near future. The effect of increased unemployment rates on housing prices is ambiguous, with two opposite directions being valid simultaneously, and the overall effect depending on the values of these two distinct effects.

The asymmetrical dynamics characterising housing prices were described by Holly and Jones (1997), Zhou (2010) and Yuksel (2016). The first to use non-linear ARDL to investigate the asymmetrical relationships surrounding housing prices were Katrakilidis and Trachanas (2012). Verheyen (2013) found an asymmetrical relationship in housing prices over the longer term, as well as a symmetrical one in the shorter term.

The ARDL model for the long run can be written as follow.

$$\mathrm{DHPI}_t = \alpha_0 + \alpha_1 \mathrm{RINT}_t + \alpha_2 \mathrm{UEM}_t + \alpha_3 \mathrm{GIND}_t + \epsilon_t \quad (2)$$

The equation (2) model suggests that changes in the housing price index represent a dependent variable and a function of the real interest rate, unemployment rate and economic growth rate.

The ordinary error correction model (ECM) can be expressed as follows:

$$\Delta\mathrm{DHPI}_t = \beta_0 + \sum_{j=1}^{p}\beta_{1j}\Delta\mathrm{DHPI}_{t-j} + \sum_{j=0}^{q}\beta_{2j}\Delta\mathrm{RINT}_{t-j} + \sum_{j=0}^{m}\beta_{3j}\Delta\mathrm{UEM}_{t-j} + \sum_{j=0}^{n}\beta_{4j}\Delta\mathrm{GIND}_{t-j} + \theta\epsilon_{t-1} + e_t \quad (3)$$

where Δ shows the initial differences characterising the variables, while ε represents the error-correction term, which is from an OLS residuals series from the long-run co-integrating regression in equation (2). The combination of equation (2) and equation (3) will produce the following ECM equation:

$$\Delta\mathrm{DHPI}_t = \psi + \eta_0\mathrm{DHPI}_{t-1} + \eta_1\mathrm{RINT}_{t-1} + \eta_2\mathrm{UEM}_{t-1} + \eta_3\mathrm{GIND}_{t-1} + \sum_{j=1}^{p}\beta_{1j}\Delta\mathrm{DHPI}_{t-j} + \sum_{j=0}^{q}\beta_{2j}\Delta\mathrm{RINT}_{t-j} + \sum_{j=0}^{m}\beta_{3j}\Delta\mathrm{UEM}_{t-j} + \sum_{j=0}^{n}\beta_{4j}\Delta\mathrm{GIND}_{t-j} + e_t \quad (4)$$

Here $\psi = \beta_0 - \theta\alpha_0, \eta_0 = \theta, \eta_1 = -\theta\alpha_1, \eta_2 = -\theta\alpha_2, \eta_3 = -\theta\alpha_3$. On the other hand $\eta_0, -\frac{\eta_1}{\theta}, -\frac{\eta_2}{\theta}, -\frac{\eta_3}{\theta}$ are the long-run coefficients of the DHPI, RINT, UEM and GIND variables, while β_1, β_2, β_3, β_4 are the short-run coefficients of the variables.

The standard model of co-integration restricted researchers to investigation of the model in a linear framework. However, the macroeconomic models may contain non-linearities, and neglect of these non-linearities could mislead us into obtaining wrong results. Consequently, the non-linear relationship in the model should be investigated.

In the study NARDL (the non-linear autoregressive distributed lag) approach is used to estimate asymmetrical effects of real interest rate, unemployment rate and economic growth rate on housing prices. The NARDL estimation method is based on Pesaran *et al.* (2001), while the ARDL model was developed by Shin *et al.* (2014). The asymmetrical ARDL model combines the non-linear long-run relationship with non-linear error correction using partial sum decompositions. The asymmetrical long-run relationship can be expressed as follows:

$$y_t = \beta^{+}x_t^{+} + \beta^{-}x_t^{-} + u_t$$

where x_t is a k × 1 vector for regressors decomposed as $x_t = x_0 + x_t^{+} + x_t^{-}$; where x^{+} and x^{-} are partial sum processes of positive and negative changes in x_t.

This study follows the approach developed by Schorderet (2002, 2003) and Shin *et al.* (2014), with a view to determining the asymmetrical pass-through of real interest rate, unemployment rate and economic growth rate on housing price. This approach requires all variables to be decomposed into positive and negative shocks. X^{+} and X^{-} are therefore partial sums of positive and negative changes in the

X variable. These are calculated as follows:

$$\begin{aligned}\mathrm{RINT}_t^{+} &= \sum_{i=1}^{t} \Delta\mathrm{RINT}_i^{+} = \sum_{i=1}^{t} max(\Delta\mathrm{RINT}_i, 0)\,; \mathrm{RINT}_t^{-} = \sum_{i=1}^{t} \Delta\mathrm{RINT}_i^{-} = \sum_{i=1}^{t} min(\Delta\mathrm{RINT}_i, 0)\\ \mathrm{UEM}_t^{+} &= \sum_{i=1}^{t} \Delta\mathrm{UEM}_i^{+} = \sum_{i=1}^{t} max(\Delta\mathrm{UEM}_i, 0)\,; \mathrm{UEM}_t^{-} = \sum_{i=1}^{t} \Delta\mathrm{UEM}_i^{-} = \sum_{i=1}^{t} min(\Delta\mathrm{UEM}_i, 0)\\ \mathrm{GIND}_t^{+} &= \sum_{i=1}^{t} \Delta\mathrm{GIND}_i^{+} = \sum_{i=1}^{t} max(\Delta\mathrm{GIND}_i, 0)\,; \mathrm{GIND}_t^{-} = \sum_{i=1}^{t} \Delta\mathrm{GIND}_i^{-} = \sum_{i=1}^{t} min(\Delta\mathrm{GIND}_i, 0)\end{aligned} \quad (5)$$

Considering equation (5), the relationship in equation (1) in the long run can be rewritten as:

$$\mathrm{DHPI}_t = \alpha_0 + \alpha_1^{+}\mathrm{RINT}_t^{+} + \alpha_1^{-}\mathrm{RINT}_t^{-} + \alpha_2^{+}\mathrm{UEM}_t^{+} + \alpha_2^{-}\mathrm{UEM}_t^{-} + \alpha_3^{+}\mathrm{GIND}_t^{+} + \alpha_3^{-}\mathrm{GIND}_t^{-} + \epsilon_t \quad (6)$$

Distinguishing the long- and short-run asymmetrical relationship, equation (4) can be rewritten as:

$$\begin{aligned}\Delta\mathrm{DHPI}_t &= \psi + \eta_0\mathrm{DHPI}_{t-1} + \eta_1^{+}\mathrm{RINT}_{t-1}^{+} + \eta_1^{-}\mathrm{RINT}_{t-1}^{-} + \eta_2^{+}\mathrm{UEM}_{t-1}^{+} + \eta_2^{-}\mathrm{UEM}_{t-1}^{-} + \eta_3^{+}\mathrm{GIND}_{t-1}^{+}\\ &+\eta_3^{-}\mathrm{GIND}_{t-1}^{-} + \sum_{j=1}^{p} \beta_{1j}\Delta\mathrm{DHPI}_{t-j} + \sum_{j=0}^{q} (\beta_{2j}^{+}\Delta\mathrm{RINT}_{t-j}^{+} + \beta_{2j}^{-}\Delta\mathrm{RINT}_{t-j}^{-})\\ &+ \sum_{j=0}^{m} (\beta_{3j}^{+}\Delta\mathrm{UEM}_{t-j}^{+} + \beta_{3j}^{-}\Delta\mathrm{UEM}_{t-j}^{-}) + \sum_{j=0}^{n} (\beta_{4j}^{+}\Delta\mathrm{GIND}_{t-j}^{+} + \beta_{4j}^{-}\Delta\mathrm{GIND}_{t-j}^{-}) + e_t\end{aligned} \quad (7)$$

Where
$\psi = \beta_0 - \theta\alpha_0, \eta_0 = \theta, \eta_1^{+} = -\theta\alpha_1^{+}, \eta_1^{-} = -\theta\alpha_1^{-}, \eta_2^{+} = -\theta\alpha_2^{+}, \eta_2^{-} = -\theta\alpha_2^{-}, \eta_3^{+} = -\theta\alpha_3^{+}, \eta_3^{-} = -\theta\alpha_3^{-}$ and $\theta = \eta_0, \alpha_1^{+} = \frac{-\eta_1^{+}}{\theta}, \alpha_1^{-} = \frac{-\eta_1^{-}}{\theta}, \alpha_2^{+} = \frac{-\eta_2^{+}}{\theta}, \alpha_2^{-} = \frac{-\eta_2^{-}}{\theta}, \alpha_3^{+} = \frac{-\eta_3^{+}}{\theta}, \alpha_3^{-} = \frac{-\eta_3^{-}}{\theta}$ are the long-run coefficients for positive and negative decomposition of growth in the housing price index, the real interest rate, the unemployment rate and the growth rate respectively.

Equation (7) can be divided into the long-run asymmetry and short-run symmetry or long-run symmetry and short-run asymmetry, following Shin *et al.* (2014). The two equations were presented in equations (8) and (9) respectively.

If asymmetries exist in the short run only, use can be made of the equation:

$$\begin{aligned}\Delta\mathrm{DHPI}_t &= \psi + \eta_0\mathrm{DHPI}_{t-1} + \eta_1\mathrm{RINT}_{t-1} + \eta_2\mathrm{UEM}_{t-1} + \eta_3\mathrm{GIND}_{t-1} + \sum_{j=1}^{p} \beta_{1j}\Delta\mathrm{DHPI}_{t-j}\\ &+ \sum_{j=0}^{q} (\beta_{2j}^{+}\Delta\mathrm{RINT}_{t-j}^{+} + \beta_{2j}^{-}\Delta\mathrm{RINT}_{t-j}^{-}) + \sum_{j=0}^{m} (\beta_{3j}^{+}\Delta\mathrm{UEM}_{t-j}^{+} + \beta_{3j}^{-}\Delta\mathrm{UEM}_{t-j}^{-})\\ &+ \sum_{j=0}^{n} (\beta_{4j}^{+}\Delta\mathrm{GIND}_{t-j}^{+} + \beta_{4j}^{-}\Delta\mathrm{GIND}_{t-j}^{-}) + e_t\end{aligned} \quad (8)$$

On the other hand, if asymmetries only exist in the long-run, the equation that can be used is:

$$\Delta \mathrm{DHPI}_t = \psi + \eta_0 \mathrm{DHPI}_{t-1} + \eta_1^{+} \mathrm{RINT}_{t-1}^{+} + \eta_1^{-} \mathrm{RINT}_{t-1}^{-} + \eta_2^{+} \mathrm{UEM}_{t-1}^{+} + \eta_2^{-} \mathrm{UEM}_{t-1}^{-} + \eta_3^{+} \mathrm{GIND}_{t-1}^{+} + \eta_3^{-} \mathrm{GIND}_{t-1}^{-} + \sum_{j=1}^{p} \beta_{1j} \Delta \mathrm{DHPI}_{t-j} + \sum_{j=0}^{q} \beta_{2j} \Delta \mathrm{RINT}_{t-j} + \sum_{j=0}^{m} \beta_{3j} \Delta \mathrm{UEM}_{t-j} + \sum_{j=0}^{n} \beta_{4j} \Delta \mathrm{GIND}_{t-j} + e_t \quad (9)$$

Equations (7), (8) and (9) all present the long-run co-integration between housing price index growth and other variables, symmetrically or asymmetrically.

The long-run co-integration can be determined using t-statistics, following Banerjee *et al.* (1998), as well as the F-statistics suggested by Pesaran *et al.* (2001). As for the linear ARDL approach, Shin *et al.* (2014) propose use of a bounds test to determine the long-run asymmetrical co-integration. The bounds test is used jointly in testing all lagged level regressors. Where the t-statistics approach is preferred, the null hypothesis should be defined as $\eta_0 = 0$ against the alternative hypothesis $\eta_0 < 0$. On the other hand, the null hypothesis is defined as $H_0{:}\, \eta_0 = \eta_1 = \eta_2 = \eta_3 = 0$ against alternative hypothesis $\eta_0 \neq 0 \text{or}\, \eta_1 \neq 0 \text{or}\, \eta_2 \neq 0 \text{or}\, \eta_3 \neq 0$, when the F-statistics approach is used. In the case of long-run asymmetry, the null hypothesis would be rejected.

The calculated Wald-F value must be compared with the tabulated F values as determined by Pesaran *et al.* (2001). The existence of symmetry in the long run is tested by the Wald test of the null hypothesis $\eta_0 = \eta^{-}{}_1 = \eta^{+}{}_1 = \eta^{-}{}_2 = \eta^{+}{}_2 = \eta^{-}{}_3 = \eta^{+}{}_3 = 0$ of, $H_0{:}\, \alpha_1^{+} = \alpha_1^{-} = \alpha_1$, $H_0{:}\, \alpha_2^{+} = \alpha_2^{-} = \alpha_2$ and $H_0{:}\, \alpha_3^{+} = \alpha_3^{-} = \alpha_3$. To check for short-run asymmetry, the null hypothesis of, $H_0{:} \sum_{i=0}^{q} \beta_{2i}^{+} = \sum_{i=0}^{q} \beta_{2i}^{-}$, $H_0{:} \sum_{i=0}^{m} \beta_{3i}^{+} = \sum_{i=0}^{m} \beta_{3i}^{-}$ and $H_0{:} \sum_{i=0}^{n} \beta_{4i}^{+} = \sum_{i=0}^{n} \beta_{4i}^{-}$ should be used. If the null hypothesis of symmetry being present is rejected, our model allows for an asymmetrical effect. By rejecting the null hypothesis regarding symmetry, asymmetrical dynamic multipliers of change in $RINT^{+}, RINT^{-}, UEM^{+}, UEM^{-}, GIND^{+}$ and $GIND^{-}$ respectively could be found. The cumulative dynamic multiplier effects for the asymmetrical variables on HDPI can be evaluated as follows:

$$\begin{gathered}
m_h^{+} = \sum_{i=0}^{h} \frac{\partial \mathrm{DHPI}_{t+i}}{\partial \mathrm{RINT}_t^{+}}; m_h^{-} = \sum_{i=0}^{h} \frac{\partial \mathrm{DHPI}_{t+i}}{\partial \mathrm{RINT}_t^{-}} \\
\lim_{h\to\infty} m_h^{+} = \alpha_1^{+}, \lim_{h\to\infty} m_h^{-} = \alpha_1^{-} \\
m_h^{+} = \sum_{i=0}^{h} \frac{\partial \mathrm{DHPI}_{t+i}}{\partial \mathrm{UEM}_t^{+}}; m_h^{-} = \sum_{i=0}^{h} \frac{\partial \mathrm{DHPI}_{t+i}}{\partial \mathrm{UEM}_t^{-}} \\
\lim_{h\to\infty} m_h^{+} = \alpha_1^{+}, \lim_{h\to\infty} m_h^{-} = \alpha_1^{-} \\
m_h^{+} = \sum_{i=0}^{h} \frac{\partial \mathrm{DHPI}_{t+i}}{\partial \mathrm{GIND}_t^{+}}; m_h^{-} = \sum_{i=0}^{h} \frac{\partial \mathrm{DHPI}_{t+i}}{\partial \mathrm{GIND}_t^{-}} \\
\lim_{h\to\infty} m_h^{+} = \alpha_1^{+}, \lim_{h\to\infty} m_h^{-} = \alpha_1^{-}
\end{gathered} \quad (10)$$

4. Data and empirical results

Monthly, quarterly or yearly data can be used to check the co-integration in the model. Hakkio and Rush (1991) and Otero and Smith (2000) show that co-integration depends more on overall sample length than the number of observations. Data used should therefore be matched with the character of the model. In this paper's model, research concentrates on long-run behaviour of the housing sector, as an investment instrument sensitive to other macroeconomic situations. Yearly or quarterly data are not considered to represent housing-sector relationships fully, as the use of even quarterly data may neglect certain relations, given the view that the response of housing prices to macroeconomic variables is not delayed for this long. All data used are therefore monthly ones, covering the period January 2010 to February 2016, as obtained from among Central Bank of Turkey statistics. The industrial production index is used as a proxy for national income due to the advantage of monthly data for this being available. Also used in this paper is the house price index for Turkey as a whole, with possible seasonality avoided by interpreting growth rates calculated on the basis of data for the previous twelve-month period. Growth rates are thus calculated on an annual basis, and are based on data from the previous year.

Validation of the order of integration of model variables shows that only the housing price index was integrated with higher than one order, then the first difference of it had solved estimation problem. Estimation using the symmetrical model shows that there is co-integration in the model. Although there is a heteroscedasticity problem, other tests confirm the validity of the estimation assumptions. On the other hand, the previous references to the probability of asymmetrical relationships in the model lead us to investigate the asymmetrical relationships. The results for estimations based on the symmetrical and asymmetrical models are as shown in Table 1.

Table 1. Empirical results for symmetrical, asymmetrical and partially asymmetrical models

	Symmetrical Model	Asymmetrical Model	Partially Asymmetrical Model
INTERSECT	–1.358184**	0.533430	0.802332*
DHPI (-1)	–0.423758*	–0.699986*	–0.724255*
RINT (-1)	0.067904***		0.040124
UEM (-1)	0.221819*		
GIND (-1)	–0.065415*		
RINT_N (-1)		0.059115	
RINT_P (-1)		0.011562	
UEM_N (-1)		–0.028985	0.098239
UEM_P (-1)		0.492341*	0.563931*
GIND_N (-1)		–0.011514	–0.018655

	Symmetrical Model	Asymmetrical Model	Partially Asymmetrical Model
GIND_P (-1)		–0.038372***	–0.049101*
D (DHPI (-1))	–0.060490	0.074707	0.077553
D (RINT)	–0.042221		–0.100965
D (UEM)	0.097118		0.108125
D (UEM (-1))	–0.282760***		–0.371673*
D (GIND)	–0.026701**		–0.012098
F-statistic	3.828998*	2.670639*	4.295925*
R2	0.360995	0.400357	0.444733
Jarque – Bera	0.644136	1.226526	0.430840
Heteroscedasticity F	2.739530*	1.721426***	1.539916
Bounds Values	3.23 – 4.35	2.45 – 3.61	2.62 – 3.79
F Bound	6.659758	4.06385	6.424795
WLR (RINT)		0.225009	
WSR (RINT)		0.123752	
WLR (UEM)		5.084911**	13.36590*
WSR (UEM)		1.571180	
WLR (GIND)		6.296601**	9.480746*
WSR (GIND)		0.379018	
ECM (-1)	–0.336283*	–0.328824*	–0.336283*
Model	ARDL (1,0,1,0)	ARDL (1,0,0,0)	ARDL (1,0,1,0)

Note: *, ** and *** denote significance at the 1%, 5% and 10% levels, respectively. Positive and negative shocks displayed by _P and _N suffixes respectively.

Source: author's own calculations.

Despite the symmetrical model being valid, the full asymmetrical model was also used to check for possible non-linearity to the relationships in the model. The Wald F-statistics for the full asymmetrical model (equation 7) show that symmetry in the short run for all variables and in the long run for RINT were accepted. The use of the Wald test with a null hypothesis of symmetry in both the long and the short runs has shown that any rejection of the null hypothesis should be interpreted as indicating the existence of asymmetry. Then the new (Partially Asymmetric) model that encompasses symmetry in the short run for all variables and long-run asymmetry for UEM and GIND only was rebuilt. Estimation for the partially asymmetrical model has revealed that no econometric problem existed in this case.

The long-run symmetrical model coefficients for RINT, UEM and GIND are of 0.16, 0.52 and -0.15 respectively. Long-run coefficients for RINT, UEM^-, UEM^+, $GIND^-$ and UEM^+ in the partially asymmetrical model are in turn 0.06, 0.14, 0.78, -0.02 and -0.07 respectively. The signs of the long-run coefficients for variables can indicate the direction of the relationship, and it can thus be concluded that the long-run relationships among the variables are positive or negative. Applying both the symmetrical and the partially asymmetrical models, it is obvious that there is a positive relationship between real interest rates and housing prices, and the relationship between unemployment rate and housing prices can also be shown-to be positive. On the other hand, when the relationship between growth rate in the industrial production index is set against housing prices, a negative direction for the relationship is to be observed. The partially asymmetrical model contains both negative and positive breakdowns of unemployment rate and growth in the industrial production index. Estimation using the partially asymmetrical model shows that negative changes within unemployment rate do not achieve statistical significance, and neither does growth of the industrial production index. In these variables it is only the positive changes that should therefore be taken account of. The dynamics of both models – symmetrical and asymmetrical – are presented in figures as follows:

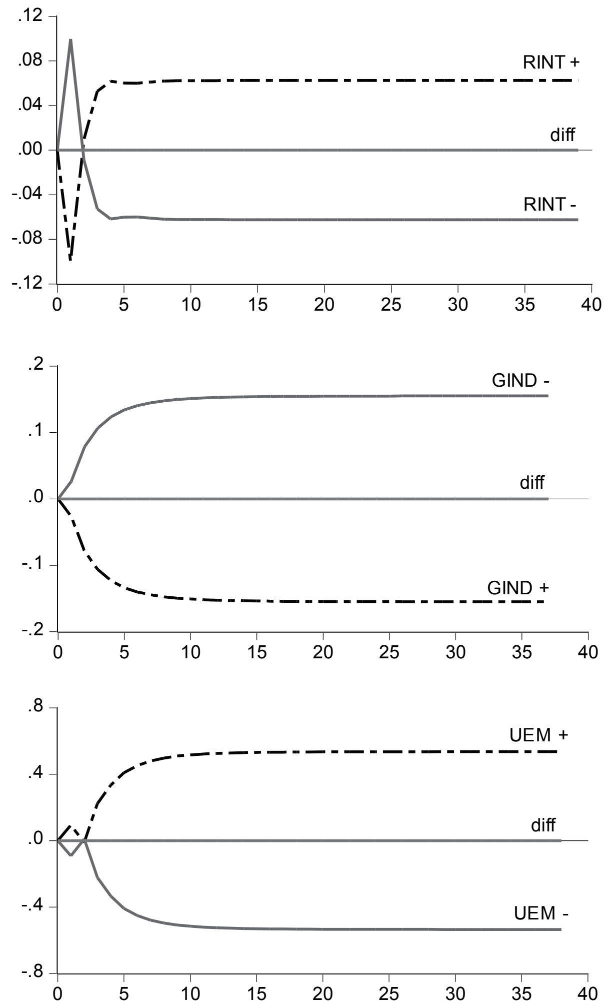

Figure 2. Dynamic multipliers for the symmetrical model

Source: author's own calculations.

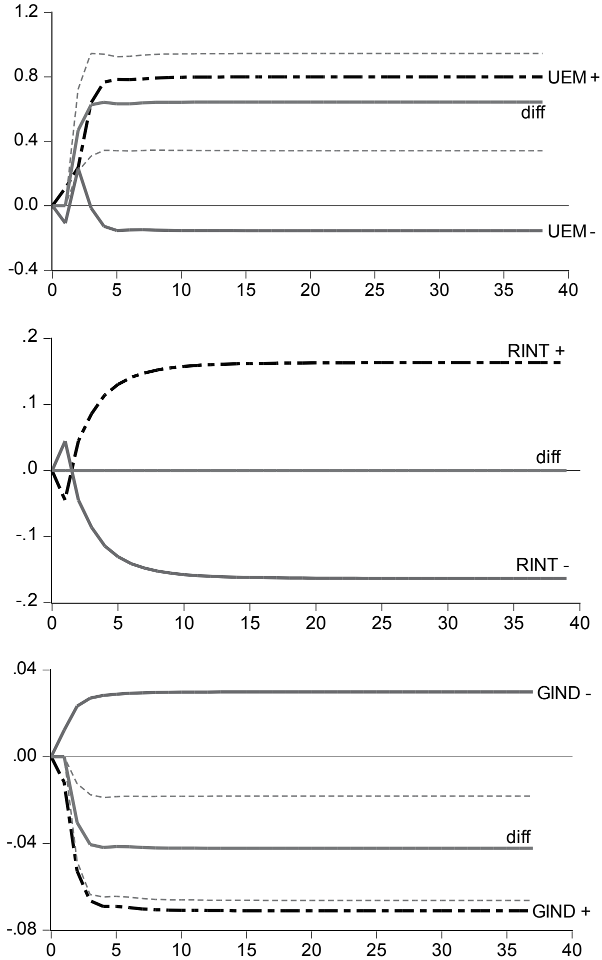

Figure 3. Dynamic multipliers for the partially asymmetrical model

Source: author's own calculations.

Analysis of the graphs for the CUSUM and CUSUMQ tests sustains the conclusion that there is no unstable condition in the long run. Furthermore, the coefficient for the error correction term in the ECM, as well as being significant, is greater than -1 and below zero, meaning that the model will be stable in the long run. It is also possible to predict that the housing-sector relationship with the main fundamental variables is changed in the long run.

5. Conclusions

The work detailed here investigated the relationship between housing prices and the main macroeconomic variables. Both linear and non-linear co-integration methods were used to discover dynamics applying in the model in both the long run and the short run. In regard to the existing literature, unemployment rate, the industrial production index and the real interest rate were all selected as explanatory variables where housing prices in Turkey are concerned. Data used in this study were monthly ones covering the period from January 2010 through to February 2016, as obtained from among Central Bank of Turkey statistics.

In contrast with most of the research done in this field, the effect of interest rate was found to have a negative sign. This can be explained by subtraction of inflation from the nominal interest rate to obtain the real interest rate variable. If nominal interest rate and inflation both have a negative effect on housing prices, and the inflation effect (in absolute terms) is greater than the nominal interest rate, then thelong-run coefficient for the real interest rate could be positive. Therefore, despite the purportedly positive coefficient for interest rates, this should be negative if separated from inflation rate.

Forethought can explain the positive relationship between unemployment rate and housing prices, given that investment in housing may save investors capital in subsequent unwanted economic circumstances. Coşkun and Ümit (2016) found that the price of housing could not be treated in the same as other property markets, given this sector's distinctive characteristics. This means that the housing sector cannot be treated as a complementary or substitutable instrument for householders. Any increase in unemployment could be interpreted as an alarm bell ringing in respect of the economic future. The asymmetrical results reveal that increased unemployment rate is significant in terms of its effect, while reduced unemployment rate does not achieve statistical significance. Therefore, when unemployment increases, the direction taken by financial assets shifts to riskless sectors. The housing sector is crucial sector among those of minimum attendant risk. However, a decline in unemployment does not have a significant effect on investors' decisions, and in this. In this paper we have shown that the alert effect of unemployment on the housing sector is a dominant one.

The main finding of this paper is a negative sign on the long-run relationship between housing prices and the industrial production index. Most authors have claimed that a positive relationship subsists between housing prices and income. In this study, the industrial production index was used as a proxy for national income, due to the advantage that availability of monthly data denotes. The special character of the housing sector and its distinctive structures can explain this finding. The housing sector is not akin to other consumable goods, or even intermediate goods, and the housing sector represents an investment instrument with a consumable and intermediary propose. Growth in the industrial sector could lead investments to the sector and absorb a certain amount of capital flow in the housing sector section. Therefore, according to the substitutionary character of the housing and industrial sectors, the relationship between these could account for the negative sign characterising the long-run relationship demonstrated in this paper.

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