# TESTING THE HOUSING BUBBLE CONDITION: EMPIRICAL ANALYSES IN THE TURKISH HOUSING MARKET

**İSMAİL CEM ÖZGÜLER**

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A Thesis Submitted To
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# ABSTRACT

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Özgüler, İsmail Cem

Ph. D. Program in Finance

Advisor: Prof. Dr. Cumhur Coşkun Küçüközmen

July, 2022

This thesis aims to investigate the long-run relationship and short-run dynamics among the Turkish housing price index, rent in real terms, and their financial, housing-sector related, and macroeconomic determinants for 17 years. Specifically, the aim is to examine housing price bubbles with a unique dataset over 2003:M01-2019:M12 through alternative tests. This dissertation compares Autoregressive Distributed Lag (ARDL) cointegration in-sample forecasts and discounted cash flow (DCF) estimates with observed prices to determine the timing, magnitude, and collapse period(s) of bubbles within the price convergence framework that is the degree of proximity between observed and fundamental prices. In particular, the generalized sup augmented Dickey-Fuller (GSADF) approach time stamps multiple explosive price behaviors. The Toda-Yamamoto causality test and the impulse response functions provide short-term insights into the Turkish real estate market. In addition, this study covering housing policies implemented in emerging and developed countries provides suggestions about affordable housing policies in Turkey. The results provide supporting evidence to the investment value theory for the real estate market that rents and price-to-rent ratio positively and mortgage rates adversely affect house prices. One remarkable outcome is that these dynamics have a greater impact on house prices than mortgage rates. The model estimates exhibit temporal overvaluations rather than bubble signals, implying that housing price appreciations, including explosive price behaviors, are consistent with fundamental advances. In the short run, the banking credit and changes in mortgage rates trigger the housing demand, and construction stalls during winter cause an increasing unemployment rate and housing prices.

Keywords: ARDL; Asset Price Bubble; Housing Policy; Housing Price Index; Rent; Turkish Housing Market

# ÖZET

KONUT BALONU DURUMUNUN TEST EDİLMESİ:
TÜRKİYE KONUT PİYASASINDA AMPİRİK ANALİZLER

Özgüler, İsmail Cem

Finans Doktora Programı

Tez Danışmanı: Prof. Dr. Cumhur Coşkun Küçüközmen

Temmuz, 2022

Bu tez, 17 yıllık dönemde reel Türkiye konut fiyat endeksi, reel kira ve bunların finansal, konut sektörü ile ilgili ve makroekonomik belirleyicileri arasındaki uzun vadeli ilişkiyi ve kısa vadeli dinamikleri incelemeyi amaçlamaktadır. Özellikle, 2003:A01-2019:A12 dönemini içeren benzersiz bir veri seti üzerinde uygulanan alternatif testler aracılığıyla konut balonunun varlığı incelenmiştir. Bu tezde, gerçekleşen ve temel (olması gereken) fiyatlar arasındaki farkın balon olduğunu gösteren fiyat yakınsama çerçevesi kapsamında, fiyat balonlarının zamanlamasını, büyüklüğünü ve sönme dönem(ler)ini belirlemek için Otoregresif Dağıtılmış Gecikme (ARDL) örnek içi eş bütünleşme ve İndirgenmiş Nakit Akışı (DCF) tahminleriyle gözlemlenen fiyatlar karşılaştırmıştır. Ayrıca, Genelleştirilmiş Eküs Genişletilmiş Dickey-Fuller (GSADF) uygulaması sonuçları hızla yükselen/şişen konut ve kira fiyat davranışını göstermektedir. Toda-Yamamoto nedensellik testi ve etki-tepki fonksiyonları, Türkiye emlak piyasası için kısa vadeli öngörüler sağlamaktadır. Tüm bunlara ek olarak, gelişmiş ve gelişmekte olan ülkelerde uygulanan konut politikalarını kapsayan bu çalışma, Türkiye'deki ekonomik konut politikalarına ilişkin öneriler sunmaktadır. Bulgular, gayrimenkul piyasasında kiraların ve fiyat-kira oranının olumlu ve konut kredisi faiz oranlarının ise ev fiyatları üzerindeki olumsuz etkisini vurgulayarak yatırım değeri teorisini destekleyen kanıtlar içermektedir. Dikkate değer diğer bir sonuç ise, bu dinamiklerin konut fiyatları üzerinde konut kredisi faiz oranlarından daha önemli bir etkiye sahip olmasıdır. Model tahminleri, fiyatlarda balon sinyalleri yerine geçici aşırı değerlemeler sergilemekte ve hızla yükselen/şişen fiyat davranışları da dahil olmak üzere uzun vadede konut fiyat değerlemelerinin temel değişimlerle tutarlı olduğunu göstermektedir. Kısa vadede banka kredileri ve konut kredisi faiz oranlarındaki değişiklikler konut talebini tetiklerken, kış aylarındaki inşaat duraklamaları artan işsizlik oranlarına ve artan konut fiyatlarına neden olmaktadır.

Anahtar Kelimeler: ARDL; Varlık Fiyat Balonu; Konut Politikası; Konut Fiyat Endeksi; Kira; Türkiye Konut Piyasası

This thesis is dedicated to:

My role model and father; Süleyman Özgüler, my mother, my wife, and my son, for their trust, endless support, and unconditional love

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My esteemed elders' generous efforts enabled me to reveal this study by sharing their most precious treasure: time, which encouraged me to complete this study through a long and grueling journey.

I would like to express my sincere thanks to my esteemed teacher, master, and admired Prof. Dr. Cumhur Coşkun Küçüközmen, who was my supervisor during the thesis period, for his endless support, faith in me, and encouragement throughout my academic career. He was a mentor both in my private life and my career path. I feel so lucky to have the opportunity to work with Mr. Küçüközmen. He is my greatest source of inspiration on this journey, with his rare energy, working ethics, and investigative attitude. This inspiring man shares many of my accomplishments with his guidance and teachings.

I owe a debt of gratitude to Assoc. Prof. Dr. Zarife Göknur Büyükkara for her time, patience, and encouragement. Her guidance contributed to overcoming great impasses. I would also like to thank Prof. Dr. Gülin Karasulu Vardar, Prof. Dr. Mert Ural, and Assoc. Prof. Dr. Berna Aydoğan for their advice, support, and commitment to my academic career. Their invaluable support has helped me overcome complicated processes throughout this study and my academic career so far. Without their presence in my academic career, I would definitely not have succeeded.

I would like to express my sincere appreciation to my friend Nezihe Ertuğrul, who shot the photo I requested and allowed me to edit the photograph to explain the asset price bubbles with a metaphor.

Last but not least, I would like to thank my wife, Bengü Özgüler, and my family for their devotion, understanding, and generous support. I am fortunate to have them.

**TABLE OF CONTENTS**

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

Akaike Information Criterion: AIC

Augmented Dickey-Fuller: ADF

Autoregressive Distributed Lag: ARDL

Backward Sup ADF: BSADF

Brazil, Russia, India, China, and South Africa: BRICS

Central Bank of the Republic of Turkey: CBRT

Commonwealth Rent Assistance Scheme: CRAS

Conditional Error Correction: CEC

Conditional Error Correction Model: CECM

Consumer's Price Index: CPI

Cumulative Sum: CUSUM

Department of Housing and Urban Development: HUD

Dickey-Fuller-GLS: DF-GLS

Discounted Cash Flow: DCF

European Central Bank: ECB

Elliott, Rothenberg, and Stock: ERS

Error Correction Model: ECM

Federal Reserve: FED

First-time homebuyer incentive: FHI

Generalized Sup ADF: GSADF

Global Financial Crisis: GFC

Gross Domestic Product: GDP

Housing Development Agency: HDA

Impulse Response Functions: IRFs

Internal Revenue Service: IRS

Kwiatkowski–Phillips–Schmidt–Shin: KPSS

Modified Wald: MWALD

National Asset Management Agency: NAMA

National Rental Affordability Scheme: NRAS

Non-Performing Loan: NPL

Ordinary Least Squares: OLS

Organization for Economic Co-operation and Development: OECD

Portugal, Italy, Greece, and Spain: PIGS

Phillips-Perron: PP

Producer's Price Index: PPI

Real Estate Investment and Development Information Network: REIDIN

Real Housing Price Index: RHPI

Real Rents: RR

Rental Assistance Demonstration: RAD

Residual Sum of Squares: RSS

Right Tailed Augmented Dickey-Fuller: RTADF

Toda-Yamamoto: TY

Value-Added-Tax: VAT

Variance Inflation Factor: VIF

Vector Autoregression: VAR

# CHAPTER 1: INTRODUCTION

## *1.1. Context and Motivation*

Comprehending the housing price and real estate bubble dynamics is essential for governing authorities, corporations, investors, and households for three main reasons: first, residential real estate is an asset form that serves both as an investment and a consumption product; second, mortgage payments and rents constitute the most significant portion of households' income; and finally, the property market accounts for a sizeable share of gross domestic product (GDP) in many countries. The primary concern of these authorities is ensuring economic and financial stability and regulating and supervising financial institutions through detailed measures. Shiller (2006: pp. 1-11), Akerlof and Shiller (2009), and Shiller (2014: pp. 1,486-1,517) determined that housing price bubbles may result in eventual collapse, affecting governments, wealth, consumption, and the financial sectors. In particular, the corruption of the loan standards can cause substantial damage to banks due to the wide-ranging repercussions of the bubble and its aftermath on the economy. Reinhart and Rogoff (2010) point out that it may even cause a banking crisis. Accordingly, the real estate and bubble dynamics critically affect the household welfare of countries and corporations. Thus, exploring bubble formations and price convergence in emerging markets is crucial to recent high real housing price returns.

Under such conditions, deteriorations in the lending discipline of banks and other financial institutions occur as credit institutions may base their credit allocation decisions on unrealistic or inconsistent future price expectations of the collateral rather than the applicants' credibility. With the assumption that house prices are rising, an investor using only interest-paying loans would profit by selling the house in the future. This assumption led to sub-prime mortgage lending with a combination of different mortgage types, including variable mortgage rates and interest-only loans in the US, causing loan allocation to customers with lower credit scores. Banks and financial institutions transfer the risk from lenders to the investors by selling and securitizing mortgage loans belonging to investors with limited repayment ability.

Price convergence refers to the degree of proximity between actual and fundamental prices (Black, Fraser and Hoesli, 2006; McMillan and Speight, 2010). Although the convergence framework has a wide range of application areas, the extensive research focusing on house prices within this framework was mainly conducted in developed countries, particularly Australia, the UK, and the USA, while much less has been done in emerging markets. Thus, this study aims to fill the gap in the literature by providing a specific framework for future studies on residential real estate bubbles in emerging markets. This thesis chooses to investigate the progressive Turkish real estate dynamics to serve this purpose.

Initially, the Turkish housing market offers an attractive investment opportunity with high return potential for international investors since it offers trade intersection points bridging Asia and Europe. Turkey had the highest rent price index between 2017Q1-2019Q4 among 36 Organization for Economic Co-operation and Development (OECD) countries (OECD, 2021). As of 2019, increased demand for houses for sale and rent resulted from a population of approximately 1.5 million non-Turkish nationals with residence or work permits (Turkish Statistical Institute, 2020), the arrival of approximately 3.6 million Syrian refugees after the 2011 civil war in Syria (The Republic of Turkey, Ministry of Internal Affairs General Directorate of Migration Management, 2020), and the migration of the rural population to city centers in search of job opportunities. In the meantime, nominal house prices have been on a persistent upsurge since 2010, based on this increasing demand. Real Estate Investment and Development Information Network (REIDIN) TR7 housing price index had a 169.75 % growth in nominal terms between 2010 and 2017. Although the growth rate started to slow after 2017, foreigners continued to influence prices, purchasing 10.14% of houses sold in Antalya between 2013 and 2019 (Turkish Statistical Institute, 2021).

Second, Case and Shiller (2003: pp. 299-362) denote that housing price growth significantly exceeded the inflation rate in the US for eight states between 2000 and 2002. They attribute this housing bubble phenomenon to unrealistic expectations of price increases. In Turkey, housing prices have reached the highest nominal returns after India among G20 countries during the 2010-2017 period (Bank for International

Settlements, 2020; FX Empire, 2020[1]). In addition, two middle-level managers in a private bank, including the author of this dissertation, cannot buy a house in Istanbul recently since house price growth significantly exceeds growth in their income, causing unaffordable prices. Despite the high returns generated on residential investment, decreases in housing affordability for lower-income households and white collars make this study more appealing for the Turkish case. Between 2010 and 2017, The Real Estate Investment and Development Information Network (REIDIN) TR7 housing price index provided a return of 48.16%, compared to rent returns of only 20.12% in real terms. This level of real return of over 45% in the housing price index suggests that prices departed from fundamentals, such as growth in inflation and GDP and returns in deposits, USDTRY, EURTRY, and gold prices.

Third, the credit-driven construction sector became the driving force of growth after 2003 in Turkey, accounting for 9 % of total GDP as of 2017:Q3 (Turkish Statistical Institute, 2021). The emerging Turkish economy has recently experienced an upswing, with steady foreign exchange rates due to the increasing attention from foreign investors in emerging markets and the financial and monetary policies of the Federal Reserve (FED) and European Central Bank (ECB). However, despite the boom, the Turkish economy faced financial fragilities after FED announced the end of monetary expansion in 2013, leading to a depreciating Turkish Lira, increasing inflation, and declining GDP growth. This situation led to falling housing demand and sales, substantially increased house prices, and thus, construction companies' reduced capacity to repay loans. The construction sector's non-performing loan (NPL) ratio increased to 9.81% as of December 2019 (Banking Regulation and Supervision Agency, 2020). These developments raise concerns over the dangers of possible boom-bust cycles for the Turkish case as an emerging market. Cesa-Bianchi, Cespedes and Rebucci (2015) state that "house prices in emerging economies, grow faster, are more volatile, less persistent and less synchronized across countries than in advanced economies."

Discussions about the housing bubble in the Turkish real estate market have recently been trending in the media and academic literature. In particular, one wonders

[1]The housing price index series for China and Saudi Arabia start from 2011 and 2014, respectively.

whether the housing price exuberances, especially between 2010 and 2017, signal any bubble formation. Hereinafter, the aspects mentioned above of the Turkish housing sector motivated this dissertation to investigate the long-run determinants and short-run linkages of the Turkish real estate market and investigate bubble dynamics inside the price convergence framework over the 2003-2019 period.

### *1.2. Research Objective*

The aim of this study is fourfold:

First, this thesis aims to investigate the grounds of the housing price index and rents in real terms, in the short and long term, respectively. This study combines several seasonality tests to adjust the series seasonally to reach this aim. Furthermore, the dissertation determines the best linear features of housing prices with the highest adjusted $R^2$ and lowest residual sum of squares figures.

Second, the aim is to test the existence of the bubble(s) within the framework of price convergence by using an extensive monthly data set in the Turkish real estate market accounting for the financial, housing-sector related, and macroeconomic predictors.

Third, this dissertation investigates explosive house price patterns and compares the fundamentals' exuberances to comprehend bubble dynamics through the Generalized Sup Augmented Dickey-Fuller (GSADF) test.

Last but not least, this study focuses on the housing policies of twelve different emerging and developed countries to construct an effective housing policy for the Turkish real estate market.

### *1.3. Scope and Research Methodology*

This study focuses on the fundamentals of the Turkish housing market by examining house prices and rents as dependent variables between 2003 and 2019. Accordingly, the disquisition removes seasonal patterns through the X-13 ARIMA-

SEATS approach and selects the variables using unit root tests and the best subset selection algorithm. This dissertation conducts two Autoregressive Distributed Lag (ARDL) cointegration estimates for housing prices and rents to investigate the long-run drivers of the Turkish housing market. The thesis checks the conditional error correction model (ECM) to investigate the speed of adjustment in the real housing price index and real rents for the equilibrium.

The thesis compares ARDL cointegration in-sample forecasts and discounted cash flow (DCF) estimates with actual prices to determine bubbles' timing, magnitude, and collapse period(s) within the price convergence framework. In particular, the GSADF approach time stamps multiple explosive price behaviors.

This dissertation employs the Toda-Yamamoto (TY) causality test and the generalized impulse response functions to investigate the short-run dynamics of real housing and rental prices.

The hypothesized research questions in this study are as follows:

- What are the fundamentals of housing and rental prices in the long run?
- Is there any departure between housing prices and their fundamentals in the long run? In other words, is there any housing bubble in the Turkish real estate market?
    - If so, what are the timing and the magnitude of the bubble(s)?
    - If not, what is the level of speed of adjustment for the equilibrium in a cointegrating relationship?
- What are the causes of housing price and rental price changes in the short run?
- What are the housing price index responses to one standard deviation innovation on their predictors?

### *1.4. Contributions of the Thesis*

This study aims to make some significant contributions to the literature:

First, to the best of my knowledge, this pioneering study is the first to attempt to capture the financial, macroeconomic, and housing-sector-related grounds of both the housing price index and rents in real terms as dependent variables of two separate ARDL models.

Second, this study seeks to identify the existence of the housing price bubbles in Turkey within the price convergence framework through alternative models: ARDL cointegration (2001), conditional error correction model (CECM), generalized sup ADF (GSADF), and discounted cash flow (DCF) which investors, construction firms and policymakers can benefit from in choosing between buying or renting a new house, starting construction, implementing policies to reduce housing prices.

Third, the dataset used extends from 2003 to 2019, which includes a period of almost unprecedented housing price growth and the global mortgage crisis, underlining the importance of the bubble search.

Fourth, this study sheds light on how far behaviors in house price dynamics can be considered explosive by comparing the GSADF results for mortgage rates, price-to-rent ratio, real housing price index (RHPI), and real rents (RR).

Fifth, this dissertation investigates the short-run dynamics of the RHPI and RR through the Toda-Yamamoto (TY) Causality tests and Impulse Response Functions (IRFs).

Finally, this dissertation examines twelve emerging and developed countries' affordable housing and rent policies, including Australia, Brazil, Canada, China, France, Germany, India, the Netherlands, Russia, South Africa, the UK, and the US. It suggests the most suitable policies for the Turkish real estate market dynamics.

### *1.5. Thesis Structure*

The organization of the thesis is as follows:

The second section briefly discusses the Turkish real estate market, including house prices' demand and supply dynamics, affordability indicators, and housing policies in the Turkish residential real estate market. This section also informs about the affordable housing policies from twelve different emerging and developed countries and discusses best practices for affordable Turkish real estate market policy.

The third chapter covers the theoretical framework, including the theory of investment value, rational expectations theory, the theory of demand and supply, and the price convergence framework.

The fourth section includes brief information about the literature on housing prices.

The fifth section introduces and describes the data, provides preliminary data analysis through seasonality and unit-root tests, and introduces an exhaustive machine learning algorithm to select the most relevant variables in explaining the real housing price index. This section also presents the model and methodology.

Section six covers empirical results.

Finally, the last section concludes and comments.

# CHAPTER 2: OVERVIEW OF THE TURKISH REAL ESTATE MARKET AND POLICIES TACKLING AFFORDABILITY

This chapter analyzes the current real estate market situation and the policies implemented regarding the housing affordability problem specific to lower-income classes. The following chapters of this thesis consider the policy examples applied in foreign housing markets and solution suggestions to increase housing affordability in Turkey.

The rest of this chapter covers demand and supply dynamics, affordability indicators in the Turkish real estate market, housing policies in Turkey, other emerging markets, and developed countries.

## *2.1. Demand & Supply Dynamics on House Prices*

The development of new settlement areas and urban transformation projects has led to a significant increase in construction activity, especially in Turkey's three prominent metropolitan regions, namely, Ankara, Istanbul, and Izmir. The large-scale construction companies' projects target high-income households. The concept of houses in a gated living area with integrated malls and entertainment centers has accelerated retail sector investments, resulting in a steadily rising GDP.

Recently, immigration to industrialized cities and rapidly increasing populations triggered metropolitan regions' housing demand resulting in rent and price increases above the income. The Turkish real estate market has high media attention and coverage since real estate investment returns exceeded alternative investment instrument returns, especially between 2010 and 2017. The growth in rent prices was far below the housing price returns, reviving concerns about the unaffordability for the lower-income groups and bubble formations as housing prices fall apart from fundamentals in Turkey.

Under this discussion, investors seek an answer to which price is suitable for purchasing a house. Between 2003 and 2019, rents rose more than housing prices in real terms, resulting in observed prices being higher than fundamental prices despite fluctuating mortgage rates. Increases in rental prices simultaneously increase housing prices. The homeowners, recently and frequently, try to evict their tenants for various excuses to rent their house for a higher fee since the rent prices increase more than expected due to high demand.

On the other hand, exuberance in housing and rental prices accelerated between 2010 and 2017 and slowed down in 2019. The seasonally adjusted housing prices expectation index exhibits no signs of an unexpected increase in housing prices in the first quarter of 2020 (Turkish Statistical Institute, 2020).

Figure 1 illustrates the construction sector's expectation index for housing sale prices in the upcoming three months.

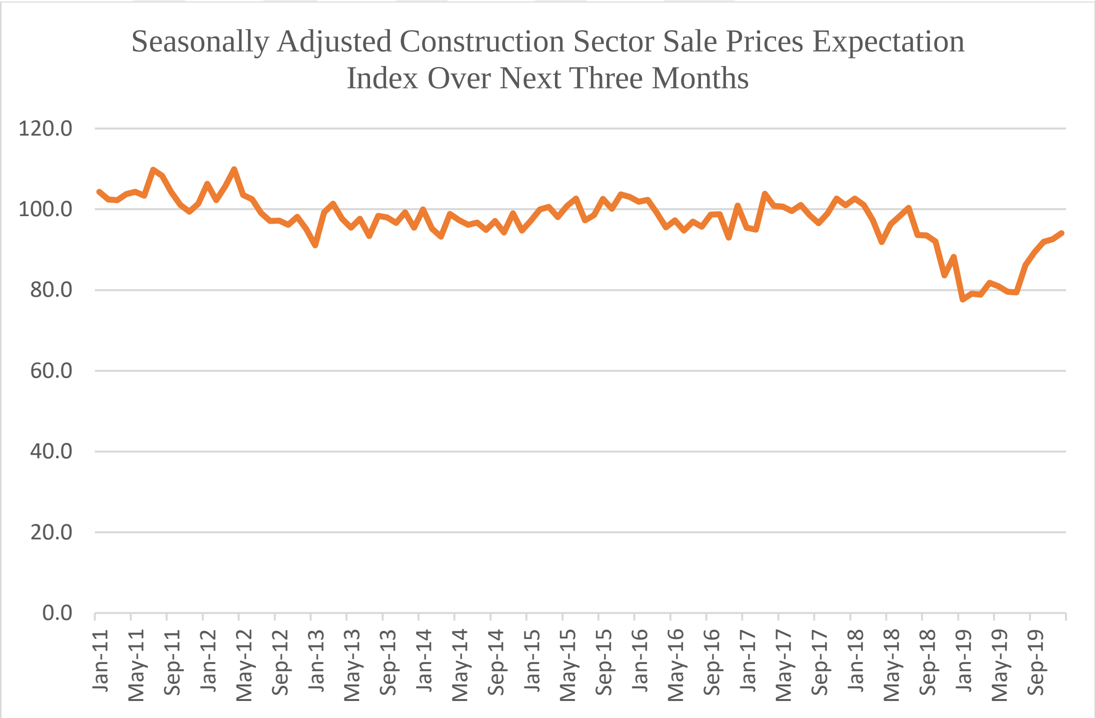



Figure 1. Construction Sector's Seasonally Adjusted Expectation Index for Sale Prices Over Next Three Months (Source: Turkish Statistical Institute, 2020)

High investment return potential increased housing demand, exuberating housing prices. The increasing income per capita triggered demand for new homes, causing boom cycles in house prices.

Figure 2 compares the number of construction permits, occupancy permits, and house sales between 2008 and 2019. The construction and occupancy permits in Figure 2 represent the determinants of the housing supply, where construction sales are a demand factor.

Figure 2 demonstrates that construction permits have begun to exceed occupancy permits until the end of 2017. The increasing spread in favor of construction permits indicates the rising appetite for housing construction investments due to increasing profit margins caused by price exuberances.

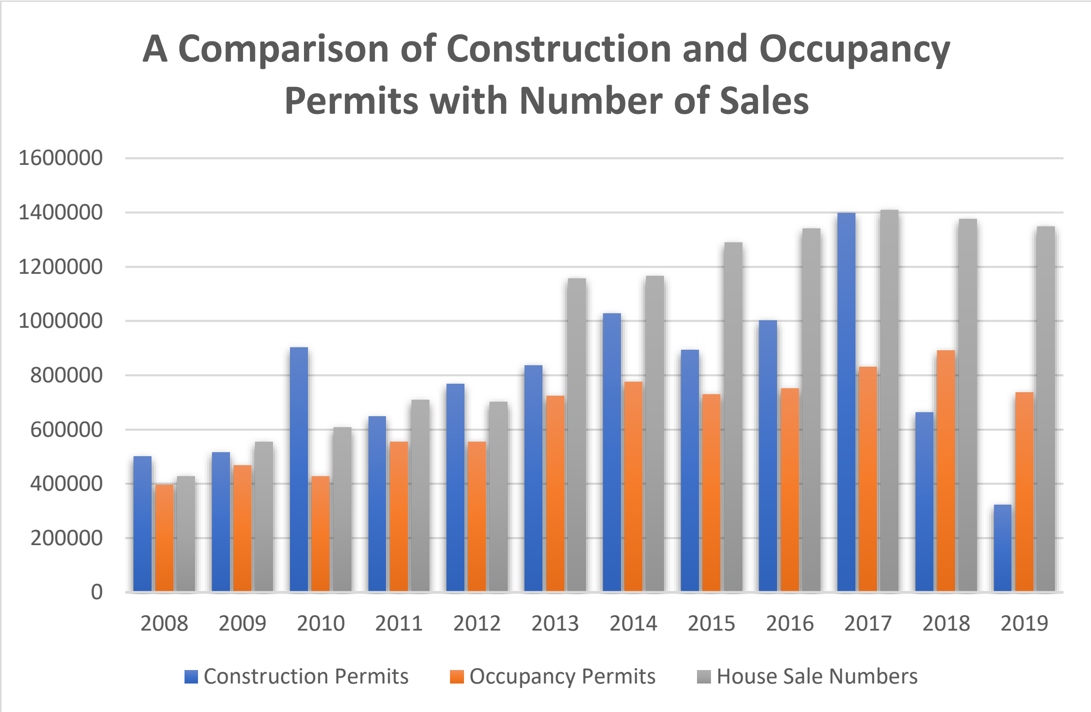



Figure 2. A Comparison of Construction and Occupancy Permits with Number of Sales Between 2008 and 2019 (Source: Turkish Statistical Institute, 2020)

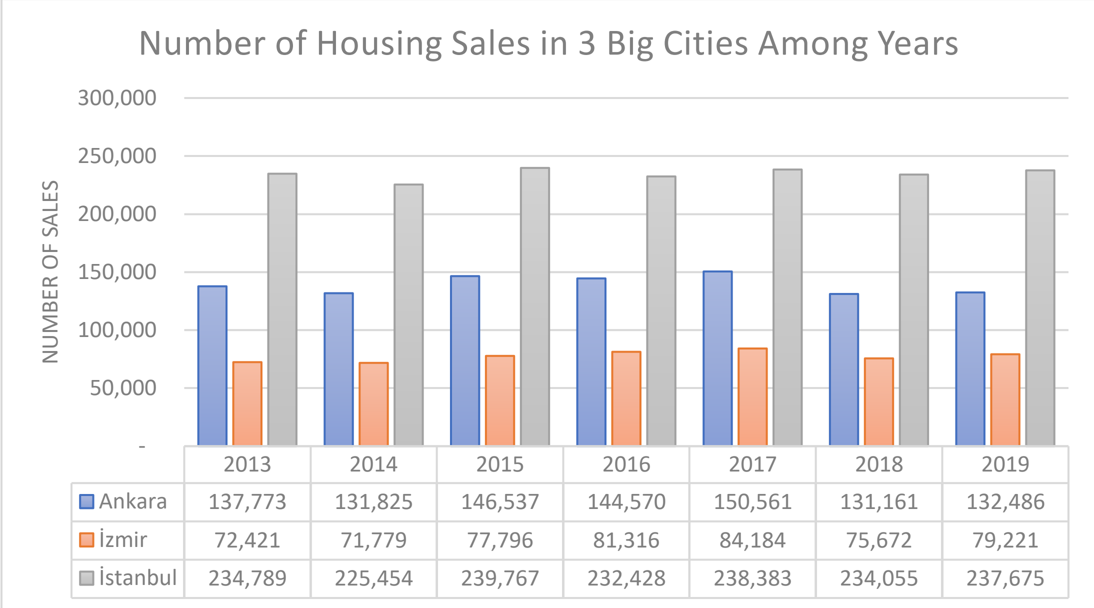
Between 2008 and 2018, the number of houses sold was below the aggregate construction and occupancy permits, increasing housing stocks. The demand and supply theory suggests that the prices will decrease in real terms or an acceleration loss in price increases in nominal terms. Accordingly, there has been downward pressure on house prices since the last quarter of 2018, and this pressure became more substantial in 2019 due to excess supply in the Turkish real estate market.

Figure 2 exhibits increasing house sales from 427,105 in 2008 to 1,348,729 as of 2019; however, homeownership rates were around 60%. More strikingly, based on below 60% of the median income criterion, the homeownership rates have decreased significantly from 58.1% to 52.1% between 2008 and 2019 (Turkish Statistical Institute). Hence, Turkey's recent rising residential real estate prices and sales led to a housing affordability dilemma, particularly among lower-income groups.

On the other hand, immigration to metropolitans, urban transformation projects, rising population, need for earthquake-resistant structures, investor preference due to relatively higher returns, and rise in foreign investors' appetite caused increasing housing demand. The GDP per capita in Turkey rose by 40.54% between 2010 and 2019 (World Bank, 2020). Growth in GDP per capita may generate increasing housing demand, which will trigger new housing starts.

House sales in Turkey rose by 5.1% year-on-year to 1,4 million items in 2017. The number of houses sold was approximately 1.4 million between 2017 and 2019 (Turkish Statistical Institute, 2020). As of 2019, house sales to foreigners constitute 3.38% of the total sales, which almost tripled between 2013 and 2019 (Turkish Statistical Institute, 2020).

Figure 3 illustrates the number of housing sales between 2013 and 2019 in Ankara, Istanbul, and Izmir.




| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| Ankara | 137,773 | 131,825 | 146,537 | 144,570 | 150,561 | 131,161 | 132,486 |
| İzmir | 72,421 | 71,779 | 77,796 | 81,316 | 84,184 | 75,672 | 79,221 |
| İstanbul | 234,789 | 225,454 | 239,767 | 232,428 | 238,383 | 234,055 | 237,675 |

Figure 3. Number of Housing Sales in 3 Big Turkish Cities Between 2013 and 2019 (Source: Turkish Statistical Institute, 2020)

Figure 3 exhibits those sales in Istanbul exceed the sales in Ankara and Izmir since the population of Istanbul is approximately 50% more than the aggregate of these two cities. Housing sales in these three cities constitute 33.32% of the Turkish real estate market sales.

Figure 4 illustrates the year-on-year change in house prices in Turkey, Ankara, Istanbul, and Izmir between 2011M01:2019M12.

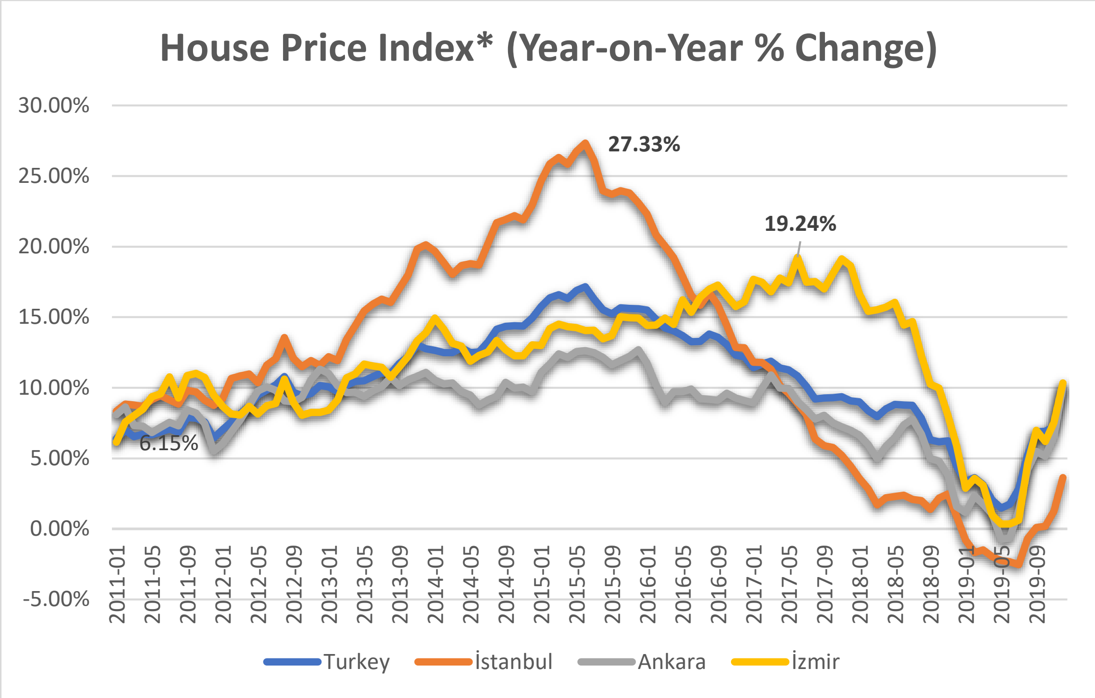



Figure 4. Turkish House Price Index Between 2011 and 2019 (YOY % Change)

*12-month moving average (Source: Turkish Statistical Institute, 2020)

According to Figure 4, the growth rate in housing prices started declining after their peak. However, each city has its own dynamics and exhibits different exuberance periods. Figure 4 shows that growth in Izmir's housing prices is higher after 2016:Q2 due to facilitating access to Istanbul with new bridges and highways, moving corporations' headquarters to Izmir, and high immigration for its climate and proximity to resorts. Overall, it is clear that demand and supply law principles demonstrate their effects, as there is an excess supply of houses in the country.

After FED announced the end of monetary expansion in 2013, it generated upswings in borrowing costs through decreasing liquidity and shifting capital flows; accordingly, the increasing USDTRY exchange rate puts upward pressure on construction costs. Between 2010 and 2016, the construction cost index increased more than the consumers' and producers' price indices. However, the real growth in housing prices, which is 48.87%, exceeded the construction costs growth, raising suspicions about price exuberance formations during the given period.

Mortgage rates influence the decision of potential buyers to buy a new house as the monthly installment payments of the borrower are dependent on mortgage rates. Figure 5 illustrates the relationship between mortgage rates and housing prices.

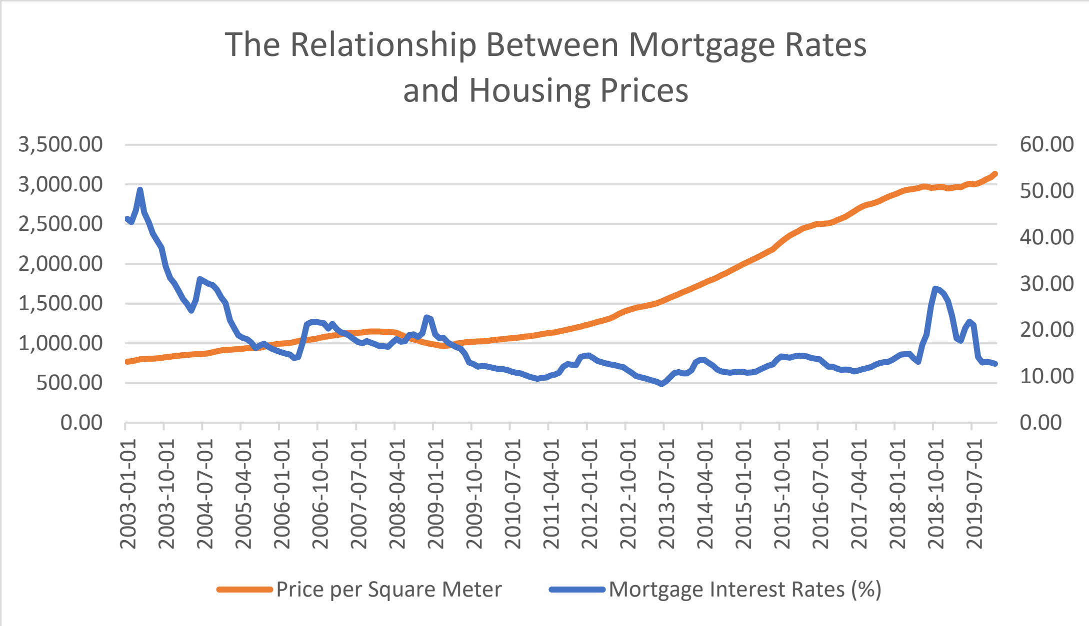



Figure 5. House Prices per Square Meter and Mortgage Interest Rates Relationship (Source: REIDIN and Central Bank of the Republic of Turkey, 2020)

The theory suggests a negative correlation between mortgage rates and house prices per $m^2$, and the sample exhibited in Figure 5 produces a -0.2953 correlation coefficient between these two indicators. Decreasing mortgage rates makes buying a new house more affordable, thus, increasing demand. On the other hand, the average house prices increased even when mortgage rates increased in Turkey from 2010 until the end of 2017.

The following subsection presents the importance of affordability indicators and their course over time.

### *2.2. Affordability Indicators*

The price-to-rent ratio and price-to-income ratio are the two indicators measuring affordability (Chen and Chiang, 2021; Zhang, Jia and Yang, 2016).

Potential buyers may utilize the price-to-rent ratio in deciding whether to buy or rent the house. If the ratio exceeds its mean, the investor may conclude that it is overvalued.

The price-to-income ratio is also a suitable parameter to judge housing affordability, where increases indicate decreasing affordability. Governments and policymakers may use the price-to-rent ratio to observe future bubble formations and closely monitor the effects of economic policy changes on the housing market to take immediate action. In other words, the price-to-rent ratio provides a better understanding of the market dynamics in the game. At the same time, this ratio serves as a tool to solve the "buy or rent" dilemma for investors. Banks and financial institutions consider this ratio as an elementary factor for mortgage lending in evaluating the loan allocation procedure.

Figure 6 exhibits Turkey's price to rent ratio between 2003:01 and 2019:12.

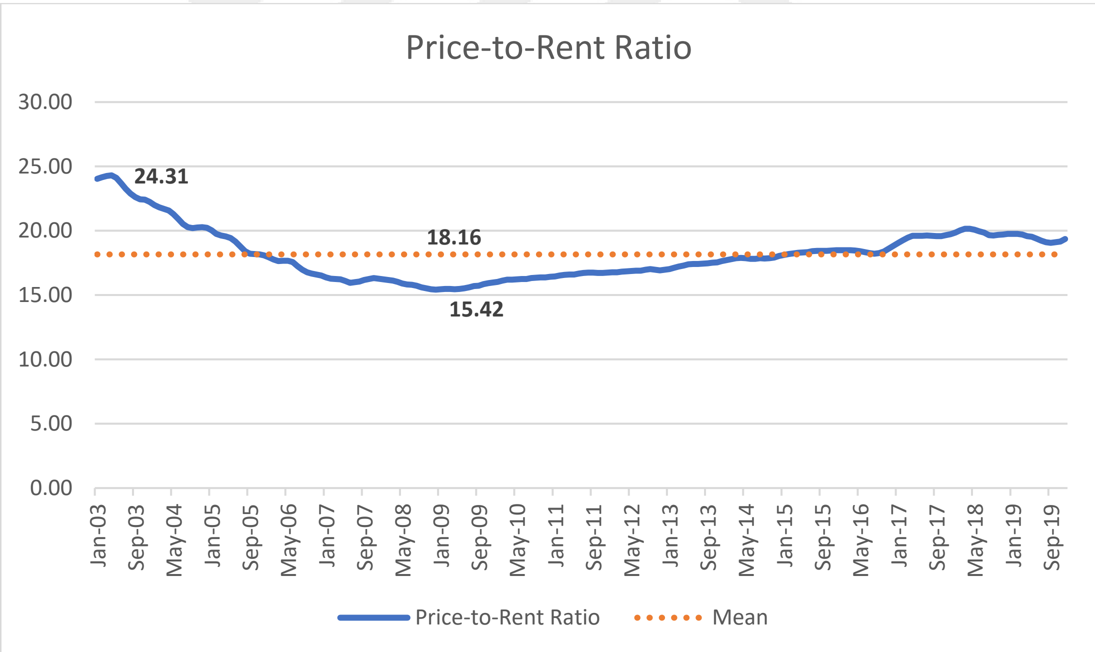



Figure 6. Price to Rent Ratio in Turkey Between 2003 and 2019 (Source: REIDIN, 2020)

The price-to-rent ratio, in Figure 6, is constructed by using REIDIN TR7 average rent prices and house prices per $m^2$. This ratio increased by 20.86% from 16.01 years to 19.35 years between 2010 and 2017, indicating house prices depart from fundamentals. Overall, the housing price volatility is relatively higher than rent prices' because rent increases are fixed at the consumer's price index (CPI) or producer's price index (PPI), ensuring gradual changes in rental prices.

Figure 6 exhibits cheaper rents than house prices before the global financial crisis (GFC) and an increasing price-to-rent ratio in the aftermath of the crisis. However, stable homeownership rates varied from 58.8% to 60.7% between 2006 and 2019 (EUROSTAT, 2021). Though purchasing a new house has become preferable to renting under economic stability, single-digit inflation figures, low mortgage rates, and the decline in house prices with the GFC.

The price-to-income ratio measures the long-term affordability of houses with the given formula: median nominal housing price divided by average nominal disposable income per capita. Figure 7 illustrates Turkey's price to income ratio between 2003:M01 and 2019:M12.

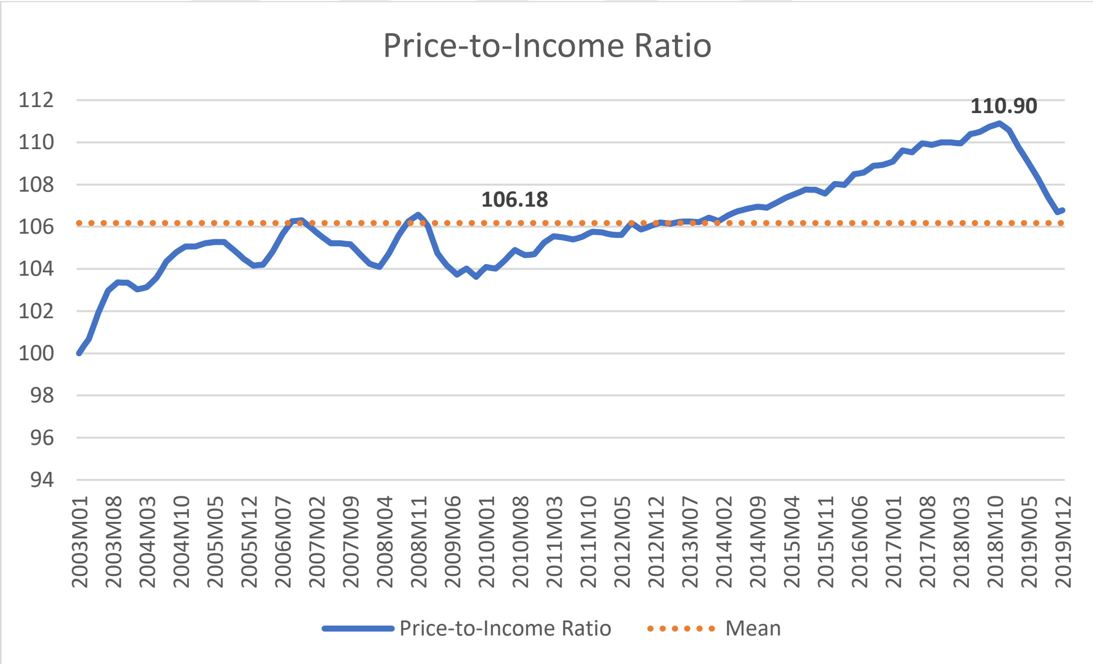



Figure 7. Price to Income Ratio in Turkey Between 2003 and 2019 (Source: REIDIN, 2020)

Figure 7 illustrates that prices increase more than income for ten years between 2009M12 and 2018M11. In these ten years, the growth in the price-to-income ratio revives concerns about bubble formation. However, if growth in prices exceeds income growth, the house prices will become unaffordable. On the contrary, housing price increases cannot be more significant than income per capita growth forever. This situation is a sign of unaffordable expensive house prices, and distortions in income distribution may result in fewer property owners and many tenants as in the feudal order. The causes behind unaffordable housing prices for lower-income households are as follows: volatile mortgage rates, indigence, unequal income distribution, and short mortgage loan maturities (Coskun, 2020).

The following section introduces Turkish housing policies in practice.

### *2.3. Housing Policies in The Turkish Real Estate Market*

Governments and legal authorities are responsible for developing affordable and livable housing policies since sheltering is a fundamental human right. Accessible housing is on the agenda in many world cities, including Turkey's metropolitans, due to the recent urbanization conditions. Currently, housing and rent prices exhibit higher growth than income in Turkey, resulting in decreased housing stock, housing security, and urban transformation projects.

The scarcity of land in city centers and high land prices trigger high construction costs, especially in Turkey's densely populated metropolitan cities, causing exuberances in housing prices and revealing the inadequacy of accessible, safe, and livable housing. In the Turkish real estate market, the current increase in construction costs due to the volatility of interest rates and the increase in the USDTRY exchange rate is an obstacle to housing production. Therefore, housing production remains below the increasing housing demand in metropolitan cities.

On the other hand, in line with price exuberances, the number of firms in the highly competitive Turkish construction sector increased from 200,000 to 330,000 between 2012 and 2018 (European Construction Industry Federation, 2013; European Construction Industry Federation, 2019). In addition, 32 % of newly established firms fail (Coskun and Pitros, 2022), and the sector's NPL ratio was 9.81% in December 2019 (Banking Regulation and Supervision Agency, 2021). Therefore, new projects target only a specific income group, primarily focusing on profits in a competitive market. At the same time, households who cannot purchase a new house prefer renting. Increasing population and more job opportunities in metropolitan areas increase the demand for rental housing, and in this context, rental prices also increase. The real estate market stands out as an essential economic, political and social area of interest for governments and policymakers in line with the explanations mentioned above.

One of the most fundamental variables in access to housing is the ratio of housing expenses to disposable household income. The housing expenses include loans, rents, and bill payments. This ratio was 28.6% on average, and lower-income groups allocate more than half of their monthly income to the most basic needs, including food and shelter (Istanbul Metropolitan Municipality & Istanbul Planning Agency, 2021).

Figure 8 presents the ratio of housing rental expenses to household income between 2003-2019.

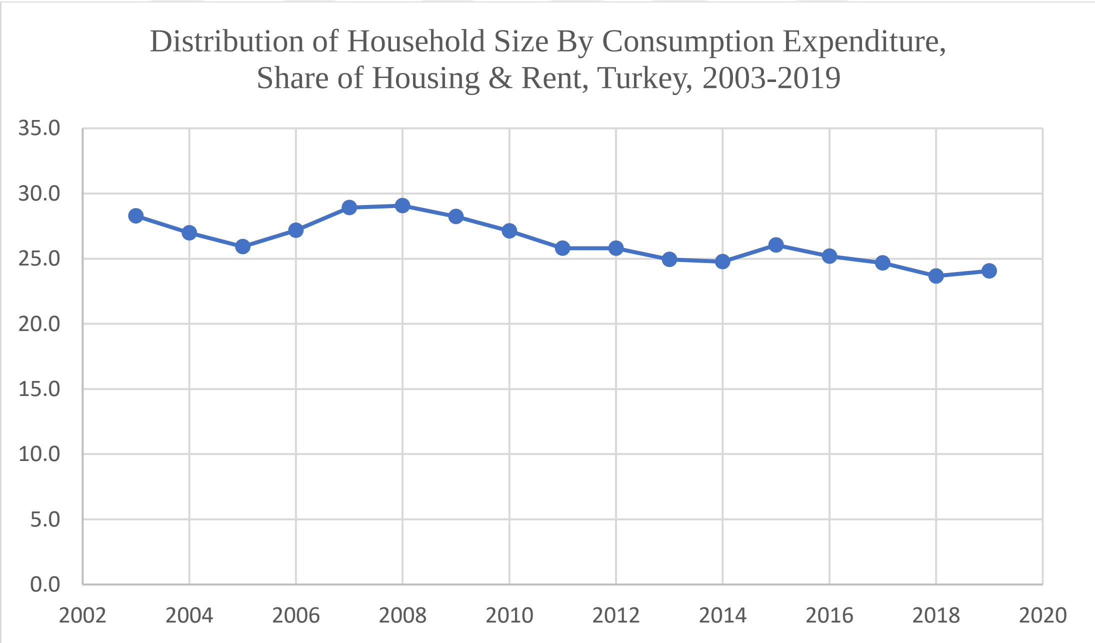



Figure 8. Distribution of Household Size by Consumption Expenditure, Share of Housing & Rent, Turkey (Source: Turkish Statistical Institute, 2020)

Gini coefficient, exhibiting income distribution inequality criteria, expresses equality in income distribution as it approaches zero and deteriorates in income distribution as it approaches one. P80/P20 ratio is the ratio of income obtained by the

20% which receives the largest share of income to the income obtained by the 20% that receives the least share. Similarly, P90/P10 ratio is the ratio of income obtained by the 10% which receives the largest share of income to the income obtained by the 10% that receives the least share. In 2019, the P80/P20 and P90/P10 ratios were 7.4 and 13.0, respectively (Turkish Statistical Institute, 2020).

The Turkish real estate market offers investment opportunities apart from meeting accommodation needs. Housing policies support the private construction sector, which undertakes the majority of production. In 2019, the private sector, public sector, and cooperatives in housing construction permits had 88.63%, 10.12%, and 1.25% shares, respectively (Turkish Statistical Institute, 2020). However, the private construction corporations do not target projects suitable for the lower-income groups as it is not profitable. Monthly installment payments of mortgage loans are well above the average household's ability to pay. Considering the housing price growth, which was above the income increase between 2010 and 2017, financing real estate models without flexibility and with long-term maturity cause households to prefer houses with worse quality and safety or lose their houses.

As the construction sector is the driving force of the growth, the Turkish government has taken measures to support residential sales, including:

- contribution up to 15,000 TRY for three-year savings in the bank housing account,
- down payment rate reduction for mortgages from 25% to 20%,
- temporary reductions in Value-Added-Tax (VAT) from 18% to 8% for houses larger than 150 $m^2$,
- temporary reductions in the title deed fees from 4% to 3%,
- Treasury guarantee for public projects,
- supports the private construction industry through Housing Development Agency (HDA),
- urban transformation codes providing rental payments during building construction or regeneration,

- grants citizenship rights to foreigners who purchase a house in Turkey and meet specific conditions.

However, current policies are inadequate to increase housing affordability for lower-income households. The housing policies exclude lower-income groups and leave this income group vulnerable to free-market dynamics. Regulations and practices remain limited regarding tenants, mainly focusing on “property.” Social housing, social housing rentals, and rent interventions for affordable residential real estate policies are ineffective due to high construction costs per $m^2$, high-interest rates for commercial loans, fluctuating mortgage rates, long-term payments, and inflation triggered by the depreciation of TRY against USD.

The mortgages generally default due to the high-interest burden when households in the low-income segment purchase a new house through mortgage financing. Flexible payment plans put low-income households under more interest burden with the current mortgage rates. Therefore, mortgage financing is not a frequently sustainable tool for low-income groups causing them to lose their houses and worsen their living conditions.

In 2016, Regulation No. 8539 on Housing Account and State Contribution initiated a state contribution of up to 15,000 TRY for three-year savings in the bank housing account for the first and only house to be purchased. However, mortgage rates impose a severe burden, and the contribution amount is insufficient compared to recent price and construction cost increases (Istanbul Metropolitan Municipality & Istanbul Planning Agency, 2021). After 2016, construction costs and housing prices growth exceeded annual deposit interest rates, so the bank housing accounts depreciated in real terms.

Enacted in 2007, Law No. 5582 aims to develop the real estate market through asset-backed and mortgage-backed securities. However, in addition to the difficulties regarding interest burden and inflation, the low housing stock quality is inconsistent for mortgages. Furthermore, the failure to grant loans to properties without building permits made it challenging to establish an effective financial system (Housing

Policies Specialization Commission Report, Ministry of Development of the Republic of Turkey, 2018).

The following subsection will examine housing policies in emerging countries.

### *2.4. Housing Policies in Emerging Countries*

This subsection examines housing policies in Brazil, Russia, India, China, and South Africa (BRICS).

Due to the rapid socio-cultural transformation from rural to urban society, as in the rest of the world, there is a shortage of seven million housing units in Brazil (Tiwari, Rao and Day, 2016). In Brazil, housing production for lower-income groups has increased with institutional capacity to provide affordable and liveable housing through new housing programs and supportive legislation at the state and municipal levels. New programs offer subsidies for the poorer.

The Brazilian government enacted the "My House, My Life Program" in 2009, consisting of a government-owned bank purchasing housing units from private construction companies. The municipal government distributes the houses to households with approximately 400 USD income, paying 5% of their monthly income (United Nations, 2013).

Brazilian System of Savings and Loans spent over 10 billion USD in mortgages for financing approximately 550,000 new houses until 2007. The private construction companies planned to release 200,000 new housing units for lower-income households (Rolnik, 2017).

The Brazilian government plans to build 3 million new houses (Brazilian Presidency of the Republic's Secretariat of Government, 2020). However, landowners' preference to seek a contractor on their own and choose a project targeting wealthier households generated the lack of cheaper land. The other challenges are the availability of cheaper land outside of the city center and the arrangement of these lands for infrastructure. Therefore, the Brazilian government should surmount this challenge by finding affordable urban land and necessary investments.

Chen (2020) reveals that the privatization of the Chinese residential real estate market enabled households living in state-owned houses to buy their houses at prices well below the market value, triggering a significant increase in consumption. However, urban housing costs are very high in China. Although the Chinese Communist Party tries to play an active role in housing reform and securing tenure rights, a significant portion of the population remains outside the growing wealth due to unfair income distribution. The Housing Provident Fund positively contributes to homeownership rates for lower-income groups.

In contrast, the privatization policy triggered unintended consequences, including a steady rise in housing prices since the 2000s, rising land prices, high vacancy rates, and high price-to-income and price-to-rent ratios. Moreover, the effectiveness of affordable housing policies for lower-income households has been weaker in recent years.

High housing costs affect consumption and savings of different household segments, but overvalued prices inhibit household labor supply. Meanwhile, rising housing prices attract the attention of non-real estate enterprises for investing in residential properties, crowding out non-residential investments. Therefore, this situation may cause deteriorations in the loan allocation by taking the collateral into account rather than the company's financial strength. Besides, Evergrande Group, China's second-largest construction company, is in default (BBC News, 2021).

Similar to Turkey, the new projects target upper-income classes in Brazil and China. On the contrary, the Russian residential real estate market has its own dynamics. The Russian residential real estate market faces qualified liveable housing issues rather than affordable housing concerns. Access to housing is a constitutional right in Russia implemented with substantial government involvement. (Tiwari, Rao and Day, 2016). Currently, there is insufficient availability of quality housing, a lack of privacy among residents of the same unit, and low-quality living spaces in Russia.

The Russian Federation has had an adequate social housing policy regarding homeownership since 1992. The post-Soviet Russian government’s active privatization framework turned socialist houses into occupants, resulting in high homeownership rates. Accordingly, the Russian residential real estate market generated an 89% homeownership rate as of December 2018 (Trading Economics, 2021), meeting the needs of poor or lower-income families. The Russians launched “The Affordable and Comfortable Housing for Russian Citizens” incentive in 2002. It is still operating to provide housing for the younger generation to reverse the declining birth rate by allocating loans to young families. The incentive also targets lower-income households, triggering new residential constructions and renovation of public substructure plants.

The Federation transfers the remaining property ownerships to municipalities. However, in most cities, the municipality is not concerned with departmental housing and utility facilities, avoiding accountability since it lacks the appropriate financial tools.

Despite the Federation’s support, profit share is not dominant in determining prices or rents; most buildings are cheap public housing, and the buildings are not suitable in size and quality. However, a large part of the housing stock needs to be renewed or repaired. On the other hand, maintenance and repair costs became unaffordable due to increased tariffs for utilities, and houses remained old and needed renovation. Although the Russian government provided subsidies and social support to citizens for public service payments to maintain social stability, most houses remain far from livable conditions (Guzikova, 2017).

The Soviet regime provided a permanent tenancy for its citizens, and the Russians regard mortgage payments as unreasonable for a property they consider a fundamental right. The privatization, overvalued prices, and limited financing options resulted in a “marketless ownership” system since young people cannot afford a new house (Zavisca, 2012).

Although India has a long history of generating housing policies and programs and establishing institutions, there are concerns about the housing supply shortages.

The Indian government has initiated several policies and programs for affordable housing. National Urban Housing & Habitat Policy promotes public-private partnerships and targets lower-income households living in the urban (Government of India, Ministry of Housing & Urban Poverty Alleviation, 2007). Model State Affordable Housing Policy offers states to pass specific acts for fiscal and regulatory reforms and innovations to promote cost-effective construction resources, accompany infrastructure development, and create strategies for inventory management (Government of India, Ministry of Housing & Urban Poverty Alleviation, 2014). The policy targets economically weaker sections and lower-income groups.

Housing policies in India target increasing homeownership rates, a population of 1.3 billion makes it impossible to provide housing for the majority based on ownership. There are many slum-like dwellings in the country due to the population density. The RAY program aims to address difficulties with ambiguous land titles. In other words, the program targets registering slums in the formal system and solving the infrastructural claims. In 2015, the Ministry of Housing and Urban Poverty Alleviation prepared The Draft National Urban Rental Housing Policy to create affordable, sustainable, and inclusive rental housing. Despite the endeavor to develop a rental housing policy, the long-standing governmental bias toward promoting house ownership remains (Nair, 2017).

There is an urgent need to overcome India's liveable housing shortage since there is no inclusion of housing as a constitutional right. In addition, most of the makeshift slums lack infrastructure. The recent Housing For All policy aims for housing with infrastructure, including water, electricity, and sewage; however, the housing policies implemented in the country are insufficient. The policies should establish appropriate subsidies for affordable housing initiatives and develop dynamic tools to support housing affordability across all income groups.

Tiwari, Rao and Day (2016) offer an inclusive evaluation of South African housing policies. The ruling National Party government had implemented the Apartheid policy. Accordingly, the citizens outside of the white minority could benefit less from services provided by the state. The political leadership had to deal with a significant housing shortage since the end of Apartheid. However, rising homeownership rates within demographically segregated cities in a low-capacity developing country are not as easy as one might expect.

The South African Constitution guarantees the right to shelter, and the government plans to provide access to compact housing with similar quality. However, there were numerous problems with delivering state-provided homes, both in quantity and quality, spanning from the legitimacy of land possession to the giving institutionalized citizenship. Therefore, despite the guarantee in the South African Constitution, the government fails to fulfill its commitments to lower-income households. Despite reformist initiatives, Apartheid-era separation remains in South African metropolitans.

In order to determine and implement affordable and livable housing policies, highly coordinated efforts of all stakeholders, including the government and construction industry professionals, academic institutions, and households, are required. However, despite the developments, especially in Brazil, this subsection concludes that the economic and housing policies of the BRICS countries remain limited.

The following subsection will examine housing policies in developed countries.

### *2.5. Housing Policies in Developed Countries*

The increasing population in metropolitans triggers housing demand, resulting in exuberances in housing prices due to excess demand. Accordingly, Japan, America, Spain, and many other countries observed a housing bubble during different periods. Each country develops its own housing policies to balance housing prices. Since the housing policies in the Turkish real estate market remains limited to affordable housing and renting, this subsection examines housing policies in developed countries to determine which policies are adaptable for Turkey.

Governments and local authorities develop various policies to fill the empty houses, including the sale of empty and weathered houses for 1 € in exchange for a promise of restoration in Sambuca, Italy, an incentive of 700 € to establish a business and live for at least three years in Molise, Italy (Euronews Turkey, 2019). In Barcelona, local authorities purchase vacant houses which are more than two years and use them for low-cost rental social housing (O'Sullivan, 2021). Similarly, the National Asset Management Agency (NAMA) purchases vacant homes and rents them to non-governmental organizations and non-profit organizations for 20 years in Ireland (National Asset Management Agency, 2019; National Asset Management Agency, 2021).

This section examines the rent and housing policies applied in Australia, Canada, France, Germany, the Netherlands, the UK, and the US.

The Commonwealth Rent Assistance Scheme (CRAS) in Australia, where the tenants-to-landlords ratio is higher, offers tax-free financial support to tenants in need. CRAS does not cover homeowners and individuals under the age of 25 living with their parents to reach those in real need. In addition, the CRAS includes only one of the individuals living together (Australian Government, Department of Social Services, 2019). The CRAS pays up to 75% of the rent above the threshold determined according to inflation every March and September. The amount and the rates vary according to households' financial conditions and the number of children.

The National Rental Affordability Scheme (NRAS) provides investment support to construction corporations to reduce rental costs and support affordable rental housing production for lower-income households in Australia. NRAS offers annual financial incentives for up to ten years to enable affordable rentals at 80% or less than the market price. The NRAS provides highly affordable houses with high living standards (Australian Government, Department of Social Services, 2019)

The Canadian government has three central policies for affordable housing. First, Canada announces a new first-time homebuyer incentive (FHI) for affordable first home purchases (Government of Canada, National Housing Strategy, 2021). The FHI provides first-time homebuyers, who have the necessary down payment of a shared equity mortgage, an incentive amount of up to 10% with the Government of Canada. The FHI program, aiming to promote house development to mitigate

Canada’s housing supply shortfalls in the most populous cities, has a budget of $1.25 billion over three years beginning in 2019.

Second, like leasing plans, the Canadian government also presents a rent-to-own program for residential real estate. The renter has the option to purchase the item for an additional amount at the maturity date of the contract or a predetermined period. The option includes a premium at the arrival of the contract. The tenant can return the house to the corporation under any financially worsening scenario.

Third, the Canadian government plans to build or renovate 1.4 million houses in the upcoming four years to enhance the housing supply (The Liberal Housing Plan, Canada, 2021).

Recent French housing policies include building cheaper dwellings with higher quality to create housing supply, providing incentives for tenants with low-income, and improving purchasing power to increase housing affordability.

Prior to the rent control code enacted between 2015 and 2017, rental prices in Paris experienced a 50% increase between 2005 and 2015 (Paris Municipality, 2022). Targeting high Parisienne rental prices, the rent control code determines the maximum rental prices. The evolution of housing, development, and quantitative (ELAN in French) focuses on constructing higher-quality houses. In 2019, the rent control code started to be enacted again upon the request of the Mayor of Paris.

The rent law includes the rent reference index, which differs by region and neighborhood, is announced quarterly, and targets protecting both the landlords and the tenants. The landlords can apply if the rent is below the rent reference index (Ministry of Economy, Finance, and Industrial and Digital Sovereignty, 2022). The rent reference index holds two different indicators: furnished and unfurnished indices. The rent law and the rent control code ensure that rental growth cannot exceed changes in the rent reference index, and the monthly rent payments do not exceed the maximum rent limit (Republique Française, 2022).

In Germany, where rent prices are high, the ratio of houses occupied by the tenants to the total number of houses exceeds 50%. This rate averages around 80% in cities, including Berlin and Hamburg (Schmidt, 2021). There is insufficient stock for rental housing in metropolitan areas to meet the needs of the growing population.

Construction companies in Germany complete new residential real estate constructions with a delay due to compliances with the construction legislation, labor shortages, and high land prices. The turmoil of the global financial crisis generated decreases in new constructions resulting in low homeownership rates and high rental prices. For instance, the decrease in the number of new constructions due to the economic recession negatively affected the housing supply in Berlin, with a population of approximately 3.5 million, and caused the rental prices to increase by 50% in the last three years. The rent cap, fixing the rental prices of 90% of the flats in Berlin for five years, came into force in February 2020 to provide affordable rental prices (Connolly, 2021). According to the rent cap, current rents higher than the maximum rent limit had to be decreased. However, the constitutional court in Karlsruhe decided to terminate the upper limit of rent because it is an intervention in the free market, and a state government cannot introduce its legislation against federal law.

The Netherlands has the most extensive social housing stock in the European Union: social houses consisting of 32% of the owned-housing stock and 75% of the rental housing stock. Enacted in 1901, The Housing Act provides access to social housing for low-income, disabled and elderly households. There are approximately 425 Woning corporations that are subject to performance measurement and inspection by government agencies. These corporations are obliged to transfer most of their revenues to new social housing production. In addition, the Netherlands government put an upper rent limit policy in practice for rent increases in the private sector in 2020 (Housing Europe, 2010).

The affordable rental incentives include the activities of the Woonbond organization and the anti-squatting system, mainly focusing on tenant rights and supplying affordable rental prices by preventing buildings from becoming ruined.

The Amsterdam-based Woonbond organization represents 53% of tenants in the Netherlands with over 1.5 million members, aiming for affordable rent, livable and safe homes, and protecting tenant rights (Housing Futures, 2018). The Woonbond organization aids shape a countrywide schedule on housing strategy formulation and provides advice to tenants through its hotline.

The anti-squatting system allows households, students, and newcomers to use vacant real estate for a low rental price from an old house, school, or office until the property is demolished or legal authorities declare another useful purpose. In this way, a small group of households can guard a building to prevent squatters from using the property. However, determining another usage purpose triggers problems for the tenants since the decision terminates the lease agreement. However, this application still offers an affordable alternative to social housing. (Dutch Review, 2022).

There are Council Housing and affordable rent programs in the UK to revive sustainable renting policies, especially for homeless or low-income citizens. The affordable rent program offers shorter-term contract options than the Council Housing incentives. The Council Housing structures include colonial houses with schools and shopping places. The Council Housing program presents several options varying from:

- introductory tenancy, giving the tenant a 12-month trial period,
- secure tenancy, offering households accommodation for their lifetime, giving the Right-to-Buy option if the tenant does not own a house, and passing the tenancy right to their children,
- flexible tenancy, offering households accommodation between two and five years and a new house at the lease end date, providing the opportunity to rent only one room and swap houses between other flexible tenants, and enabling to pass the lease on to another person in need (Council Housing, ND)

The Council Housing reduced its housing stock through sales to tenants and housing associations. Accordingly, the most important source of affordable housing in the UK has been housing associations, managing 54% of social housing (Housing Europe, 2010).

Like the Dutch anti-squatting system, the British government offers vacant units allocated for commercial use in London. In this way, the government generates housing supply, supports sectors financially, temporarily decreases unemployment via renovation activities, and prevents the uncanny and idle situation due to empty buildings (Mayor of London, 2021).

The affordable housing policies provided by the US federal government remain at a limited level. The federal government of the United States provides housing subsidies through the Internal Revenue Service (IRS) and the Department of Housing and Urban Development (HUD). The US federal government offers public housing with lower rental prices than the residential real estate market prices, allowing households to dwell in more suitable places close to the city center. HUD's housing policies, on the other hand, cause welfare to rise since HUD authorizes and funds the housing authorities. In 2020, the public housing units were over one million (Andrews, 2020). Local governments in the United States regulate housing construction, services, and residency.

The IRS presents housing tax incentives to significantly lower the cost of owning a house relative to renting. However, according to income and inflation levels, residential real estate costs change due to IRS incentives. In contrast, the personal income tax code has significant and reverting covert allowance results. The allowance is only for property owners, who are often wealthier than tenants. The second IRS program offers loans to contractors who are starting the construction of a new residential property for low-income tenants who pay 30% of their income in rent (Department of Housing and Urban Development, 2019). On the other hand, loans are securitized, sold to investors, and the revenue is invested in projects.

The social housing programs initially consisted of high-quality buildings and various income groups. However, the projects lowered occupancy standards in the following period and targeted low-income people due to Congress' failure to provide adequate funding. The social housing neighborhood has a high crime rate, widespread drug use, and a low level of education (Semuels, 2015). Most of the traditional low-income social buildings established at the initial stage were demolished due to the above reasons and the waning political support. Congress and HUD launched a new

Rental Assistance Demonstration (RAD) program in 2012 (Wikipedia, ND). RAD contributes to the renovation and recreation of eligible real estate with the help of private contractors and investors.

As a result, among the practices for affordable housing mentioned above, the applicable policies in the Turkish residential real estate market are as follows: Since Turkey has a coast on the Mediterranean Sea, the Italian housing policy can be beneficial in reducing housing demand in metropolitans. Transferring ownership for a small fee in exchange for a promise of renovation may also indirectly support agricultural activities while setting a new trend for returning to rural life. This study finds the Canadian policies appropriate, including the rent-to-own program, giving the tenant the purchase option at a predetermined period, and providing incentives for first-time homeowners up to 10% of the purchase price. The British Council Housing scheme, offering various options for tenants in need, may eliminate income inequality and promote an affordable renting policy for the Turkish real estate market.

Following this section, Chapter 3 introduces the theoretical framework covering asset price bubbles and the theories of rational expectations, investment value, and demand and supply.

# CHAPTER 3: THEORETICAL FRAMEWORK

### *3.1. Asset Price Bubbles Within the Price Convergence Framework*

An asset price bubble occurs when prices have unrealistic or inconsistent future forecasts. The term bubble connotes volatile, overvalued, fragile, and temporary asset prices. In periods of bubble formations, the price or the price range of an asset is significantly higher than the asset's fundamental value. Therefore, the level of bubbles through the price convergence framework, i.e., the difference between actual and fundamental house prices.

To better understand the bubble term, this study uses the illustration displayed in Figure 9, exhibiting a glass of beer with foam.

The bottom part of the glass in Figure 9 presents the fundamentals of pure beer consisting of grain, malted barley, wort protein, yeast, ethyl alcohol, and hops. However, there exists beer foam on the top of the glass. Gas bubbles, primarily carbon dioxide, produce beer foam that rises to the surface. The remaining elements of the beer foam are wort protein, yeast, and hop residue.

Although consumers perceive the whole glass as beer in Figure 9, beer foam forms a particular part of the glass. The entire glass represents the observed price of an overvalued asset. Accordingly, beer foam also includes similarities to asset price bubbles. The formation of asset price bubbles occurs when the observed asset prices exceed their fundamental values. The metaphor alluded to inflated and fragile rising prices built solely on-air, similar to beer foam at the top of the glass, which is mostly nothing but gas and can be consumed quickly in the first sip. The price convergence framework measures the timing and magnitude of bubbles by comparing asset price departures from their fundamentals. Price convergence refers to the degree of proximity between actual and fundamental prices.


Figure 9. Similarities Between Beer Foam and Asset Price Bubbles

"Manias" is the synonym and the ancestor of the term bubble. The first documented speculative asset price bubble in history was the Dutch tulip mania between 1634 and 1637, where the futures contract prices of particular tulip bulbs soared to unprecedented heights (Dash, 2001). Tulip bulb prices were rising due to speculative tulip bulb trading in the futures market by investors who had never seen the bulbs, and many investors gained and lost fortunes in the blink of an eye. The "mania" term connotes observed asset prices varying significantly from fundamentals.

The bubble concept derives its name from the inflated British South Sea stock, which sparked one of the earliest major financial crises between 1711 and 1720 (House of Commons Journal, 1803). The joint-stock company generated income, strengthened its equity position, and decreased the national debt's cost by allowing private equity inflows. The British government privileged the firm by holding a monopoly in 1713 to supply enslaved Africans to South America (Paul, 2009), where the Spanish enemy forces were in control. Accordingly, the company could not profit from its granted monopoly on slave trading. However, banks were allocating loans to investors to buy shares backed by the same shares as collateral. The increase in share prices was inevitable due to the leverage effect that caused the increase in demand. Due to the factors aforementioned, the company's stock skyrocketed in value in 1720 before plummeting to just beyond its initial float price. The British economy suffered significantly after the crash in stock prices, with investors bearing the brunt of the losses. The Royal Exchange and London Assurance Corporation Act 1720, also known as the Bubble Act of 1720, forbidding the formation of joint-stock companies without the approval of the royal charter, initially used the term bubble in a code (Raithby, 1811).

There are various indicators of housing price bubbles: First, rare exuberances in prices or ratios, including prices, i.e., price-to-rent ratio or price-to-income ratio, occur compared to their previous levels, leading to high marketing or media coverage presence, unintentionally backing the evolution of the bubble. Bubbles often take a stimulating psychological route with various behavioral patterns ranging from personal price perceptions to social manias. This route can generate a non-natural product price, as illustrated in Figure 9. In the 2008 global financial crisis (GFC), the price-to-income ratio exhibited explosive patterns in the US real estate market, and housing costs were exceptionally high compared to income. Second, the price-to-rent ratio in real estate compares property prices to monthly/yearly rental prices. Higher values imply that homeowners generate fewer rental earnings on their housing investment. Third, expansions in credit volume or utilization of excessive leverage while purchasing a new house may be the source of an asset price bubble as lower mortgage rates promote credit growth. Last but not least, there is an expectation and misconception that housing prices will constantly rise in the market during asset price bubbles.

Intrinsic price behaviors cannot solely explain bubble formations. An asset's price upsurge is a bubble rather than a price exuberance if it adversely affects economic stability. Therefore, this research investigates whether there was a period or a recent bubble formation in the Turkish real estate market. This thesis assumes that speculative price appreciations due to irrational expectations and the departure of prices from fundamentals cause bubble formation. The lower the price convergence between fundamentals and actual prices, the more negligible the bubble formation probability.

### *3.2. The Theory of Rational Expectations*

The rational expectations theory in economics assumes that although there are significant cross-sectional disparities in individuals' views, the expectation averages are more accurate than primal models and as accurate as complicated calculation mechanisms (Muth, 1961). In other words, all the agents act rationally on average, not wasting the scarce information (Diappi, 2013), forming their expectations based on the economic conjuncture. Accordingly, each agent knows the exact economic model and accepts the expectations and optimal forecasts with all available information.

The theory assumes that the anticipated future value of a variable is equivalent to the model's forecasted value, where the systematic errors converge to zero when forecasting the future.

The theory suggests that the models, including uncertainty, benefit from rational expectations theory regarding intrinsic robustness. The model's forecast outcomes of economically contributing predictors do not separate systematically or predictably from equilibrium outcomes to attain a robust model. Accordingly, many econometric models based on a macroeconomic perspective utilize assumptions in the rational expectations theory.

The rational expectation theory suggests that investors' expectations shape an asset's actual and future prices, and the price convergence framework is the deviation of actual and fundamental prices.

### *3.3. The Theory of Investment Value*

Investors use mortgage loans during property purchases since they do not have enough equity or liquid assets. When interest rates are low, investors may prefer to use mortgage loans, considering their cost of capital. However, some investors intend to restructure the existing mortgage loan with a lower rate known as remortgaging. Nevertheless, consumer support loans allocated with the property as collateral, a type of equity withdrawal loan, offer opportunities to buy a second house for non-residential purposes. These types are considered "forward mortgages" since they involve borrower repayments resulting in debt decreases while the property price rises.

Banks capitalize their interest earnings after each installment, where the amount of interest constitutes most of the first installments calculated in loan payment plans. Interest continues to accrue on the principal of the remaining debt, and therefore, the investor continues to pay interest until maturity. Similarly, discounting the future installment payments with the mortgage rate presents the present value of the loan, and the procedure is the inverse of compounding.

The investment value theory introduces a new valuation approach called the discounted cash flow methodology, measuring the fundamental price of an asset by discounting its expected future cash flows with the notions of the time value of money.

Equation 1 represents discounting the present value of an asset:

$$PV = \sum_{t=1}^{n} \frac{CF_t}{(1+\frac{1}{m})^{mt}} \quad (1)$$

where $CF, i, m, n,$ and $t$ denote the total loan payments; in other words, the future value of total payments, compound interest rate, the frequency of installment payments within a year, number of installments, and the number of years, respectively.

However, the Turkish banking system allocates mortgage loans tax-free and fund-free at a simple interest rate. In general, the frequency of installment payments is monthly, and banks allocate the majority of loans in TRY. Similar to Equation (1), the present value of a future cash flow – installment payment - at time $t$ is:

$$PV = \frac{CF_t}{(1+i)^t} \tag{2}$$

where $CF, i,$ and $t$ denote cash flow, the discount rate, and the number of years, respectively.

Equation (3) presents the present value of a sequence of equal monthly installments at the end of $t$ years:

$$PV = \frac{CF}{i}\left[1 - \frac{1}{(1+i)^t}\right] \tag{3}$$

where $CF, i,$ and $t$ denote monthly installments, the discount rate, and the number of years, respectively.

Equation (4) describes the present value of a sequence of identical payments collected each year in perpetuity.

$$PV = \sum_{t=1}^{\infty} \frac{CF}{(1+i)^t} = {}^{CF}/_{i} \tag{4}$$

Assume that the cash flows are monthly rents received, and the discount rate is the mortgage rate. Accordingly, the fundamental value of the real housing price index is as follows:

$$P_{house_t} = {}^{rent_t}/_{mir_t} \tag{5}$$

where $P_{house_t}$ denotes the overall real fundamental price of a house, $rent_t$ connotes real rent (RR) price and $mir_t$ is the discount rate representing mortgage rates at time $t$.

The discounted cash flow (DCF) approach includes regular payment earnings, i.e., rents. The approach utilizes a proper discount factor, i.e., mortgage rates, and calculates the present value of any net regular future payment earnings. The DCF model aims to measure the level of price convergence and test the existence and size of a bubble formation or an overvaluation in overall house prices. Thus, academics consider DCF to evaluate whether the price of an asset is at a speculative stage, although the model has limitations.

### *3.4. The Demand and Supply Theory for The Residential Real Estate*

Based on two discrete laws, namely demand and supply, the theory is an economic model investigating how a competitive market determines or adjusts prices of (non-)financial assets or commodities where the quantity demanded and quantity supplied at the current price are equal. In other words, the interaction of supply and demand determines or adjusts the actual price of a commodity: The law of demand suggests that investors or consumers will demand less of a commodity at higher prices, whereas the law of supply proposes that supply increases at higher commodity prices. The resulting observed price is the equilibrium price representing an arrangement between producers (sellers) and consumers (buyers).

The commodity price and numerous other predictors, including the prices of other commodities, seasonal patterns, consumer income, and preferences, determine the quantity demanded of a product. Fundamental economics offer constant predictors, *ceteris paribus*, except the commodity prices and investigate the linkages between different price points and the quantities demanded or supplied.

Figure 10 and Figure 11 illustrate the price-quantity combinations exhibiting shifts in demand and supply, respectively. The price is on the vertical ($y$) axis, and quantity is on the horizontal ($x$) axis.

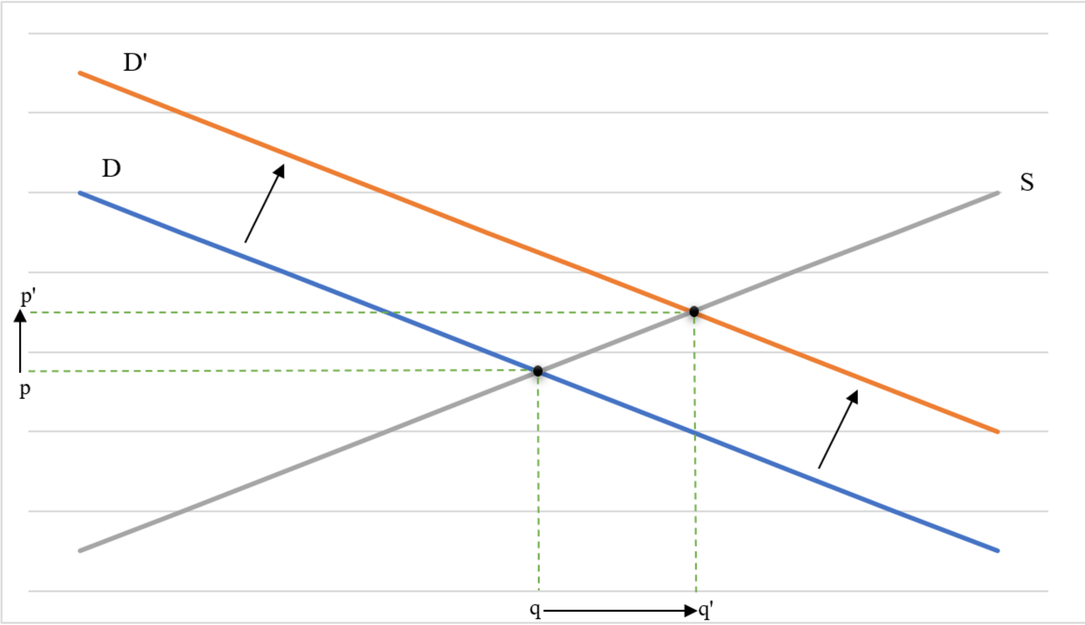



Figure 10. A Shift in Demand

Figure 10 depicts downward-sloping demand, indicating that consumers are willing to purchase more of the commodity at lower prices. Any change in predictors except price would result in a shift in demand, whereas the demand follows changes in commodity prices.

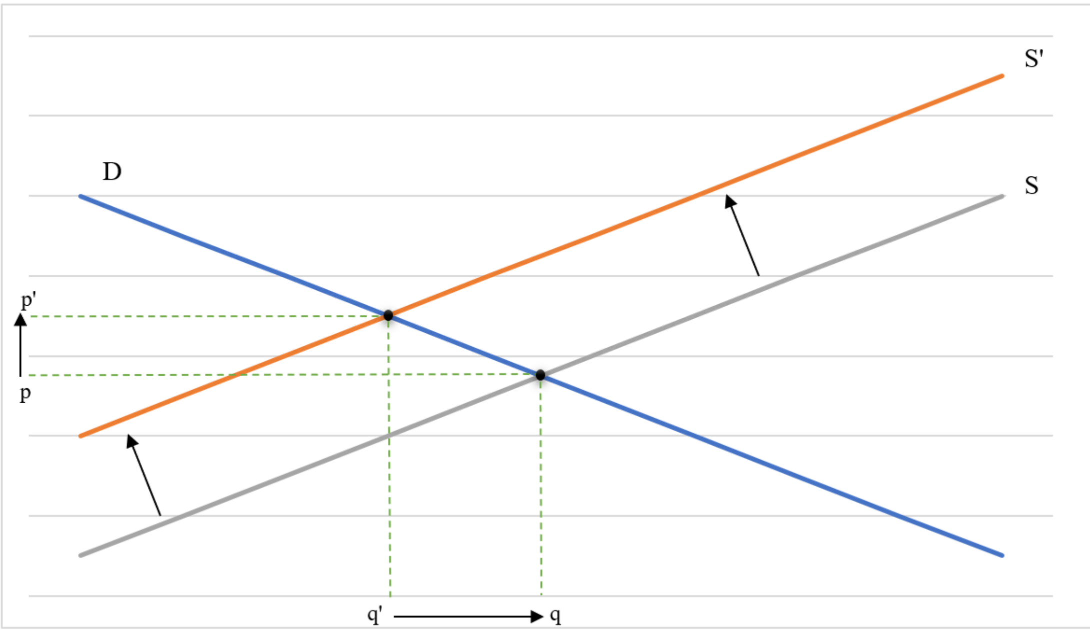



Figure 11. A Shift in Supply

In theory, the quantity supplied of a commodity depends on numerous predictors, including the production technology influencing the production velocity, cost of goods sold, substitute product prices, and other production factors. Figure 11 presents the price-quantity combinations of the upward-sloping supply, representing producers' desire to sell more products in a higher-priced market. Changes in predictors influencing price would shift the supply. However, changes in commodity prices only change the quantity supplied on the supply line.

Market equilibrium balances the price mechanism through supply and demand: The product price increases where the quantity demanded increases; if suppliers want to sell more at the current price, the product price drops. Accordingly, the product price tends to move towards the equilibrium price. This trend and the subsequent supply and demand equilibrium are called the market mechanism and market equilibrium.

Although the theory of demand and supply examines the relationship between price and quantity, this thesis employs a linear econometric model by Pesaran, Shin and Smith (2001) by including various predictors following the principles of the theory of demand and supply. Pirounakis (2013) summarizes the most important predictors of housing demand and supply, including current income, expected income, location (proximity to work and facilities), transportation costs, features of the house, mortgage rates, maintenance costs, building lifetime, expected price increases, demographic factors, educational level, household wealth, deposit rates, capital-gains tax, homeownership rates, property tax, land availability, expected price at the completion, construction costs, land costs, producer's required rate of return, building technology, commercial loan interest rates, and loan volume. Chapter 5 will present details of the data and the methodology.

This chapter covered the theoretical framework for this dissertation. Chapter 4 will introduce the studies on asset price bubbles and the real estate market.

# CHAPTER 4: LITERATURE REVIEW

The structure of the relationship between the real housing price index (RHPI) and the regression and causality methods observes the determinants of RHPI with the same order of variables for a very long time. However, examining the linkages between the real housing price index and its predictors integrated of order zero and one is relatively new and uncompleted. The time series requires seasonal adjustment to establish a stable and not misspecified model for measuring the timing and magnitude of housing price bubbles. Accordingly, this chapter consists of studies on seasonality, the housing price predictors, the definition of bubbles and their ways of measures, and related studies on the Turkish real estate market.

## *4.1. Studies on Seasonal Pattern Identification*

Numerous studies in the literature focus on determining seasonality in time series. Beaulieu and Miron (1992) and Audas and Goddard (2001) define three forms of seasonality by employing unit root tests: deterministic, stationary stochastic, and non-stationary stochastic. The deterministic seasonality approach includes dummy variables as it is constant over time. The series exhibits variations in time under stable stochastic seasonality conditions, where the seasonal patterns are not consistent. In contrast, Hylleberg et al. (1990) and Audas and Goddard (2001) suggest that seasonal changes increase in magnitude between consecutive observations for series exhibiting non-stationary stochastic seasonal patterns.

Studies identify seasonal patterns based on autocorrelation charts, a graph of seasonal subseries, or a spectral figure. The QS test is a modified version of the Ljung-Box (1978) correlograms computed on seasonal intervals. The QS test considers autocorrelations with positive values. Maravall (2012) proposes to approximate the correct distribution (p-values) of the QS statistic with a simulation using 1 million replications. The modified QS test checks for positive autocorrelation at $12^{th}$ and $24^{th}$ lags. Friedman (1937) observes seasonal patterns on a monthly or quarterly basis, according to the frequency of the data, by taking samples from the same population or populations with equal medians. Assuming that the series follows a chi-square distribution, Kruskal and Wallis (1952) model a non-parametric methodology to evaluate whether samples originate from the identical distribution. Similar to the Kruskal-Wallis seasonality test, graphing the monthly or quarterly averages of a time series enables to exhibit seasonal patterns where the average of a month/quarter exceeds the average of other months/quarters. According to the null hypothesis, the time series does not include seasonal patterns during equal monthly/quarterly averages.

Brockwell and Davis (1991) modify the sample size by changing the time series frequencies up to six cycles per year to create seasonal frequencies similar to the Fourier distribution to eliminate the leakage problem. The scheme estimates seasonal patterns on the periodogram spectrum, altering a signal from time to frequency. Based on selected seasonality, this approach highlights seasonal patterns and collects data for each season in separate mini-time plans. The test performance improves in small samples.

Lothian and Morry (1978) merge F-test to identify seasonality, known as 'M7' by the United States Census Bureau X-12-ARIMA package output. The study identifies seasonal patterns in all series except for the crude steel. Lytras, Feldpausch and Bell (2007) include dummies for fixed seasonal effects in the regression for the F-test and compare them with other diagnostics available in X-12-ARIMA adjustment. The study concludes that the FM test outperforms the M7, D8, F, and spectrum diagnostic tests. The FM test is easy to apply since the F distribution table exhibits critical values. On the contrary, the power of the F-test is relatively low.

Beaulieu and Miron (1992) suggest paying attention to statistical differences in the data and seasonality structure to prevent inaccuracies leading to bias and information loss in seasonal modeling. Based on the difficulties encountered in determining which test yields the most reliable results, Webel and Ollech (2018) created an overall seasonality test scheme by utilizing 18 candidate tests. With an extensive 600,000 ARIMA process replications, the modified QS and Friedman tests were found the most informative under a recursive component exclusion procedure in conditional random forests. In addition, the scheme results have low misclassification rates while avoiding unnecessary complexity in the model.

Most studies on seasonality in house prices or indices examine the US, UK, and Australia experiences, apart from studies offering new methodologies for determining seasonal patterns. Case and Shiller (1989) suggest positive autocorrelations in house prices. Their study tests seasonality by employing an F-test and detects seasonal patterns in Chicago and San Francisco. Kuo (1996) replicates Case and Shiller's partitioned sample regression method and illustrates the strong significance of higher prices in Chicago and San Francisco. In contrast, Rosenthal (2006), Rossini (2002), and Wright and Frino (2009) find no evidence of seasonal effects on housing prices. Kajuth and Schmidt (2015) and Ngai and Tenreyro (2014) acknowledge strong evidence for seasonal forms in UK and US housing markets by identifying hot and cold seasons on housing prices. These studies document seasonal booms and busts in the UK and US markets that exhibit deterministic seasonal patterns. Ngai and Tenreyro (2014) identify amplified volatility in house price returns of 6.5% for the UK and 4.6% for the US overall, although some US cities exhibit seasonality price differences of up to 6.7%. Kaplanski and Levy (2012) find a significant and persistent seasonality effect, with prices 3.75% higher in the summer. Miller et al. (2013) detect seasonality in US housing prices at the aggregate level and monthly price changes up to 1.93%.

### *4.2. Determinants of Housing Prices*

Empirical studies examine the linkages between housing prices and their determinants using either macroeconomic and financial variables or housing-sector-related determinants as the explanatory variables. Shen et al. (2016), Irandoust (2019), and Bahmani-Oskooee and Ghodsi (2018) focus exclusively on macroeconomic determinants of housing prices, including economic growth, credit, income, and unemployment rates.

Shen et al. (2016) the number of credit and housing booms and their duration in China and its provinces, finding out that more housing booms occur than credit booms, and housing booms last more than three years in some provinces. Irandoust (2019) reveals the bidirectional Granger causality between the housing price index and the unemployment rate in Germany and Switzerland between 1991 and 2016.

Surprisingly, the study also suggests that the housing price index Granger causes unemployment rates in Italy, Netherlands, Sweden, and Spain. However, the empirical evidence does not link the housing price index and the unemployment rate in the UK and France.

Quigley (1999) observes high expansions in credits in cases of housing booms; however, the study cannot explain short-run real estate price disparities through economic variables. Miles (2020) finds evidence for an asymmetric long-run association between UK house prices and income. In addition, the study by Gathergood (2011) finds that greater unemployment risk lowers the likelihood of house purchases.

Studies explaining the relationship between house prices and financial market instruments use financial indicators, such as gold prices, exchange rates, and stock market index, especially in OECD countries and emerging markets. In India, Mallick and Mahalik (2015) cannot provide empirical evidence on the relationship between gold price, effective exchange rate in real terms, net portfolio investments, and house prices. Simo-Kengne, Gupta and Aye (2015) in South Africa find no evidence for the impact of financial instruments' prices on house prices by employing a BVAR approach between 1979:Q1 to 2011:Q4. In contrast, in Qatar, Al Refai, Eissa and Zeitun's (2021) non-linear ARDL results detect dynamic linkages between house prices and stock prices. Lee (2017) employs the ARDL Bounds test in Hong Kong and suggests that stock prices and residential property prices are cointegrated. Irandoust (2021) finds that stock prices Granger cause house prices in France, Italy, Netherlands, Sweden, and the UK, where France, Netherlands, and Sweden exhibit more significant causality effects than the rest. Bahmani-Oskooee and Wu (2018) find supporting evidence for unidirectional causality running from house prices towards exchange rates in 9 of 18 OECD countries and the opposite direction in the other 9. Valadkhani, Nguyen and O'Brien (2019) shed light on the asymmetric links between house prices and mortgage rates by distinguishing the positive and negative impacts on mortgage rate changes via the non-linear ARDL approach. In an Australian sample, spanning from 1995 to 2017, they find that house prices show greater positive reactions than negative mortgage rate changes.

The other variant of literature offers empirical evidence on real estate sector-specific features on house prices. Xu et al. (2018) explain real estate valuation by separating housing prices into land and building prices, and they examine the effect of house age on the house and rental prices in China. The study suggests that older houses exhibit higher price growth, where land price growth exceeds building price growth, and the rental prices depreciate more than the house prices. Ambrose, Eichholtz and Lindenthal (2013) estimate Amsterdam's price-to-rent ratios between 1650 and 2005, revealing a couple of significant deviations from the mean. The price exuberances departing from fundamentals can be insistent and lengthy that the error correction term in prices may be insignificant in the short-run. Engsted and Pedersen (2015) employ the price-to-rent ratio in predicting housing returns following risk premium in the majority of 18 OECD countries, finding differences in rent return prediction among countries and instabilities among sub-samples. Hlaváček and Komárek (2009) employ affordability indicators, including price-to-income and price-to-rent ratios, to identify price exuberance periods in the Czech real estate market.

Several studies employ housing-sector-related variables primarily to explain rent prices, including location, neighborhood environment, infrastructure, house size, and house conditions. Won and Lee (2018) suggest that location, distance to university, and neighborhood environment variables positively influence rental prices. Muhammad (2017) points out decreasing rental prices where the real estate is close to the sewage. The results indicate that rent prices increase away from the Nala Lai – the open drain – to avoid the open sewage odor. By employing three different machine learning algorithms, Zhang, Shen and Liu (2019) predict rent prices through features varying from the number of rental houses, location, distance to the subway line, decoration conditions, to the total floor, the number of bedrooms, living rooms, and bathrooms. Teye et al. (2017) reveal that Amsterdam's housing prices Toda-Yamamoto Granger cause all the Dutch areas except Zeeland. The empirical findings propose a long-term cointegrating relationship between Amsterdam's house prices and six Dutch cities.

Studies combining multiple macroeconomic and financial predictors include Chang, Chen and Leung (2012), Chang, Chen and Leung (2011), Liu and Chen (2016), which explain the determinants of Singaporean, American, and Taiwanese housing markets, respectively, varying from real estate investment trust returns to the growth rate. Aqsha and Masih (2018) employ ARDL cointegration and determine high positive impacts on inflation and GDP, low influence of interest rate, and no effect of MYRUSD exchange rate on Malaysian house prices. Chen and Cheng (2017) provide evidence for interest rate and real income growth as the sources of price-to-income ratio volatility. In contrast, Coskun and Umit (2016) find no empirical evidence for Maki cointegration among RHPI, stock market index returns, foreign exchange rate of U.S. Dollar to Turkish Lira, gold price, and deposit interest rates. Hepsen and Vatansever (2012) find positive cointegrating linkages among Dubai residential property price index, gold prices, direct foreign trade volume, and adverse influence on the number of completed residential units.

### *4.3. Bubble Definition and Measurement*

The definition of the bubble term is not universally accepted (Kim, 2004). The term "bubble," implying inflated and fragile prices, originates from the dramatic increase in South Sea Company stocks in England in 1720. More recently, Kindleberger (1987) defines bubbles as a continuous upsurge in asset price, with expectations of further rises causing new purchases. However, individual scholars tend to focus more narrowly on a single specific aspect of this conceptual framework, including sudden price increases (Baker, 2002), unrealistic future price increase expectations (Case and Shiller, 2003 and Stiglitz, 1990), significant price down surges during bubble busts (Siegel, 2003), and increases of difference between prices and fundamental values (Garber, 2000; Flood and Hodrick, 1990).

Among numerous studies concentrating on the timing and magnitude of bubbles are Hui and Yue (2006), Jiang, Song and Liu (2011), Barrell, Kirby and Riley (2004), and Tomfort (2017), who respectively estimate housing prices bubbles of over 20% in Shanghai, over 25% in Perth, above 30% in the UK, and over 100% in Japan. Similarly, Case and Shiller (2003) exhibit that, between 1985 and 2022, the price-to-income ratios for US states surpassed their long-term average by at least 20%, especially in the early 90s. In addition, Black, Fraser and Hoesli (2006) present a price convergence framework based on the present value technique to determine whether UK housing prices depart from fundamentals between 1973:Q4 and 2004:Q3, finding out overvaluations up to 25% as of September 2004. Besides, Hou (2010) finds bubble formations of approximately 30% and 40% in 2005 and 2007, respectively, in Beijing.

Tomfort (2017) and Tomfort (2012) employ DCF and ARDL cointegration in measuring the separation between house prices and its several fundamentals. Da Nóbrega Besarria, Paes and Silva (2018) determine bubble formations in Brazilian housing prices through the Gregory-Hansen cointegration approach. Anundsen (2019) discovers that price exuberances which are the separation between observed and fundamental housing prices in the United States may be linked to subprime mortgages during the 2000s. Caspi (2016) employs GSADF to demonstrate the absence of a housing bubble scheme, although the expansions of the fundamentals, namely, rent prices and interest rates, support the latest housing price upsurge. Liu et al. (2017) examine the current price appreciations in China and reveal that recent overvaluations are much smaller than in 1980s Japan, thus helping to allay fears of a severe housing price bubble in China.

### *4.4. Studies on The Turkish Real Estate Market*

Studies on the Turkish experience employ various approaches, including vector autoregression (VAR), Granger causality, variance decomposition, impulse response functions, and multiple regression models. Ozcelebi (2011) reveals that the construction sector is sensitive to shocks in the macroeconomic variables, where an increase in the real GDP increases the construction activity. Interest rates adversely and the credit volume positively influence construction activity. Kargı (2013) investigates the linkages between economic growth and the Turkish construction industry and suggests that the growth process supports the construction industry in line with other developing countries. The study indicates that the construction sector is negatively correlated with inflation. Hepsen and Kalfa Bas (2009) exhibit that shocks to national income, interest rates, and mortgage loan volume positively impact housing market activities. Accordingly, the housing market's performance strongly influences the overall macroeconomy and growth.

Although there are numerous studies investigating the existence of a housing bubble in Turkey, the empirical evidence does not reveal the presence of a bubble. Erol

(2015) cannot detect any bubble formations between 2007:M07 and 2012:M12 through various ordinary least squares approaches by comparing the Spanish and the US bubble experience, supporting that the housing price increases are accordant with fundamentals. Binay and Salman (2008) compare Turkey's price-to-income and price-to-rent ratios to other countries, not detecting any bubble formations in Turkey and suggesting that the Turkish property market is relatively strong. Buyukduman (2014) examines Istanbul's three big districts through 25 years long dataset; however, the indicators do not imply a bubble presence in the Turkish real estate market. Coskun (2013) suggests that Turkey is less prone to real estate and securities crises compared to the US since the volume of primary and secondary markets is relatively low in Turkey.

Recent studies regarding Turkey determine or forecast housing prices with financial, macroeconomic, and housing-sector-related predictors, either combined or separately. Coskun and Jadevicius (2017) find noteworthy increases, with some potential overvaluations over 2010-2014; however, neither regression nor Right Tailed Augmented Dickey-Fuller (RTADF) estimates nor price-to-income and price-to-rent ratios exhibit bubble signals. Tunc (2020) focuses on the role of credit supply on house prices for Turkey and provides evidence that an expansion in credits has an imposing and significant influence on prices. Ceritoglu et al. (2019) focus on price exuberance periods through housing-sector-related factors via the GSADF approach. Vatansever, Demir and Hepsen (2019) employ autoregressive models in forecasting house prices among 196 districts in five Turkish cities. Finally, using the Bounds test, several ordinary least squares (OLS) approaches, and ARIMA models to investigate the determinants of housing prices, Coskun et al. (2020) provide empirical evidence for long-run cointegrating linkages among construction costs, house price indexes, housing rents, and mortgage rates. None of these outcomes could demonstrate any bubble formation in the case of Turkey.

Speculation over bubbles in the Turkish housing market has been triggered by unaffordable prices and high real price growth, especially from 2010 to 2017. Nevertheless, most academic studies failed to find any significant signs of bubble formation. Given this paradox, the aim of this study is threefold. First, this dissertation examines the determinants and the causes of the RHPI and rents in the long and short run, respectively. The second aim is to test, in particular, the existence of the bubble within the price convergence framework by using a comprehensive monthly data set in the Turkish housing market, accounting for the financial, housing-sector related, and macroeconomic predictors together. The final aim is to use alternative tests for identifying the presence of bubbles if any.

# CHAPTER 5: DATA AND METHODOLOGY

## *5.1. Data*

This study examines long-run linkages and bubble dynamics of house prices and rents by utilizing a data set extending from 2003 to 2019. The monthly dataset in this study includes 22 different financial, housing-sector-related, and macroeconomic variables. The data set consists of 204 monthly observations for 17 series and 51 quarterly observations for five series.

This study uses the minimum gross wage in real terms as a proxy for income, which is the core source of savings. In addition to their long-term savings, households may prefer financing a portion of their real estate purchase through credit at a favorable mortgage rate. There may be a bond between the unemployment rate and the housing supply due to temporary workers in the construction sector, especially during summer. The construction corporations' value and credibility may increase with the rising housing prices, affecting the share price of real estate investment trusts and the XMGYO index. In addition, highly credible construction corporations can also use loans for housing projects. Due to the recent depreciation of the Turkish Lira against the US Dollar, households tend to use the US dollar as an alternative investment tool in the same way they use gold. However, the dollar directly influences construction costs, reflecting costs in rental and housing prices. Investors consider the price-to-income and price-to-rent ratios when buying or renting the property.

The data for the REIDIN TR7 Housing Price Index starts from 2003. Among studies examining Turkish housing dynamics, the current one is one of the most extended periods spanning from 2003 to 2019, with 204 monthly observations. The real housing price index (RHPI) and the rent prices (RR) include seven major Turkish cities: Adana, Ankara, Antalya, Bursa, Izmir, Istanbul, and Kocaeli. These seven cities alone account for 42.37% of Turkey's population (Turkish Statistical Institute, 2020). This study excludes 2020 from the data set due to imbalances in house and rent prices in the COVID-19 pandemic, fluctuations in mortgage rates, and a substantial earthquake in Izmir (30 October 2020). Izmir has a significant influence, as the third most populous province in Turkey, with 12.41% of the total population of the seven cities in the sample (Turkish Statistical Institute, 2020).

The data set contains 21 predictors impacting both supply and demand sides of property values. The purposes of choosing this data set in this research are as follows:

- The consumer's price index positively contributes to the real housing price index,
- since the construction sector is the driving force of GDP in Turkey, this dissertation includes real GDP and growth rate,
- industrial production index and real gross minimum wage as a proxy for income,
- household debt-to-GDP ratio as a housing affordability indicator,
- price-to-income ratio, and price-to-rent ratio as housing affordability and price bubble indicators,
- BIST100, gold prices, USDTRY foreign exchange rate, and XMGYO index as alternative investment instruments,
- credit growth rate, homeownership rate, mortgage rates, real credit volume, rental prices, unemployment rate, and youth unemployment rate as demand-side predictors,
- building permits per $km^2$, and real construction costs as supply-side predictors.

This study uses various data sources for the quarterly and monthly time series (see Table 14 for variable definition). First, REIDIN provided the RHPI and average rent price series, i.e., the model's dependent variables and the price-to-rent ratio, one of the independent variables. Second, this dissertation uses the house price index and average household disposable income to construct monthly aggregate price-to-income ratios. Third, The Central Bank of the Republic of Turkey's (CBRT) EDDS Data Central was the source of the following data: BIST100 index closing prices, construction cost index, credit growth rate, credit volume (in a million Turkish Liras), Republican gold sale price (TRY/piece), industrial production index, the foreign exchange rate of US Dollar to Turkish Lira in terms, and mortgage rates. Fourth, Bloomberg and the Ministry of Family, Labor, and Social Security were the sources of the XMGYO Index closing prices and the gross minimum wage. In addition, the Turkish Statistical Institute provided the data for the consumer's price index, the growth rate, unemployment level, and youth unemployment rate. Finally, Bank for International Settlements, FRED, and EUROSTAT provide household debt to GDP ratio, GDP, and homeownership rates.

This study employs the cubic spline interpolation approach to maintain the monthly values for the credit growth rate, credit volume, GDP, growth rate, homeownership rate, household debt to GDP ratio, and youth unemployment rate. The rest of the series has a monthly frequency. The series has natural logarithmic forms to impose elasticity except for credit growth, growth rate, and mortgage rates. This study deflates the construction cost index, credit volume, foreign exchange rate of US Dollar to Turkish Lira, GDP, gross minimum wage, the housing price index, gold price, gross minimum wage, rent, and rent price series via consumer price indices.

Figure 12 presents 17 different monthly time series included in this dissertation between 2003 and 2019.

Figure 12 presents structural breaks for the dependent variables employed in the ARDL approach: the real housing price index and real rents. Therefore, this study employs Lee-Strazicich (2003) unit root tests for dependent variables in the ARDL model to test for multiple structural breaks.

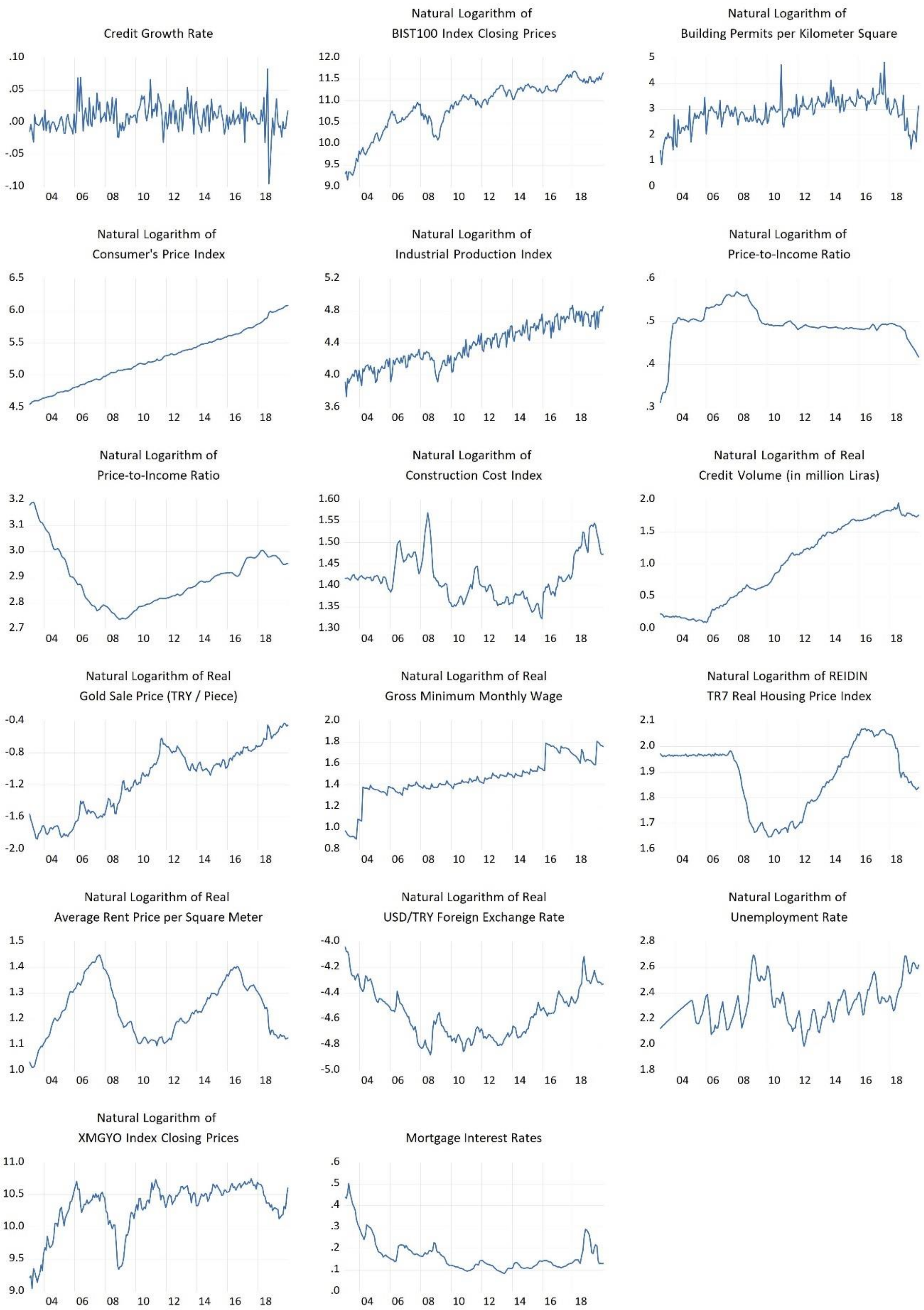



Figure 12. An Illustration of Monthly Variables Included in The Study

Figure 13 exhibits seven different quarterly and yearly time series included in the study between 2003 and 2019.

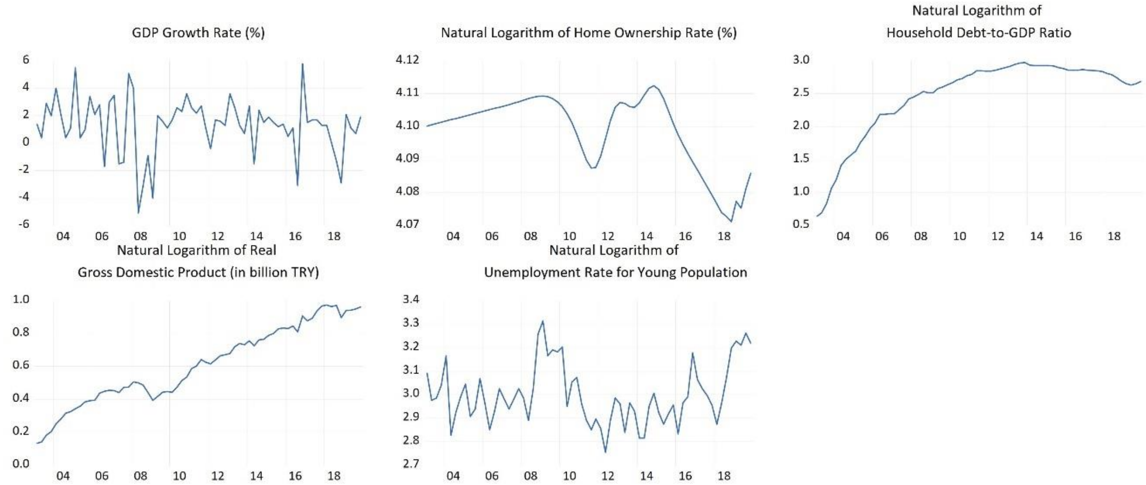



Figure 13. An Illustration of Quarterly Variables Included in The Study

Table 1 exhibits the descriptive statistics of data employed in the study.

Table 1. Descriptive Statistics

| Variable | Mean | Median | Max. | Min. | Std. Dev. | Skewness | Kurtosis | J-B |
|---|---|---|---|---|---|---|---|---|
| *lncpi* | 5.27 | 5.24 | 6.09 | 4.55 | 0.41 | 0.15 | 2.05* | 8.48[a] |
| *lngdp* | 0.60 | 0.61 | 0.98 | 0.13 | 0.24 | -0.06*** | 1.95* | 9.48[a] |
| *gr* | 1.28 | 1.41 | 6.09 | -5.63 | 1.96 | -0.73*** | 4.37** | 34.18[a] |
| *lnipi* | 4.37 | 4.37 | 4.80 | 3.86 | 0.26 | 0.04 | 1.70* | 14.32[a] |
| *lngmw* | 1.46 | 1.44 | 1.78 | 0.91 | 0.19 | -0.73*** | 4.51** | 37.43[a] |
| *lnhdtgbp* | 2.46 | 2.70 | 2.98 | 0.64 | 0.61 | -1.59*** | 4.62** | 108.29[a] |
| *lnu* | 2.31 | 2.29 | 2.65 | 2.06 | 0.14 | 0.72 | 2.85* | 17.86[a] |
| *cgr* | 0.01 | 0.01 | 0.08 | -0.09 | 0.02 | -0.16*** | 8.65** | 271.93[a] |
| *lncv* | 1.01 | 1.10 | 1.93 | 0.10 | 0.63 | -0.08*** | 1.45* | 20.70[a] |
| *lnyu* | 3.00 | 2.97 | 3.28 | 2.83 | 0.11 | 0.86 | 3.09** | 25.26[a] |
| *lnbist100* | 10.86 | 11.03 | 11.69 | 9.16 | 0.59 | -0.97*** | 3.27** | 32.31[a] |
| *lnrg* | -1.14 | -1.01 | -0.43 | -1.87 | 0.42 | -0.25*** | 1.77* | 15.00[a] |
| *lnru* | -4.56 | -4.56 | -4.04 | -4.88 | 0.19 | 0.45 | 2.31* | 10.99[a] |
| *lnx* | 10.30 | 10.42 | 10.75 | 9.05 | 0.39 | -1.48*** | 4.48** | 93.54[a] |
| *lnbpkm2* | 2.88 | 2.93 | 4.93 | 1.05 | 0.53 | -0.42*** | 4.52** | 25.55[a] |
| *lnho* | 4.10 | 4.10 | 4.11 | 4.07 | 0.01 | -1.04*** | 2.90* | 36.81[a] |
| *lnpr* | 2.89 | 2.88 | 3.18 | 2.74 | 0.11 | 0.70 | 3.06** | 16.51[a] |
| *lncc* | 1.42 | 1.41 | 1.55 | 1.34 | 0.05 | 0.65 | 2.62* | 15.48[a] |
| *lnhpi* | 1.89 | 1.96 | 2.07 | 1.65 | 0.13 | -0.49*** | 1.91* | 18.17[a] |
| *lnrr* | 1.23 | 1.22 | 1.44 | 1.02 | 0.11 | 0.15 | 1.96* | 10.05[a] |
| *lnpi* | 0.49 | 0.49 | 0.57 | 0.31 | 0.04 | -1.59*** | 8.49** | 341.95[a] |
| *mir* | 0.17 | 0.14 | 0.50 | 0.08 | 0.08 | 1.96*** | 7.05** | 270.70[a] |

Notes to Table 1: Std. Dev., max., min., and J-B denote standard deviation, maximum, minimum, and Jarque-Bera. Table 14 describes the definitions of the variables. Superscripts *, **, ***, and a represent platykurtic, leptokurtic variables, variables with negatively skewed distributions, and variables without normal distributions.

Table 1 presents those eleven variables are leptokurtic, and the rest are platykurtic with thinner tails. Besides, fourteen of the series' distributions have a long-left tail. The standard deviation-to-mean (coefficient of variation) statistics illustrate some disparity for real gold prices that these series are highly volatile compared to the rest of the financial series. However, Jarque-Bera statistics reveal that neither series exhibits a normal distribution.

### *5.2. Preliminary Analysis*

#### *5.2.1. Identifying and Removing Seasonal Patterns Through X-13 ARIMA-SEATS*

This dissertation employs the X13 ARIMA-SEATS approach to determine identifiable seasonality and eliminate seasonal patterns. However, this methodology cannot identify seasonality for series with zero or negative values, and this approach is not applicable for the credit growth rate and growth rate series. In addition, this study does not seasonally adjust these two series because the QS, Friedman, Kruskal-Wallis, and F-test on seasonal dummies cannot identify seasonal patterns for credit growth rate and growth rate. Table 2 presents the results.

Table 2. Traditional Seasonality Test Results

| Variable | QS | Friedman | KW | F |
|---|---|---|---|---|
| *cgr* | 0.00 | 3.26 | 4.28 | 0.55 |
| *gr* | 0.00 | 2.49 | 4.19 | 2.09 |

Notes to Table 2: cgr and gr denote credit growth rate, and growth rate, respectively. QS, Friedman, KW, and F denote statistics for seasonal autocorrelation, Friedman stable seasonality test, Kruskal-Wallis test, and statistical test for seasonal stability correspondingly. The null hypothesis for both four tests is no seasonality effect in the series. According to Maravall (2012), critical values are 3.83 and 7.09 for the QS test; 10.57 and 13.62 for Friedman (1937); 7.82 and 11.35 with 3 degrees of freedom for Kruskal and Wallis (1952); 2.75 and 4.10 for quarterly series on F-test with 95% and 99% confidence levels, respectively.

X-13 ARIMA-SEATS includes a test of 3 different combinations to identify seasonality. Table 3, Table 4, and Table 5 present the traditional F-test, Kruskal-Wallis, and the moving seasonality test results.

Table 3. Test for the Presence of Seasonality Assuming Stability in the Original Series

| Variable | Sum of Squares (Between periods) | Mean Square (Between periods) | Sum of Squares (Residual) | Mean Square (Residual) | Sum of Squares (Total) | Degrees of Freedom (Total) | F-Value |
|---|---|---|---|---|---|---|---|
| *lnhpi* | 11.58 | 1.05 | 24.51 | 0.13 | 36.09 | 203 | 8.25*** |
| *lnpi* | 5.46 | 0.50 | 138.81 | 0.72 | 144.27 | 203 | 0.69 |
| *lnpr* | 2.97 | 0.27 | 2.86 | 0.15 | 5.83 | 203 | 18.18*** |
| *lncv* | 801.39 | 72.85 | 2513.21 | 13.09 | 3314.60 | 203 | 5.57*** |
| *lnrg* | 311.17 | 28.29 | 2855.25 | 14.87 | 3166.42 | 203 | 1.9 |
| *lngmw* | 189.66 | 17.24 | 738.32 | 3.85 | 927.98 | 203 | 4.48*** |
| *lnrr* | 70.83 | 6.44 | 45.80 | 0.24 | 116.64 | 203 | 26.99*** |
| *lnru* | 6.24 | 0.57 | 72.71 | 0.38 | 78.95 | 203 | 1.50 |
| *lnu* | 1347.83 | 122.53 | 268.39 | 1.40 | 1616.22 | 203 | 87.66*** |
| *lnx* | 16.13 | 1.47 | 89.66 | 0.47 | 105.79 | 203 | 3.14*** |
| *mir* | 1415.58 | 128.69 | 5230.37 | 27.24 | 6645.95 | 203 | 4.72*** |
| *lngdp* | 142.48 | 12.95 | 203.08 | 1.06 | 345.57 | 203 | 12.25*** |
| *lncpi* | 0.03 | 0.00 | 1.10 | 0.01 | 1.12 | 203 | 0.46 |
| *lnipi* | 4.33 | 0.39 | 136.03 | 0.71 | 140.35 | 203 | 0.56 |
| *lnhdtgdp* | 1.58 | 0.14 | 21.69 | 0.11 | 23.27 | 203 | 1.27 |
| *lnyu* | 6.64 | 0.60 | 68.34 | 0.36 | 74.98 | 203 | 1.70 |
| *lnbist100* | 4.64 | 0.42 | 67.47 | 0.35 | 72.11 | 203 | 1.20 |
| *lnbpkm2* | 752.09 | 68.37 | 11436.20 | 59.56 | 12188.29 | 203 | 1.15 |
| *lnho* | 0.00 | 0.00 | 0.02 | 0.00 | 0.02 | 203 | 1.92 |
| *lncc* | 1.18 | 0.11 | 35.86 | 0.19 | 37.05 | 203 | 0.58 |

Notes to Table 3: Table 14 describes the definitions of the variables. The table notifies whether there is stable seasonality in the time series. Superscript *** denotes the rejection of the null hypothesis at 1% level. The F-test's critical values are 1.84 and 2.34, respectively, with 95% and 99% confidence levels. The decision is made based on the F-test for the presence of seasonality, assuming stability testing for three possible outcomes: (i) identifiable seasonality, (ii) possible identifiable seasonality, (iii) non-presence of identifiable seasonality. The degrees of freedom between months is 11, and the degrees of freedom for residuals is 192.

Table 4. Nonparametric Test for the Presence of Seasonality Assuming Stability in the Original Series

| Variable | Kruskal–Wallis Statistic | Degrees of Freedom | Probability Level |
|---|---|---|---|
| *lnhpi* | 74.03*** | 11 | 0.00 |
| *lnpi* | 2.09 | 11 | 1.00 |
| *lnpr* | 106.14*** | 11 | 0.00 |
| *lncv* | 92.04*** | 11 | 0.00 |
| *lnrg* | 12.47 | 11 | 0.33 |
| *lngmw* | 56.03*** | 11 | 0.00 |
| *lnrr* | 129.81*** | 11 | 0.00 |
| *lnru* | 20.58** | 11 | 0.03 |
| *lnu* | 172.01*** | 11 | 0.00 |
| *lnx* | 39.47*** | 11 | 0.00 |
| *mir* | 50.01*** | 11 | 0.00 |
| *lngdp* | 96.15*** | 11 | 0.00 |
| *lncpi* | 1.28 | 11 | 1.00 |
| *lnipi* | 2.88 | 11 | 0.99 |
| *lnhdtgdp* | 41.41*** | 11 | 0.00 |
| *lnyu* | 15.28 | 11 | 0.17 |
| *lnbist100* | 19.89** | 11 | 0.05 |
| *lnbpkm2* | 4.54 | 11 | 0.95 |
| *lnho* | 15.93 | 11 | 0.14 |
| *lncc* | 7.66 | 11 | 0.74 |

Notes to Table 4: Table 14 describes the definitions of the variables. The null hypothesis for the Kruskal-Wallis test is based on the non-existence of the seasonality effect in the series. Superscript *** denotes the rejection of the null hypothesis at 1% level. According to Kruskal and Wallis (1952), critical values for 11 degrees of freedom are 19.68 and 24.73, respectively, with 95% and 99% confidence levels.

Table 5. F-Test for Moving Seasonality and Identifiable Seasonality Results in the Original Series

| Variable | Sum of Squares (Between years) | Mean Square (Between years) | Sum of Squares (Error) | Mean Square (Error) | F-Value | Identifiable Seasonality |
|---|---|---|---|---|---|---|
| *lnhpi* | 5.16 | 0.32 | 11.43 | 0.06 | 4.97*** | Y |
| *lnpi* | 54.87 | 3.43 | 41.05 | 0.23 | 14.70*** | N |
| *lnpr* | 0.91 | 0.06 | 1.1 | 0.01 | 9.06*** | Y |
| *lncv* | 1049.63 | 65.6 | 1118.48 | 6.35 | 10.32*** | Y |
| *lnrg* | 346.87 | 21.68 | 1231.58 | 7 | 3.10*** | N |
| *lngmw* | 151.82 | 9.49 | 390.92 | 2.22 | 4.27*** | Y |
| *lnrr* | 3.95 | 0.25 | 24.15 | 13.72 | 1.80** | Y |
| *lnru* | 7.11 | 0.44 | 29.99 | 0.17 | 2.61*** | N |
| *lnu* | 82.34 | 5.15 | 156.9 | 0.89 | 5.77*** | Y |
| *lnx* | 12.63 | 0.79 | 31.03 | 0.18 | 4.48*** | N |
| *mir* | 1542.76 | 96.42 | 1842.89 | 10.47 | 9.21*** | N |
| *lngdp* | 31.86 | 1.99 | 78.63 | 0.45 | 4.46*** | N |
| *lncpi* | 0.14 | 0.01 | 0.49 | 0.00 | 3.21*** | N |
| *lnipi* | 4.95 | 0.31 | 69.29 | 0.39 | 0.79 | N |
| *lnhdtgdp* | 9.09 | 0.57 | 9.15 | 0.05 | 10.93*** | N |
| *lnyu* | 13.94 | 0.87 | 23.63 | 0.13 | 6.49*** | N |
| *lnbist100* | 10.00 | 0.62 | 22.21 | 0.13 | 4.95*** | N |
| *lnbpkm2* | 1274.24 | 79.64 | 6520.40 | 37.05 | 2.15*** | N |
| *lnho* | 0.01 | 0.00 | 0.01 | 0.00 | 6.65*** | N |
| *lncc* | 4.03 | 0.25 | 14.72 | 0.08 | 3.01*** | N |

Notes to Table 5: Table 14 describes the definitions of the variables. The null hypothesis for F-test is based on the non-existence of the seasonality effect in the series. Superscripts *** and ** denote the rejection of the null hypothesis at 1% and 5% levels, respectively. The F-test's critical values are 1.70 and 2.10, respectively, with 95% and 99% confidence levels. Thus, if the first two tests signal stable seasonality and the third test shows no moving seasonality, then identifiable seasonality is confirmed. The degrees of freedom between years is 16, and the degrees of freedom for errors is 176.

This study determines identifiable seasonality through the X-13 ARIMA-SEATS approach in all six-time series shown in Table 3, Table 4, and Table 5.

Checking residual seasonality enables us to validate that the adjustment procedure removed seasonal patterns from the series. The seasonally adjusted series should not include any residual seasonality or calendar effects signals, and the test is parallel to detecting identifiable seasonality in the unadjusted series. The null hypothesis is that the adjusted series does not include seasonal patterns. Table 6 presents the results of seasonality for seasonally adjusted series.

Table 6. Test for the Presence of Seasonality in the Seasonally Adjusted Series

| Variable | F-stat on residual seasonality in the entire series | F-stat residual seasonality in the last three years |
|---|---|---|
| *lnhpi* | 0.04 | 0.17 |
| *lnpr* | 0.04 | 0.38 |
| *lncv* | 0.13 | 0.22 |
| *lngmw* | 0.57 | 1.03 |
| *lnrr* | 0.05 | 0.17 |
| *lnu* | 0.17 | 0.18 |

Notes to Table 6: Table 14 describes the definitions of the variables. The null hypothesis for F-test is based on the non-existence of seasonality patterns in the adjusted series. The F-test's critical values are 2.31 and 3.29, respectively, with 95% and 99% confidence levels.

The results in Table 6 show no signs of residual seasonality in the entire seasonally adjusted series and the last three years of the series.

### *5.2.2. Unit Root Tests*

This thesis employs seven different unit root test approaches, including;

- Augmented Dickey-Fuller (ADF) test by Mac Kinnon (1996),
- Phillips-Perron (1988),
- Kwiatkowski et al. (1992),
- Dickey-Fuller-GLS (DF-GLS) by Mac Kinnon (1996) and Elliot, Rothenberg and Stock (1996),
- Elliot, Rothenberg and Stock (1996),
- Ng-Perron (2001), and
- Lee-Strazicich (2003) unit root tests.

However, this study employs Lee-Strazicich unit root tests only for dependent variables in the ARDL model to test for one/two structural break(s). Table 7.a and Table 7.b present the evaluation of the unit root test results, whereas the tables in the Appendix section give the test statistics in detail.

Table 7.a. Summary of The Unit Root Test Results

| Variables | ADF Unit Root Tests | | PP Unit Root Tests | | KPSS Unit Root Tests | | DF-GLS Unit Root Tests | |
|---|---|---|---|---|---|---|---|---|
| | Model: Intercept | Model: Trend & Intercept | Model: Intercept | Model: Trend & Intercept | Model: Intercept | Model: Trend & Intercept | Model: Intercept | Model: Trend & Intercept |
| *lnbist100* | I (1) | I (1) | I (1) | I (1) | I (1) | I (1) | I (1) | I (1) |
| *lnbpkm2* | I (0) | I (1) | I (0) | I (0) | I (0) | I (0) | I (2) | I (2) |
| *lncpi* | I (1) | I (1) | I (1) | I (1) | I (0) | I (0) | I (0) | I (1) |
| *lngdp* | I (2) | I (0) | I (2) | I (2) | I (1) | I (0) | I (0) | I (2) |
| *gr* | I (0) | I (0) | I (0) | I (0) | I (0) | I (0) | I (0) | I (0) |
| *lnho* | I (2) | I (2) | I (2) | I (2) | I (2) | I (1) | I (0) | I (0) |
| *lnhdtgdp* | I (0) | I (0) | I (0) | I (0) | I (0) | I (0) | I (1) | I (2) |
| *lnipi* | I (1) | I (1) | I (1) | I (0) | I (0) | I (2) | I (2) | I (2) |
| *lnpr* | I (0) | I (0) | I (1) | I (0) | I (1) | I (0) | I (1) | I (2) |
| *lncc* | I (1) | I (1) | I (1) | I (1) | I (2) | I (0) | I (1) | I (1) |
| *lnrg* | I (1) | I (1) | I (1) | I (1) | I (1) | I (1) | I (2) | I (1) |
| *lngmw* | I (1) | I (1) | I (1) | I (1) | I (0) | I (2) | I (1) | I (1) |
| *lnhpi* | I (1) | I (1) | I (1) | I (1) | I (2) | I (0) | I (1) | I (1) |
| *lnrr* | I (1) | I (1) | I (1) | I (1) | I (2) | I (2) | I (1) | I (2) |
| *lnru* | I (1) | I (1) | I (1) | I (1) | I (0) | I (1) | I (1) | I (1) |
| *lnu* | I (1) | I (1) | I (1) | I (1) | I (0) | I (2) | I (1) | I (1) |
| *cgr* | I (0) | I (0) | I (0) | I (0) | I (1) | I (1) | I (0) | I (0) |
| *lncv* | I (1) | I (1) | I (1) | I (1) | I (2) | I (1) | I (1) | I (1) |
| *lnpi* | I (0) | I (0) | I (0) | I (0) | I (0) | I (2) | I (2) | I (1) |
| *lnx* | I (1) | I (1) | I (1) | I (1) | I (1) | I (0) | I (1) | I (1) |
| *lnyu* | I (1) | I (1) | I (1) | I (1) | I (2) | I (0) | I (1) | I (1) |
| *mir* | I (0) | I (0) | I (0) | I (1) | I (1) | I (1) | I (1) | I (1) |

Notes to Table 7.a: Table 14 describes the definitions of the variables. ADF, PP, KPSS, and DF-GLS denote Augmented Dickey-Fuller, Phillips-Perron, Kwiatkowski-Phillips-Schmidt-Shin, and modified Augmented Dickey-Fuller-GLS unit root tests, respectively. The null hypothesis is the existence of a unit root for ADF, PP, and DF-GLS unit root tests and no unit root for the KPSS unit root test.

The results in Table 7.b exhibit that five variables are integrated of order zero, and 15 variables are integrated of order one. In addition, the homeownership rate and the natural logarithm of gross domestic product in real terms are integrated into order two, i.e., I (2). Accordingly, this research eliminates these two series since I (2) variables are not applicable in the ARDL model.

Table 7.b. Summary of The Unit Root Test Results

| Variables | ERS Point Optimal Unit Root Tests | | Ng-Perron Modified Unit Root Tests | | I (0) | I (1) | I (2) | Result |
|---|---|---|---|---|---|---|---|---|
| | Model: Intercept | Model: Trend & Intercept | Model: Intercept | Model: Trend & Intercept | | | | |
| *lnbist100* | I (1) | I (1) | I (1) | I (1) | 0 | 12 | 0 | I (1) |
| *lnbpkm2* | I (1) | I (1) | I (2) | I (2) | 5 | 3 | 4 | I (0) |
| *lncpi* | I (1) | I (1) | I (1) | I (1) | 3 | 9 | 0 | I (1) |
| *lngdp* | I (2) | I (2) | I (2) | I (2) | 3 | 1 | 8 | I (2) |
| *gr* | I (0) | I (0) | I (0) | I (0) | 12 | 0 | 0 | I (0) |
| *lnho* | I (0) | I (0) | I (0) | I (0) | 5 | 1 | 6 | I (2) |
| *lnhdtgdp* | I (2) | I (2) | I (2) | I (2) | 6 | 1 | 5 | I (0) |
| *lnipi* | I (1) | I (1) | I (2) | I (2) | 2 | 5 | 5 | I (1) |
| *lnpr* | I (1) | I (2) | I (1) | I (2) | 4 | 5 | 3 | I (1) |
| *lncc* | I (1) | I (1) | I (1) | I (1) | 1 | 10 | 1 | I (1) |
| *lnrg* | I (1) | I (1) | I (2) | I (1) | 0 | 10 | 2 | I (1) |
| *lngmw* | I (1) | I (1) | I (2) | I (1) | 2 | 9 | 1 | I (1) |
| *lnhpi* | I (1) | I (1) | I (1) | I (1) | 1 | 10 | 1 | I (1) |
| *lnrr* | I (1) | I (2) | I (1) | I (2) | 0 | 7 | 5 | I (1) |
| *lnru* | I (1) | I (1) | I (1) | I (1) | 1 | 11 | 0 | I (1) |
| *lnu* | I (1) | I (0) | I (1) | I (1) | 2 | 9 | 1 | I (1) |
| *cgr* | I (0) | I (0) | I (0) | I (0) | 10 | 2 | 0 | I (0) |
| *lncv* | I (1) | I (1) | I (1) | I (1) | 0 | 11 | 1 | I (1) |
| *lnpi* | I (2) | I (2) | I (2) | I (2) | 6 | 1 | 5 | I (0) |
| *lnx* | I (1) | I (1) | I (1) | I (1) | 1 | 11 | 0 | I (1) |
| *lnyu* | I (1) | I (1) | I (2) | I (2) | 1 | 8 | 3 | I (1) |
| *mir* | I (1) | I (1) | I (1) | I (1) | 3 | 9 | 0 | I (1) |

Notes to Table 7.b: Table 14 describes the definitions of the variables. ERS denotes Elliot-Rothenberg-Stock. The null hypothesis is the existence of unit root for ERS, Ng-Perron unit root tests.

Table 8 presents the Lee-Strazicich unit root test results with one structural break.

Table 8. LS Unit Root Tests of Data for Model C

| | Level | | First Difference | |
|---|---|---|---|---|
| Variable | Test Statistics | Breakpoint | Test Statistics | Breakpoint |
| *lnhpi* | -2.90 | 2011M12 | -5.02*** | 2011M04 |
| *lnrr* | -2.56 | 2010M07 | -4.20* | 2011M04 |

Notes to Table 8: lnhpi and lnrr denote the natural logarithms of the real housing price index and real rents. The null hypothesis is the existence of a unit root with one structural break. Critical values for models taken from Lee and Strazicich (2003) are -4.82, -4.26, and -3.99 for 1%, 5%, and 10% significance levels in Model C, respectively. The signs ***, **, * indicate a structural break at 1%, 5%, and 10% significance levels, respectively. Akaike Information Criterion (AIC) is employed to confirm the results.

Table 9 indicates the Lee-Strazicich unit root test results with two structural breaks.

Table 9. LS Unit Root Tests with Two Structural Breaks for Model C

| Variable | Level | | | First Difference | | |
|---|---|---|---|---|---|---|
| | Lags | Test Statistics | Breakpoint | Lags | Test Statistics | Breakpoint |
| *lnhpi* | 5 | -4.20 | 2009M06 & 2015M03 | 7 | -5.79* | 2008M08 & 2011M04 |
| *lnrr* | 6 | -3.46 | 2009M09 & 2014M07 | 2 | -5.52* | 2007M07 & 2016M03 |

Notes to Table 9: lnhpi and lnrr denote the natural logarithms of the real housing price index and real rents. The null hypothesis is the existence of a unit root with two structural breaks. Critical values for models taken from Lee and Strazicich (2003) are -6.41, -5.85, and -5.51 for 1%, 5%, and 10% significance levels in Model C, respectively. The signs ***, **, * indicate two structural breaks in the series at 1%, 5%, and 10% significance levels, respectively. Akaike Information Criterion (AIC) is employed to confirm the results.

The results in Table 8 and Table 9 illustrate stationarity conditions with two structural breaks in 2008:M08 and 2011:M04 for the real housing price index (RHPI) and 2007:M07 2016:M03 for real rent (RR) series' first differences, respectively.

### *5.3. Feature Selection Through Unit Root Tests and Best Subset Selection Algorithm*

After eliminating two predictors, namely, the homeownership rate and the natural logarithm of gross domestic product in real terms, this dissertation employs the best subset selection algorithm by Wen et al. (2019). The algorithm finds better fitting subsets than other algorithms, though it includes an exhaustive search with branching-and-bounding. The main task of the best subset selection algorithm is to fit a distinct ordinary least squares regression for each probable combination of the independent variables.

The algorithm has two stages: First, the algorithm exhaustively calculates all fitting models with k number of independent variables. Second, it chooses a unique model by cross-validating prediction error. This dissertation employs the best subset selection algorithm and selects the model based on testing error estimates with the highest adjusted R2 and lowest residual sum of squares (RSS).

The best subset selection algorithm identifies 11 predictors in determining the real housing price index, which are growth rate, natural logarithms of price-to-income ratio, price-to-rent ratio, real credit volume, real gold price, real gross minimum wage, real rent price per $m^2$, the real foreign exchange rate of US Dollar to Turkish Lira, level of unemployment, XMGYO Index closing prices and mortgage rates.

The minimum number of predictors is 11. These predictors are the most informative in determining the real housing price index. The highest adjusted $R^2$ is close to 1, and the lowest RSS is 0.00042445. Figure 14 illustrates the adjusted $R^2$ according to the selected variables. The black and white boxes exhibit the selected and eliminated variables, respectively.

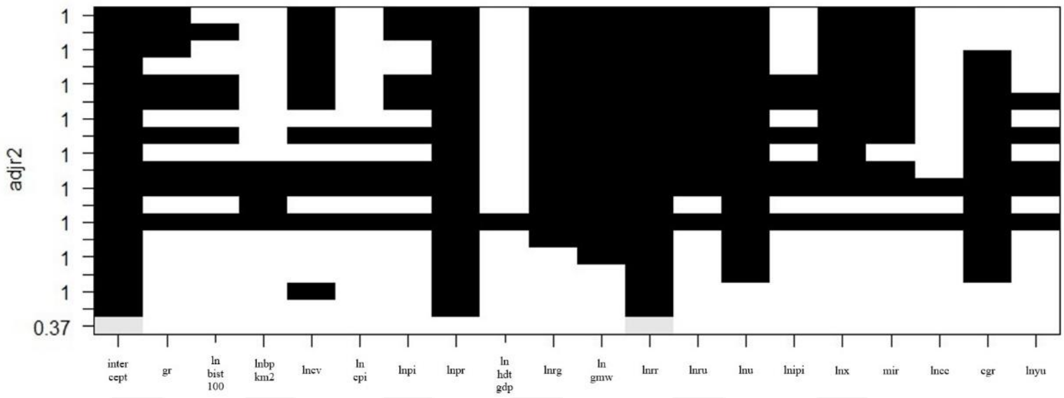



Figure 14. Adjusted R-Squared Levels Through the Best Subset Selection Algorithm

Figure 15 presents the changes in RSS value as the number of variables included in the model increases.

The best subset selection algorithm eliminates the following variables in explaining the linear relationship between the real house price index and its predictors: credit growth rate, the natural logarithm of building permits per $km^2$, consumer’s price index, household debt-to-GDP ratio, industrial production index, youth unemployment rate; and surprisingly, the natural logarithm of BIST100 Index closing prices, real construction costs.

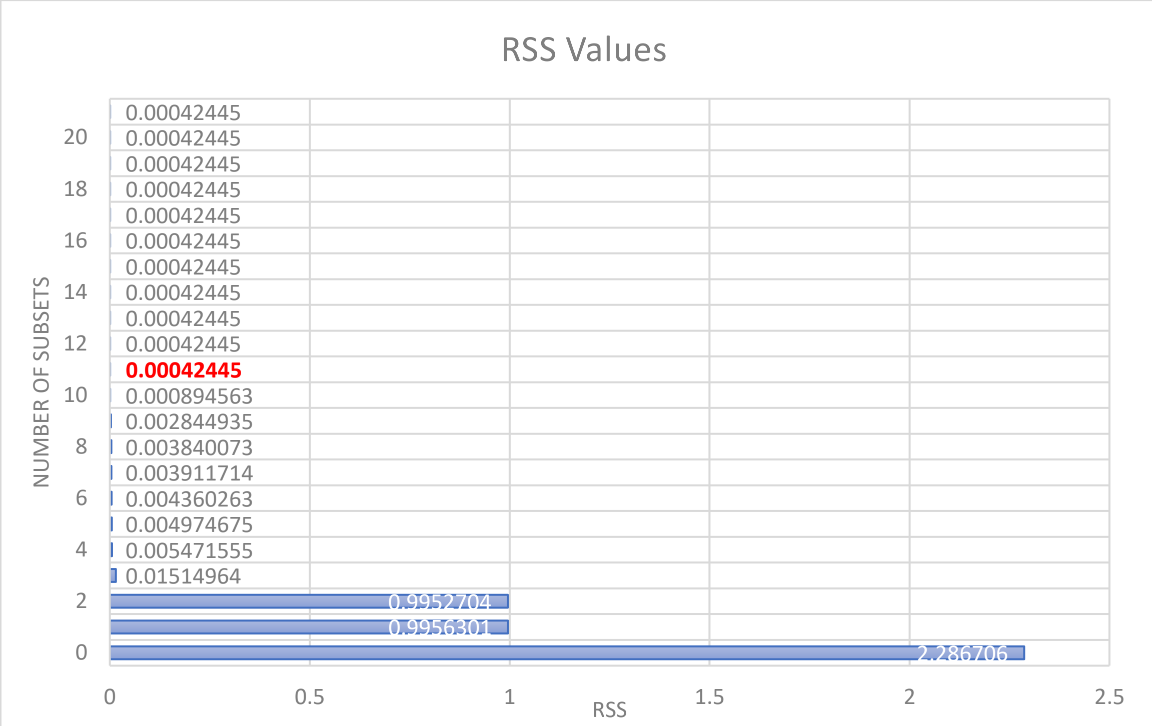


Figure 15. Level of RSS Through Best Subset Selection Algorithm

As seen in Figure 15, RSS reaches its minimum value in the 11th predictor, consistent with the maximum adjusted $R^2$ condition that there are 11 series except for the intercept outcome.

### *5.4. The Correlation Matrix*

In an ordinary least squares (OLS) regression analysis, the variance inflation factor (VIF) measures the severity of multicollinearity. The rule of thumb presents multicollinearity problems where VIF is greater than 10. O'Brien (2007) is skeptical of the rule of thumb where VIF is greater than 10. When VIF reaches these threshold values, researchers often attempt to reduce the collinearity by eliminating one or more variables from their analysis, using Ridge Regression to analyze their data, or combining two or more independent variables into a single index. These techniques for curing problems associated with multicollinearity can create more severe problems than those they solve.

The ARDL long-run form and Bounds test and the Conditional Error Correction Model (CECM) by Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001) introduce diagnostic tests as follows:

- serial correlation tests with the assumption that disturbances are serially uncorrelated,
- the fit of regression tests against non-normal errors and heteroscedasticity,
- recursive estimation of the conditional ECM and the associated cumulative sum (CUSUM) and cumulative sum (CUSUM) of squares plots.

The studies presenting ARDL and CECM do not introduce VIF for diagnostic tests. However, VIF applies to the OLS approach. Indeed, this study employs the ARDL model with four maximum lags for dependent variables and regressors. Therefore, the lagged values of the dependent variable (autoregressive components) and the lagged values of the regressors among each other may increase the VIF levels in the ARDL and CECM model.

Due to the reasons above, this study employs a correlation matrix to present the statistical relationship between two variables and exhibit that neither of the variables has a substantial degree of accuracy between each other.

Table 10. Correlation Matrix of Data

| | lnhpi | lnrr | gr | lnpi | lnpr | lncv | lnrg | lngmw | lnru | lnu | lnx | mir |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lnhpi | 1.00 | 0.06 | -0.07 | 0.60 | 0.11 | -0.17 | 0.16 | 0.61 | 0.55 | -0.12 | 0.13 | 0.26 |
| lnrr | | 1.00 | -0.05 | 0.59 | -0.27 | 0.10 | -0.09 | 0.37 | -0.17 | -0.10 | 0.49 | -0.32 |
| gr | | | 1.00 | -0.09 | 0.13 | -0.09 | -0.08 | -0.09 | -0.03 | -0.19 | 0.18 | -0.14 |
| lnpi | | | | 1.00 | -0.67 | -0.22 | -0.21 | 0.15 | -0.52 | -0.07 | 0.27 | -0.40 |
| lnpr | | | | | 1.00 | 0.03 | -0.12 | -0.18 | 0.65 | -0.04 | -0.34 | 0.64 |
| lncv | | | | | | 1.00 | 0.68 | 0.67 | -0.04 | 0.35 | 0.58 | -0.52 |
| lnrg | | | | | | | 1.00 | 0.68 | -0.10 | 0.36 | 0.55 | -0.55 |
| lngmw | | | | | | | | 1.00 | -0.10 | 0.48 | 0.62 | -0.66 |
| lnru | | | | | | | | | 1.00 | 0.21 | -0.41 | 0.69 |
| lnu | | | | | | | | | | 1.00 | -0.02 | -0.12 |
| lnx | | | | | | | | | | | 1.00 | -0.68 |
| mir | | | | | | | | | | | | 1.00 |

Notes to Table 10: Table 14 describes the definitions of the variables.

### *5.5. The Model*

This section provides brief information about the model and the methodology investigating real housing price index (RHPI) and real rent (RR) dynamics and the search for the bubble possibilities.

This study develops its theoretical framework for long-term Turkish house price predictors and bubble dynamics through discounted cash flow, rational expectation theory, and the theory of demand and supply.

This thesis selects demand and supply theory to explain the long-run dynamics of housing prices and real rents; the quantities demanded and supplied in the given location determine the housing price in month t. This study employs the same demand and supply predictors in explaining RHPI and RR to investigate whether these two dependent variables have similar fundamentals. Previous studies modeling demand as a function of credit volume, gold prices, income (gross minimum wage as a proxy for income in this study), mortgage rates, price-to-income, price-to-rent, and rental prices include Yiu and Xu (2012), Coskun and Umit (2016), Holly and Jones (1997), Klyuev (2008), Chen and Cheng (2017), and Engsted and Pedersen (2015). Taking a different approach, DiPasquale and Wheaton (1994) describe the determinants of long-run equilibrium supply in an efficient market as a linear function of price. However, there is evidence that predictors, including growth rate, the foreign exchange rate of USDTRY, level of unemployment, and real estate investment trust returns, may still be significant determinants of housing supply (Aye et al. 2014; Bahmani-Oskooee and Wu, 2018; Chang, Chen and Leung, 2011; Irandoust, 2019; Bahmani-Oskooee and Ghodsi, 2018). Let $X_{d,t}$ and $X_{s,t}$ be the vector of demand and supply variables. The long-run demand and supply can be written as follows:

$$D_t = D(hpi_t, X_{s,t}) \tag{6}$$

$$S_t = S(hpi_t, X_{s,t}) \tag{7}$$

where $hpi_t$ denotes the RHPI in month $t$.

In the economic literature, Muellbauer and Murphy (1997) explain the linear house price index model as a set of supply and demand functions with the following equation:

$$hpi_t = f(X_{d,t}, X_{s,t}, Z_t) \tag{8}$$

where $Z_t$ indicates the various qualitative predictors influencing housing prices. Thus, the linear long-term RHPI equation can be formulated by using the aforementioned theoretical framework and combining equations from (6) to (8). According to the ARDL approach by Pesaran, Shin and Smith (2001), the variables in the linear symmetric equation explaining the housing price index and the rent prices are as follows:

$$hpi_t = \mathrm{F}(hpi_{t-p}, gr_{t-q}, pi_{t-q}, pr_{t-q}, cv_{t-q}, rg_{t-q}, gmw_{t-q}, rr_{t-q}, ru_{t-q}, u_{t-q}, x_{t-q}, mir_{t-\mathrm{q}}) \tag{9}$$

$$rr_t = \mathrm{F}(rr_{t-p}, gr_{t-q}, pi_{t-q}, pr_{t-q}, cv_{t-q}, rg_{t-q}, gmw_{t-q}, hpi_{t-q}, ru_{t-q}, u_{t-q}, x_{t-q}, mir_{t-\mathrm{q}}) \tag{10}$$

where $hpi$ and $rr$ denote the RHPI and rent, the inputs $gr, pi, pr, cv, rg, gmw, ru, u, x$ and $mir$ connote growth rate, price-to-income ratio, price-to-rent ratio, credit volume, gold price, gross minimum wage, the foreign exchange rate of U.S. Dollar to Turkish Lira, level of unemployment, XMGYO index closing prices and mortgage rates respectively, the subscripts $t$, $p$, and $q$ denote the period, the $p^{th}$ lag of the dependent variable and $q^{th}$ lag of the independent variables on time $t$. As seen in the equation (9) function, changing values on all the variables exist over time, indicating time-variant values and lags in the empirical study.

Equations (9) and (10) predict that all function features have a long-term cointegrating relationship. In order to test the long-term linkages between dependent variables and their predictors, it is necessary to determine the equation in growth form. It is essential to consider all variables in natural logarithmic forms, except growth rate and mortgage rates. In this study, the terms' *ln*' and'Δ' are utilized before variables to denote the natural logarithm and the first differences of variables, respectively.

### *5.6. The Methodology*

The summary of the methodology used in this study is as follows: The preliminary analysis through the X-13 ARIMA-SEATS approach manipulated the data to remove seasonal patterns. In addition, this study chose six different unit root tests to ensure stationarity features of the variables without seasonal patterns. The best subset selection algorithm described the best predictors with the highest $R^2$ and the lowest RSS.

However, this dissertation employs Lee-Strazicich unit-root tests for one and two structural breaks in dependent variables, and the ARDL long-run form and Bounds test and the Conditional Error Correction Model by Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001) to determine the long-run relationship between housing prices, rents, and its predictors. This dissertation measures the adjustment speed for the equilibrium in a cointegrating relationship. After that, the study seeks evidence for (the lack of) a bubble in the housing sector by comparing and interpreting the GSADF by Phillips, Shi and Yu (2015), Discounted Cash Flow approach of Williams (1938), ARDL estimation results. At last, the dissertation investigates the short-run dynamics of the housing price index and rents in real terms through the Toda-Yamamoto causality tests and generalized impulse response functions by Pesaran and Shin (1998).

#### *5.6.1. ARDL Long-Run Form and Bounds Test*

This dissertation uses the ARDL procedure, developed by Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001), to estimate the cointegrating relationship between the RHPI and RR and their predictors.

This study employs the Bounds test, which has two main advantages over the traditional cointegration tests of Engle-Granger (1987) and Johansen (1991, 1995).

First, the model estimates series regardless of their level of integration unless integrated of order two. Second, the ARDL approach is more appropriate than traditional cointegration tests in small and finite sample data sizes. In addition, the ARDL model is an alternative tool to avoid the spurious regression problem.

The following equation (11) measures the long-run relationship through the ARDL Bounds test approach.

$$\Delta y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 x_{1_{t-1}} + \cdots + \beta_n x_{m_{t-1}} + \sum_{j=1}^{p} \delta_i \Delta y_{t-1} + \sum_{j=0}^{q} \lambda_{i_1} \Delta x_{1_{t-j}} + \cdots + \sum_{j=0}^{q} \lambda_{i_m} \Delta x_{m_{t-j}} + \epsilon_t \quad (11)$$

where $p$, $q$, $\Delta$, $m$, $\epsilon$ are the optimal lag lengths for dependent and independent variables, the first difference of the variables, number of predictors, and error-term, respectively, and β, $\delta$, and $\lambda$ denote coefficient terms. For equation (11), the null hypothesis of no cointegration is defined by $H_0: \beta_1 = \beta_2 = \cdots = \beta_m = 0$. The null hypothesis is rejected if the value of the F-Bounds test statistic exceeds the upper critical value. After rejecting the null hypothesis for equation (11), considering an Autoregressive Distributed Lag $(p, q_1, \dots, q_m)$:

$$y_t = \beta_0 + \sum_{j=1}^{p} \delta_i y_{t-j} + \sum_{j=1}^{q} \lambda_i x_{1_{t-j}} + \cdots + \sum_{j=1}^{q} \lambda_i x_{m_{t-j}} + \epsilon_t \quad (12)$$

A cointegration vector is an essential and sufficient circumstance to advance with the conditional error correction (CEC) form. Therefore, the empirical approach estimates a CEC model for testing short-term cointegrating dynamics. This CEC model of the vector autoregression ($VAR(p)$) model is similar to an ARDL model in equation (11):

$$\Delta y_t = \beta_0 + \beta_1 \mathrm{EC}_{t-1} + \sum_{j=1}^{p} \delta_i \Delta y_{t-j} + \sum_{j=1}^{q} \lambda_{i_1} \Delta x_{1_{t-j}} + \cdots + \sum_{j=1}^{q} \lambda_{i_m} \Delta x_{m_{t-j}} + \epsilon_t \quad (13)$$

The $EC$ term is the abbreviation for the error-correction term. The $EC$ term must be negative and statistically significant. For equation (13), the null hypothesis of no cointegration is defined by $H_0: \lambda_{i_1} = \lambda_{i_2} = \cdots = \lambda_{i_m} = 0$.

#### 5.6.2. *Bubble Tests*

This dissertation employs ARDL in-sample forecasts and the discounted cash flow (DCF) model in this study to determine the fundamental values of house prices. The DCF model is based on the theory of investment value, assuming that a potential buyer anticipates a consistent annual operating profit during the property's lifetime. The DCF model considers housing as financial assets, which provide periodical cash flows as rents, thus linking housing prices, rents, and mortgage rates. The main hypothesis of the DCF model under rational expectations is that discounting expected future cash flows of the asset presents the fundamental value of that asset. The rational expectation theory suggests that investors' expectations shape an asset's actual and future prices, and the price convergence framework is the deviation of actual and fundamental prices. Based on rational expectation theory, Flood and Hodrick (1990), Mikhed and Zemcik (2009), and Liu et al. (2017) use the price convergence framework to measure the magnitude of the bubble component.

The theory of investment value determines the DCF methodology, a valuation approach utilized in estimating the fundamental price of an asset by discounting its expected future returns with the notions of the time value of money. Accordingly, the fundamental value of real housing price is as follows:

$$P_{house_t} = \frac{Rent_t}{mir_t}$$

$P_{house_t}$ denotes the overall real fundamental price of a house, $Rent_t$ connotes RR price, and $mir_t$ is the discount rate representing mortgage rates at time $t$.

The DCF model aims to measure the level of price convergence and test the existence and size of a bubble formation or an overvaluation in overall house prices. Thus, academics consider DCF to evaluate whether the price of an asset is at a speculative stage, although the model has limitations.

The study of Liu et al. (2017) recommends that $B_t = \frac{P_t - P_t^*}{P_t}$ can measure the timing and magnitude of housing price bubbles, where $B_t$, $P_t$ and $P_t^*$ represent the magnitude of the bubble term in month $t$, the actual real housing price, and predicted prices. If the actual price exceeds the fundamental price in month $t$, house prices may exhibit exuberance patterns or a bubble stage. Under the given circumstances, the investors should be cautious about buying, in contrast to the case in which the fundamental price exceeds the actual housing price in month $t$, i.e., the asset is undervalued.

GSADF is a more conventionally used date-stamping approach in determining multiple periods of explosiveness and deflations in asset prices. Consider the traditional ADF test:

$$\Delta y_t = \mu + (\rho - 1)y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta y_{t-1} + \epsilon_t \tag{14}$$

where $\mu$, $(\rho - 1)$, $k$, $\Delta$, $\beta_i$, and $\epsilon_t$ connote the intercept, autoregressive coefficient, maximum number of lags, difference operator, the coefficients of the lagged first difference, and error-term, respectively. For the GSADF test, the null hypothesis is $H_0: \rho = 0$, and the alternative hypothesis for explosive behavior is $H_1: \rho > 0$.

Assume a sample interval of $[0, 1]$. The SADF test recursively computes the autoregressive coefficient and ADF test statistics with an expanding window where $r_1$ and $r_2$ are the fraction of the sample conditional on $0 < r_1 < r_2 < 1$. $r_w$ and $r_0$ are the fractional window size of the regression and fixed initial window, respectively, where $r_w = r_2 - r_1$ and $r_w > 0$. The backward sup ADF (BSADF) statistic is the sup value of the ADF statistic sequence:

$$BSADF_{r_2}(r_0) = \sup\{ADF_{r_1}^{r_2}\} \tag{15}$$

where $r_2 \in [0, r_2 - r_0]$. The GSADF test recursively computes the BSADF statistic:

$$GSADF(r_0) = \sup\{BSADF_{r_2}(r_0)\} \tag{16}$$

where $r_2 \in [r_0, 1]$.

### 5.6.3. *Toda-Yamamoto Causality Test*

Since the unit root test results reveal the series are integrated of order zero and order one, i.e., I (0) and I (1), this dissertation employs Toda-Yamamoto causality tests. This thesis investigates the causal relationships between the real housing price index as a dependent variable through the Toda and Yamamoto (1995) approach. Wolde-Rufael (2006) states that the Toda-Yamamoto causality approach expands the lag order of the VAR model arbitrarily by inserting extra lag(s) up to the maximum order of integration. Elian and Suliman (2015) confirm that the Toda-Yamamoto causality test has valid statistical tests and inferences for Granger causality at level VAR values regardless of the cointegrating relationship. In brief, this methodology has several advantages against other traditional causality tests: independence of the order of integration, no requirement for a long-term cointegrating relationship between variables to apply this methodology, and therefore, reducing the bias concerning the variables' unit root tests, and cointegrating linkages.

The Toda-Yamamoto causality test uses the level values of the variables, which is based on the Vector Autoregressive (VAR) model at the level $p = k + d_{max}$ where $k$ and $d$ connote optimal lag length and maximum order of integration, respectively.

Considering a VAR of $(k + d_{max})^{th}$ order:

$$y_t = \beta_0 + \sum_{i=1}^{k} \beta_{1\mathrm{i}} \mathrm{y}_{t-i} + \sum_{j=k+1}^{k+d_{max}} \beta_{2\mathrm{j}} \mathrm{y}_{t-i} + \sum_{i=1}^{k} \partial_{1\mathrm{i}} \mathrm{z}_{t-i} + \sum_{j=k+1}^{k+d_{max}} \partial_{2\mathrm{j}} \mathrm{z}_{t-i}\, \epsilon_t \quad (17)$$

where $y_t$ connotes the response to the Granger causality of $z$, if $\beta_{3\mathrm{i}} \neq 0$ for all $i$. In effect, it is identical to testing the series' non-causality (Toda, 1995). $k$ is the lag length, $d_{max}$ is the maximal order of integration, $\beta$ and $\partial$ denote the coefficient terms, and $\epsilon_t$ represents the error term.

This dissertation investigates the short-run dynamics of the real housing price index and real rent dynamics through the Toda-Yamamoto causality approach.

$$lnhpi_t = \theta_0 + \sum_{i=1}^{k} \omega_{1i} \text{lnhpi}_{t-i} + \sum_{j=k+1}^{k+d_{max}} \omega_{2j} \text{lnhpi}_{t-j} + \sum_{i=1}^{k} \delta_{1i} \text{lnx}_{t-i} + \sum_{j=k+1}^{k+d_{max}} \delta_{2j} \text{lnx}_{t-j} + \sum_{i=1}^{k} \varphi_{1i} \text{lnrr}_{t-i} + \sum_{j=k+1}^{k+d_{max}} \varphi_{2j} lnrr + \cdots + \epsilon_t \quad (18)$$

where $\omega$, $\delta$, and $\varphi$ denote the parameters for lagged predictors, $k$ is the lag length, $d_{max}$ is the maximal order of integration, and $\epsilon_t$ represents the error term.

### *5.6.4. Impulse Response Functions*

The Toda-Yamamoto approach is subject to critics since it exclusively presents for causal linkages within a time frame. Since the Impulse Response Functions (IRFs) approach measures the relative strength of causal relationships prior to the specified sample period, the variance investigations reveal short-term insights between the dependent variable and its predictors.

The original VAR $(k)$ is augmented with the maximum order of integration $(d_{\max})$ by considering a VAR of $(k + d_{max})^{th}$ order for the Toda-Yamamoto approach. The generalized impulse response functions do not depend on the ordering of the variables in the VAR models (Pesaran and Shin, 1998; Koop, Pesaran and Potter, 1996). The IRFs plot the response of any predictors to shocks in each other, including their own (Becketti, 2013). The dynamic structure of VAR enables a shock to the $i^{th}$ variable, not only straightforwardly influences the $i^{th}$ variable, but also spreads the shock to the other endogenous variables. The IRF examines the shock effects of one standard deviation on the current and future values between endogenous variables. However, the outcome implication of the IRFs is straightforward when the responses are simultaneously uncorrelated: The $i^{th}$ response of the variable is simply a shock to the $i^{th}$endogenous variable.

As mentioned above, the IRFs function traces how the series responds to a one standard deviation shock of another series over a 12-period horizon. IRFs describe the essence of short-term dynamic relations between endogenous variables (Xu and Lin, 2017). Equation 19 presents The IRFs statistic formulae:

$$lnhpi_{i,j}^{p} = \frac{\partial Y_{i,t+p}}{\partial \mu_{jt}} (p = 1,2, \dots) \qquad (19)$$

where $lnhpi_{i,j}^{p}$ is a component of $lnhpi_{p}$, whose location is in line $i$ and column $j$, and $p$ denotes the lag phase. Considering all the other error terms are constant for the endogenous variables in Equation 19 in the $t + p$ period, $\mu_{jt}$ of the $i^{th}$ order of the variable has an impulse on the $I^{th}$ order of an endogenous variable. As a result, the reactions elicited by a shock in $Y_j$ constitute responses denoted as $lnhpi_{i,j}^{0}, lnhpi_{i,j}^{1}, \dots, lnhpi_{i,j}^{p}$.

The cumulative response function is as follows:

$$Y_j: \sum_{P=0}^{\infty} lnhpi_{i,j}^{p} \qquad (20)$$

# CHAPTER 6: EMPIRICAL RESULTS

### *6.1. ARDL Long-Run Form Cointegration, Bounds Tests, and Conditional Error Correction Model*

The unit root test results (see Appendix B) confirm that two variables out of 22, namely, homeownership rate and the natural logarithm of GDP, are integrated of order two: I (2). Therefore, this dissertation eliminates these two variables above and selects eleven predictors through the best subset selection algorithm to employ Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001) techniques for determining the long-term cointegrating relationship.

Given the revealed decreasing power of classical ADF tests in the presence of structural breaks (Perron, 1989), this study employs Lee-Strazicich (2003) test on RHPI and RR for model C. The 2003-2019 period covers several possible structural breaks: property price depreciation during the 2008 global crisis, expansionary effect on aggregate demand and housing prices resulting from drastic fall in mortgage rates between 2009 and 2011, the exponential Turkish Lira depreciation, and contraction in GDP per capita (The World Bank, 2020). Lee-Strazicich unit root test outcome suggests including dummy variables for the dependent variable as a fixed regressor in ARDL estimations since the results (see Table 9) illustrate stationarity conditions with two structural breaks in 2008:M08 and 2011:M04 for the RHPI, and in 2007:M07 and 2016:M03 for RR series' first differences, respectively.

This research selects AIC for optimal lag length selection in the ARDL models. The maximum lag length for dependent variables and regressors is four with restricted constant. Table 11 reports the cointegration results among the RHPI, RR, and regressors.

Table 11. ARDL Models Estimated Long-Run Coefficients

| **Dependent variable: *lnhpi*** | | | | **Dependent variable: *lnrr*** | | | |
|---|---|---|---|---|---|---|---|
| Variable | Coef. | Std. Error | t-Statistic | Variable | Coef. | Std. Error | t-Statistic |
| gr | -0.0002 | 0.0001 | -2.14** | gr | 0.0002 | 0.0001 | 1.95* |
| lnpi | -0.0009 | 0.0059 | -0.15 | lnpi | -0.0001 | 0.0058 | -0.02 |
| lnpr | 0.9980 | 0.1827 | 5.46*** | lnpr | -1.0017 | 0.1832 | -5.47*** |
| lncv | 0.0009 | 0.0010 | 0.88 | lncv | -0.0002 | 0.0008 | -0.28 |
| lnrg | -0.0020 | 0.0012 | -1.65 | lnrg | 0.0016 | 0.0013 | 1.20 |
| lngmw | -0.0008 | 0.0020 | -0.41 | lngmw | 0.0008 | 0.0021 | 0.37 |
| lnrr | 0.9964 | 0.2236 | 4.46*** | lnhpi | 1.0023 | 0.1922 | 5.22*** |
| lnru | 0.0032 | 0.0019 | 1.70* | lnru | -0.0032 | 0.0022 | -1.46 |
| lnu | -0.0021 | 0.0015 | -1.42 | lnu | 0.0019 | 0.0014 | 1.32 |
| lnx | 0.0007 | 0.0008 | 0.87 | lnx | -0.0008 | 0.0007 | -1.14 |
| mir | -0.0103 | 0.0048 | -2.15** | mir | 0.0081 | 0.0043 | 1.88* |
| c | -2.2169 | 0.3851 | -5.76*** | c | 2.2300 | 0.3483 | 6.40*** |
| ect | -0.8117 | 0.1931 | -4.20*** | ect | -0.8260 | 0.1950 | -4.24*** |
| Bounds Test Results for Cointegration in the ARDL Model | | | | | | | |
| Dependent variable: *lnhpi* | F-Statistic | 95% Lower Bound | 95% Upper Bound | Dependent variable: *lnrr* | F-Statistic | 95% Lower Bound | 95% Upper Bound |
| ARDL (4, 3, 2, 4, 0, 0, 4, 4, 3, 0, 3, 2) | 6.26*** | 1.98 | 3.04 | ARDL (4, 4, 3, 2, 4, 0, 0, 4, 3, 0, 3, 2) | 6.32*** | 1.98 | 3.04 |

Notes to Table 11: Table 14 describes the definitions of the variables. The signs ***, **, * indicate a long-run cointegrating relationship in the series at 1%, 5%, and 10% significance levels, respectively. coef., std. error and ect represent coefficient, standard error, and error correction term, respectively.

This research selects AIC for optimal lag length selection in the ARDL models. The maximum lag length for dependent variables and regressors is four with restricted constant. Table 11 reports the cointegration results among the RHPI, RR, and regressors.

The smallest AIC values suggest ARDL (4, 3, 2, 4, 0, 0, 4, 4, 3, 0, 3, 2) and ARDL (4, 4, 3, 2, 4, 0, 0, 4, 3, 0, 3, 2) models for RHPI and RRs, respectively. The results (Appendix C for diagnostics) of the F-bounds test prove the existence of long-run cointegrations at the 1% significance level, suggesting no bubble formation on the RHPI and RRs for the long-term Turkish experience. The error correction term in Table 11 implies that the models adjust about 81.17% for the RHPI and 82.60% for RRs of any movements into disequilibrium within one period. Thus, despite real appreciations in the housing price index and rents between 2010 and 2017, house and rent prices mean reverting to the fundamentals in the longer term.

Table 11 exhibits the statistical insignificance of coefficients between house prices or rents and price-to-income ratio, credit volume, gold prices, minimum gross wage, unemployment rate, and XMGYO index in Turkey between 2003:M01 and 2019:M12. The 17-year period encountered significant internal/external shocks, including the 2008 global crisis, fluctuations in mortgage rates, and depreciation of the Turkish Lira. Therefore, the aforementioned empirical finding may have been influenced by structural breaks.

Generally, it is expected that the growth rate should positively impact the RHPI as the construction sector is its driving force. Surprisingly, the growth rate has a limited negative cointegration coefficient. Apart from the growth rate, mortgage rates have a significant negative linkage with the RHPI. By contrast, Table 11 indicates that the price-to-rent ratio, RR, and the foreign exchange rate of the US dollar to the Turkish Lira positively impact the RHPI. Specifically, a one-unit increase in growth rate may result in a 0.02% decrease in the measured house prices.

Of all variables, only four exhibit statistically significant results explaining RR prices: growth rate, price-to-rent ratio, RHPI, and mortgage rates. The price-to-rent ratio has an adverse impact naturally, and the growth rate, mortgage rates, and RHPI positively influence RRs, although the impact of the growth rate is slight.

The main finding of this study is that a 1% change in RR prices or price-to-rent ratio influences approximately a 1% positive change in the RHPI. The outcome is identical for RHPI and price-to-rent ratio in explaining RRs, suggesting similar fundamentals for house prices and rents in Turkey. The findings are consistent with DiPasquale and Wheaton (1994) and Coskun and Jadevicius (2017), who suggest a strong relationship between house prices and rents. The provided empirical evidence also supports for price-to-rent ratio findings of Sommer, Sullivan and Verbrugge (2013), McQuinn, Monteiro and O'Toole (2019), and Cronin and McQuinn (2016).

The findings indicate the inverse relationship between mortgage rates and housing prices. The results in Table 11 reveal that a one-unit increase in mortgage rates may result in a 1.03% decrease in the RHPI and a 0.81% increase in RRs, ceteris paribus. The results provide supporting evidence for Shi (2011) and Valadkhani, Nguyen and O'Brien (2019), i.e., mortgage rates negatively affect the RHPI, although considerably less than rents and price-to-rent ratios. The findings demonstrate that any future contractionary monetary policy involving higher interest rates – causing mortgage rate rises – will impose downward pressure on housing prices. However, nominal prices may remain stable or rise with a descending slope due to price stickiness after the mortgage rate increases.

On the other hand, many borrowers entered into a booming real estate market, expecting future price increases, due to dramatically falling mortgage rates. This situation and the relatively low impact of mortgage rates on house prices and rents lead to doubts over the existence of asymmetric relationships, implying that the impact of a decline in mortgage rates on housing price changes may be more significant than that of an increase. Therefore, policymakers must expose the asymmetric response of house prices to mortgage rates to decrease further risks and ensure financial stability.

Contrary to Tunc's (2020) findings of positive linkages between credit volume and house prices for the Turkish housing market, this study's results find no significant long-run relationship. The reasons are that Tunc (2020) covers only the 2007 and 2017 periods and includes only aggregate mortgage and consumer credits. In contrast, this study covers a more extended period and considers real aggregate credit volume, including negative real mortgage loan growth after 2017.

One unit change in the growth rate has a limited positive impact below 1% on RR prices, as increases in income per capita cause a rise in rent prices. From an empirical point of view, this outcome is not surprising, as the GDP growth rate is subject to various structural changes over time. The results support Aye et al.'s (2014) results in the emerging South African economy regarding the lack of a long-run relationship between GDP and house prices.

Similar to the findings of Gallin (2006) and Miles (2020), the results exhibit no signs of a linear relationship between housing prices and income-related predictors, namely, price-to-income ratio and gross minimum wage. This evidence revives concerns over housing affordability for a particular segment of households due to inequality in income distribution.

None of the remaining macroeconomic variables in this study, such as the unemployment rate, has a significant effect on real estate prices, perhaps, due to stable homeownership rates and high seasonal labor mobility. The empirical results provide evidence supporting Simo-Kengne (2019), Gathergood (2011), and Irandoust (2019). Similarly, none of the remaining predictors has any influence on rental prices.

Table 11 exhibits that the USDTRY exchange rate has low positive impacts on the RHPI. The effects of XMGYO index closing prices and gold prices are insignificant on the RHPI. These results imply that these financial instruments are neither a substitute nor competent for real estate investment. The findings support Coskun and Umit's (2016) study on the Turkish case. The findings show that potentially unique investment dynamics for each investment instrument, including stocks, US dollar, gold and real estate, and investor profiles differ according to their risk perception. Domestic investors prefer to invest in the Turkish real estate market due to high real returns, especially between 2010 and 2017. Therefore, the share of domestic investors in housing sales is higher than the share of foreign and institutional investors for the Turkish experience. Correspondingly, the share of domestic investors is much smaller than foreign and institutional investors in the Turkish stock market custody accounts. Parallel to the explanations above, the findings also disconfirm the linkages between XMGYO index closing prices and house prices. As the growth rate and USDTRY exchange rate have limited influence on RHPI, the empirical outcome provides supporting evidence for the theory of investment value, i.e., the DCF model linking rents as future cash flows and mortgage rates as the discount rate and housing prices as the asset's value. Under rational expectations, the theory behind the DCF model is that discounting expected future rent payments for houses through mortgage rates presents the fundamental housing price.

Cointegration approaches estimating the fundamental housing prices to determine the level of price bubbles are subject to criticism because the estimation of the model is based on the entire sample period considered. Readers should carefully evaluate the results as the recent literature emphasizes the fundamental weaknesses of the ARDL bounds test: size, power properties, and the elimination of inconclusive inferences. McNown, Sam and Goh (2018) determine that ARDL bounds test results based solely on the significance of the F-test, and single t-tests are insufficient to prevent degenerate cases. Another weakness revealed by Chudik et al. (2016) is that the ARDL-type estimator is not robust against misspecification of dynamics and error serial correlation. Other limitations of the ARDL approach are that it is a type of symmetric linear regression and, therefore, is not sufficiently flexible for analyzing joint short-and-long-run asymmetries. It has limitations in revealing potentially significant disparities in how predictors react to positive and negative shocks.

### *6.2. Bubble Tests*

The ARDL cointegration outcome presents relationships between housing prices and their predictors. However, the DCF approach is more appropriate for investigating the temporary bubble formations' timing, magnitude, and collapse period because of possible short-run overvaluations or temporal bubble formations in housing prices. This approach compares the actual and fundamental house prices, and the GSADF test timestamps multiple explosive price behaviors.

This empirical approach creates an in-sample forecast of the estimated ARDL model. It estimates housing prices through the DCF methodology according to equation (12) and the DCF formula to determine the fundamental value of the RHPI. Figure 16 illustrates ARDL in-sample forecasts, DCF estimates, and the natural logarithm of the RHPI.

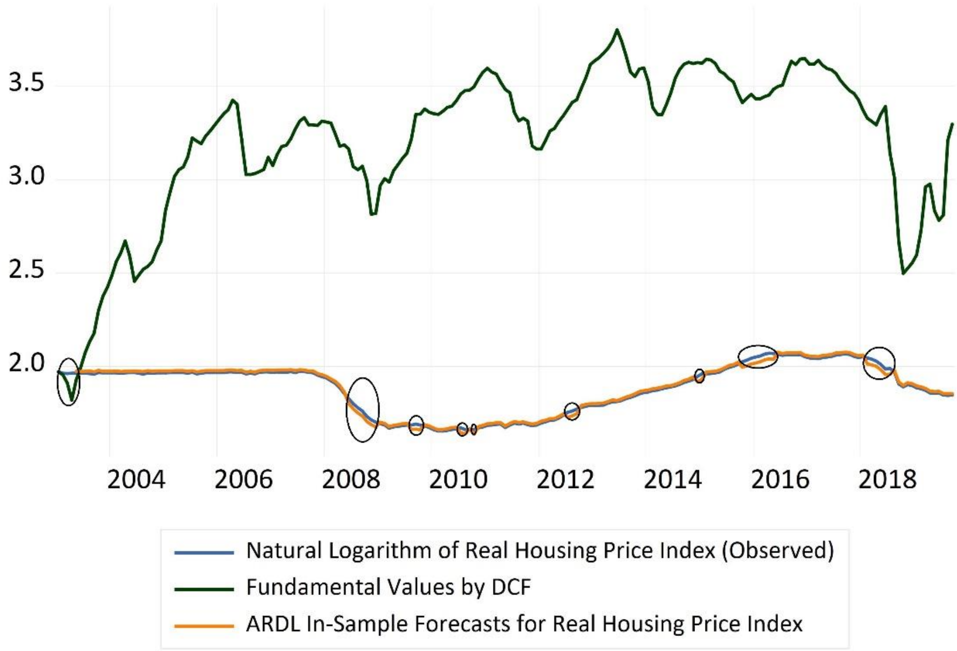



Figure 16. A Comparison of Actual and Fundamental House Prices

Figure 16 compares the fundamental and actual RHPIs to test the bubble's existence and determine the timing of price appreciations in circles. The lower the price convergence between fundamentals and actual prices, the more negligible the bubble formation probability.

Figure 16 provides supporting evidence for the finding of an absence of bubble formation in the RHPI in the long term because of the robustness of the estimated ARDL (4, 3, 2, 4, 0, 0, 4, 4, 3, 0, 3, 2) model and use of seasonally adjusted series. The RHPI converges to its fundamentals in value, with only slight separations between actual and fundamental prices, which eventually converge themselves, rapidly narrowing the gap between actual and fundamental house prices.

The deviations between actual and fundamental house prices are more pronounced for DCF model estimates than ARDL in-sample forecasts. The price convergence is low between the fundamental housing price index estimated by the DCF model and the observed RHPI. Actual prices are below their fundamentals for 199 of the 204 observations. Between 2003 and 2019, rents increased more than housing prices in real terms, leading to higher fundamental prices than intrinsic prices, despite fluctuating mortgage rates. Despite DCF model estimates discovering overvaluations of up to 7.97% between 2003:M01 and 2003:M05, fundamental changes can explain valuations of housing prices, which exhibit rare, irregular, and temporal explosive behaviors.

The ARDL and DCF model estimates exhibit higher fundamental prices than the actual housing prices in most of the study period, indicating that house purchase remains a good long-term investment in Turkey, even at current market prices.

This dissertation additionally employs the GSADF approach to investigate explosive price behaviors in the intrinsic dynamics of housing prices. This study compares periods of exuberance in the RHPI, RR, price-to-rent ratio, and mortgage loan interest rate to comprehend whether fundamentals can explain the boom phases. In line with the recommendations of Phillips, Wu and Yu (2011) and Phillips, Shi and Yu (2015) that an explosive period must be greater than the duration of the sample size log form in this study, the results illustrate exuberance periods as lasting at least three months.

Table 12 presents the GSADF test results, rejecting the null hypothesis and implying that the series illustrate explosive behaviors according to equation (16).

Table 12. GSADF Test Results

| Variable | Test Statistics | P-value |
|---|---|---|
| lnhpi | 2.7043** | 0.01 |
| lnpr | 1.7720* | 0.07 |
| lnrr | 2.4397** | 0.01 |
| mir | 1.7515* | 0.07 |

Notes to Table 12: lnhpi, lnpr, lnrr, and mir represent the natural logarithm of the real housing price index, the natural logarithm of the price-to-rent ratio, the natural logarithm of the real rents, and mortgage rates, respectively. The signs **, * indicate explosive behavior in the series at 5% and 10% significance levels, respectively. The table reports estimated GSADF statistics with an initial window size of 36 months. All unit root test equations contain three lags. Monte Carlo simulation with 1,000 replications derives critical values of 2.7181, 1.9996, and 1.7043 at 99%, 95%, and 90% confidence intervals respectively.

Figures 17, 18, 19, and 20 illustrate the GSADF test results investigating boom periods, comparing the timing of exuberances and collapses in house prices with its fundamentals.

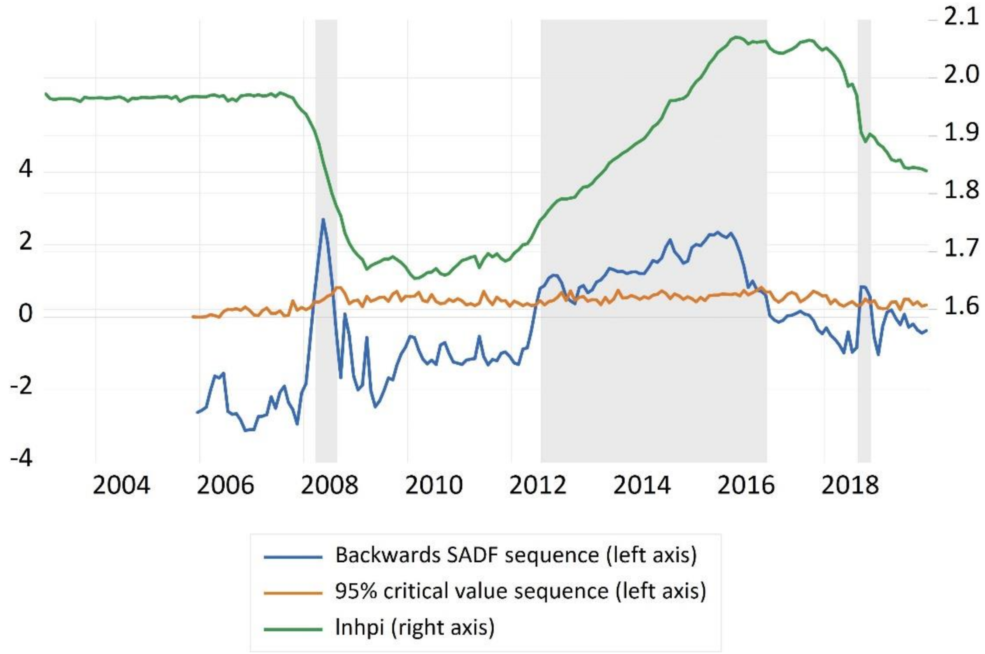



Figure 17. GSADF Test Results of The Natural Logarithm of The Real Housing Price Index

The shaded areas in Figure 17 illustrate bubble formation and collapse periods for the selected variable. The GSADF test results detect the collapse of a bubble period in housing prices between 2008:M03 and 2008:M08, and exuberances in the Turkish RHPI over 2012:M07–2016:M11. However, implosions in rent prices and price-to-rent ratio support the existence of explosive behaviors in housing prices in the given period, implying that house price exuberances are generally compatible with fundamental patterns.

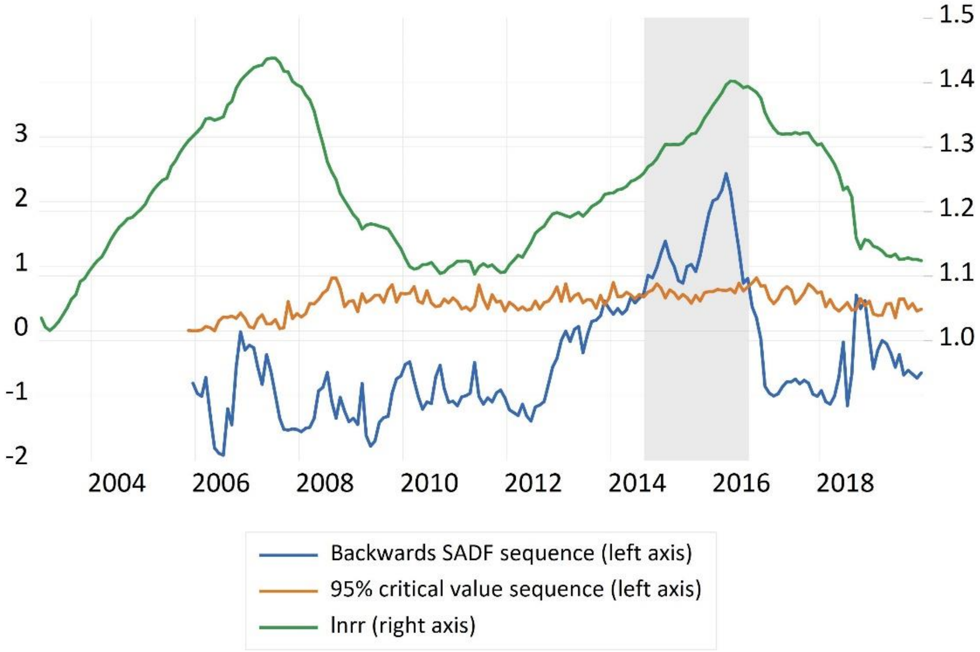



Figure 18. GSADF Test Results of The Natural Logarithm of The Real Rent

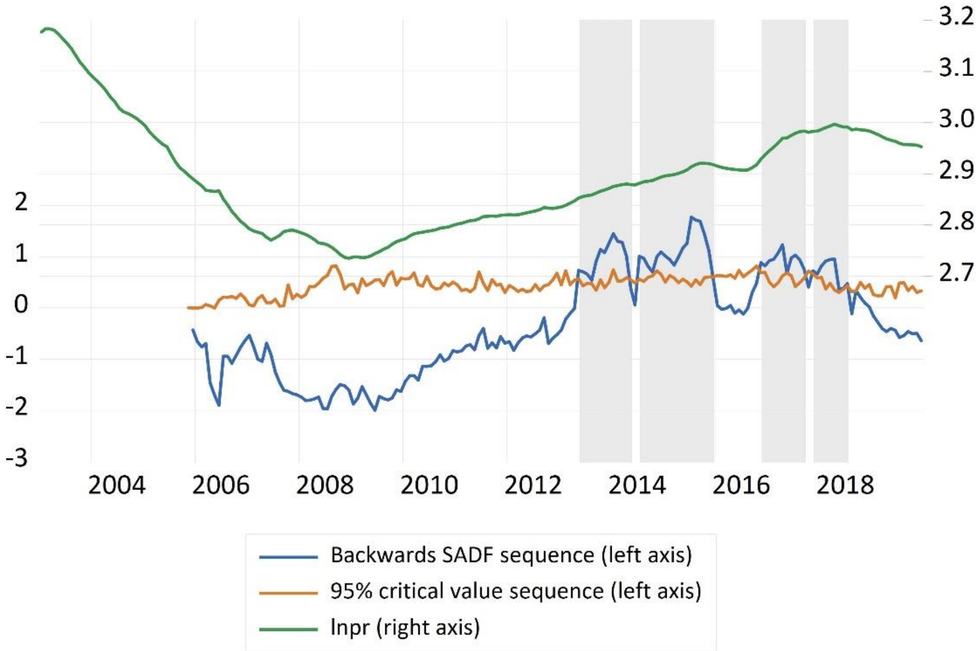



Figure 19. GSADF Test Results of The Natural Logarithm of The Price-to-Rent Ratio

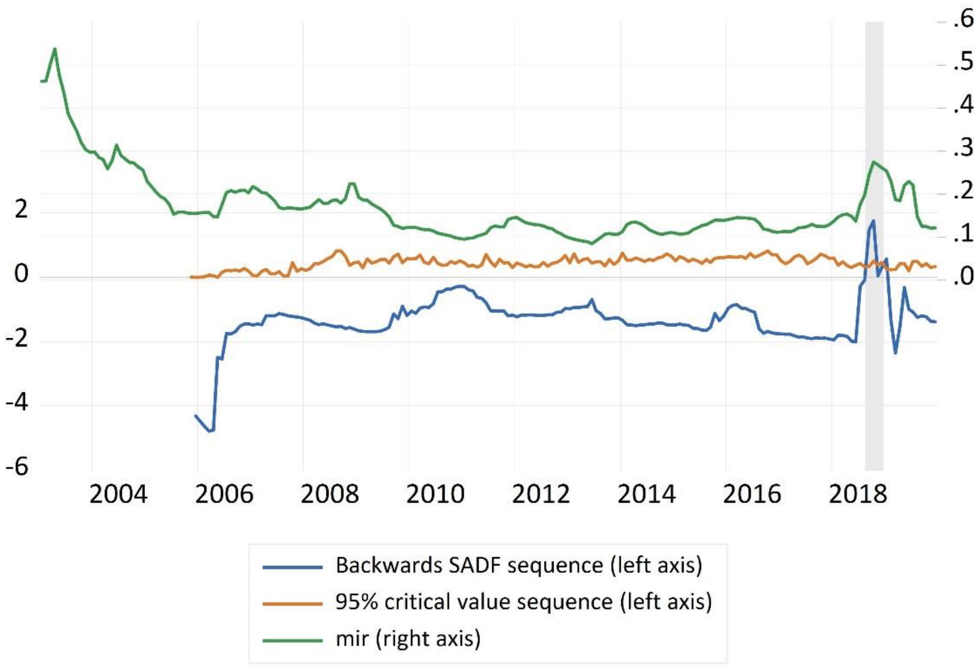



Figure 20. GSADF Test Results of Mortgage Rates

Despite the steep rise in mortgage rates, the outcomes exhibit high house price appreciations between 2018:M08 and 2018:M11. This result implies that irrational expectations may cause temporal price exuberances in the Turkish housing markets. In general, the GSADF results are compatible with changes in fundamentals, revealing that explosive housing price patterns are short-lived.

According to empirical and graphical results, the null hypothesis of no cointegration for equation (12) is rejected. The deviations between prices and their fundamentals are stationary at their level. The results imply that, despite rare, irregular, and temporal overvaluations for the Turkish housing market experience and rapid price rises in real terms, especially between 2010 and 2017, there is no empirical evidence of a bubble formation throughout 2003:M1–2019:M12. This excessive real return in the Turkish housing market between 2010 and 2017 shows the lasting impact of the high level of price depreciation in the 2008 global crisis. In addition, the empirical outcome provides no strong evidence of an irrational housing demand created by investors acting on the assumption of continuously increasing housing prices. In this context, house prices are accordant with the fundamentals. Therefore, under several reasonable presumptions about fundamentals, purchasing a house at current market prices appears as an attractive long-term investment in the Turkish case.

GSADF is an effective approach for timestamping bubble formations or deflations by considering only the asset price, but less so for determining the source of price exuberances. The GSADF approach outperforms the RTADF and CUSUM methodologies in the presence of multiple bubbles. Therefore, this study uses the GSADF test to investigate bubble dynamics by comparing results for house prices and mortgage rates, price-to-rent ratio, and RRs. However, the GSADF model is less appropriate in determining the bubble's magnitude through the price convergence framework than the DCF approach, which measures fundamental prices, including rental prices and interest rates.

However, it is important to recognize that the DCF model has several limitations; it does not consider the transaction costs, maintenance and leverage costs, or growth rate in house prices, and is also sensitive to fluctuations in interest rates. Another drawback is that estimated fundamental prices depend on mortgage rates exhibiting highly volatile movements. Despite these limitations, Tomfort (2017) uses DCF to measure the fundamental house prices, detecting house price overvaluation by around 100% in Japan in the late 1980s and above 100% in the USA between 1998:Q4 and 2006:Q2. Gilles et al. (2006), Tomfort (2012), and Klotz, Lin and Hsu (2016) also use DCF and find empirical evidence of bubbles in Ireland, Hong Kong, Shanghai, Spain, and the UK. Scholars should further test in different markets with different time durations to build on these findings and validate the model's reliability. In this study, the ARDL cointegration (2001) and GSADF (2015) models support the DCF model results in determining bubbles' existence, magnitude, and timing in the housing market.

### *6.3. Toda-Yamamoto Causality Test*

The outcome exhibited that temporary price exuberances occurred. However, the ARDL cointegration test demonstrates equilibrium price formations in the long run. In addition, the bubble tests did not provide evidence of bubble formations in the short term, although there were temporary exuberances in prices.

The Granger causality test depicts a cointegrating relationship indicating at least unidirectional causation (Granger, 1988). The Granger causality test has a vital criticism that the estimations are highly subtle to the chosen lag length. Unlike the Granger causality test, The Toda-Yamamoto (TY) causality test has robust econometric tests at level VAR values regardless of the integration of variables (Elian and Suliman, 2015). The TY causality approach synchronizes well with the ARDL approach because its application requires similar information, including lag length and maximum order of integration (Jawad et al., 2017). Since the TY causality test does not necessitate pre-testing the long-run equilibrium linkages, it avoids the possible bias related to cointegration and unit root tests (Zhang, 2011).

This section will examine the short-run linkages of the real housing price index and real rent prices through the TY causality test since the variables employed in this study are a mixture of integrated of order zero and order one. Accordingly, the calculation of maximum lag length under the TY requires the addition of the optimum lag length ($k$) and the maximum order of integration ($d_{max}$) of the variables equals 1. Notice that the lag order is selected based on the sequential modified LR test statistic and the Akaike Information Criterion (AIC). Therefore, this study uses the maximum lag length of six ($k$ + $d_{max}$ = 5 + 1 = 6) to apply the Toda and Yamamoto causality test.

Table 13 presents the results of the Toda-Yamamoto causality test.

The inverse roots of the estimated VAR are within the unit circle, implying that the estimated VAR model is stable (see Table 27). However, Table 26 presents that the residuals exhibit normal distribution patterns. In addition, the diagnostic tests do not indicate serial autocorrelation or heteroscedasticity problems (see Appendix.D).

Table 13. Toda-Yamamoto Causality Test Results

| Dep. Var. → | Δlnhpi | Δgr | Δlnpi | Δlnpr | Δlncv | Δlnrg | Δlngmw | Δlnrr | Δlnru | Δlnu | Δlnx | Δmir |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δlnhpi | - | ***14.10***** | 4.11 | 3.41 | 10.26 | 6.73 | 4.95 | 3.15 | 4.86 | ***11.57**** | 2.89 | 5.54 |
| Δgr | 7.52 | - | ***11.52**** | 9.65 | ***19.83****** | ***14.17***** | 8.78 | 6.87 | 5.12 | 8.20 | 6.43 | 2.56 |
| Δlnpi | ***11.65**** | 9.42 | - | ***21.87****** | ***17.72****** | 3.25 | 6.34 | 5.78 | ***12.06**** | 4.00 | ***13.69***** | ***20.66****** |
| Δlnpr | 6.80 | ***15.33***** | 4.18 | - | ***13.99***** | 6.73 | 5.79 | 2.93 | 8.82 | ***15.38***** | 2.34 | 5.95 |
| Δlncv | ***40.03****** | ***18.17****** | ***12.79***** | ***11.07**** | - | 9.76 | 9.24 | ***34.75****** | 10.59 | 12.17* | 1.42 | 6.29 |
| Δlnrg | ***11.60**** | 7.68 | 7.99 | 6.72 | ***16.15***** | - | ***14.22***** | 5.77 | 5.34 | 5.12 | 6.44 | 1.55 |
| Δlngmw | 2.59 | 7.95 | 7.27 | ***17.82****** | ***10.93**** | 6.74 | - | 4.56 | 3.08 | 3.71 | 4.85 | ***42.13****** |
| Δlnrr | 5.82 | ***14.79***** | 2.99 | 3.32 | 9.86 | 7.28 | 8.18 | - | 3.65 | ***12.86***** | 1.43 | 6.64 |
| Δlnru | 7.86 | 10.28 | ***11.60**** | ***12.40**** | ***23.17****** | 7.99 | 2.88 | 8.12 | - | 5.72 | ***13.25***** | ***32.79****** |
| Δlnu | 6.43 | ***20.25****** | ***15.08***** | 8.22 | ***29.04****** | 5.42 | 6.00 | 4.71 | 3.47 | - | 2.12 | 9.86 |
| Δlnx | 5.94 | 6.90 | ***17.40****** | 7.72 | ***10.90**** | 7.03 | 7.54 | 5.37 | ***21.39****** | 6.65 | - | 4.43 |
| Δmir | ***11.99**** | 9.51 | ***11.33**** | ***14.38***** | ***12.07**** | 5.00 | ***16.06***** | ***13.35***** | 8.47 | 10.33 | 4.37 | - |

Notes to Table 13: Table 14 describes the definitions of the variables. The test statistics represent the modified Wald (MWALD) test statistic. The null hypothesis is the non-causality between two variables. Superscripts *, **, and *** denote the rejection of the null hypothesis at 10%, 5%, and 1%, respectively. The MWALD test statistics represented in bold and italic is statistically significant. Dep. Var. stands for the dependent variable. The max. lag-length is set at six with six degrees of freedom.

The results in Table 13 exhibit unidirectional causality running from real credit volume and mortgage rates to the real housing price index and real rent prices. This research presents supporting evidence for the studies of Arestis and Gonzalez (2014), Basten and Koch (2015), and Oikarinen (2009). The results confirm that banking credit triggers the housing demand hypothesis: The findings highlight how the increases in real credit volume and changes in mortgage rates direct the demand for housing and thus the increase in housing prices. This positive relationship also reveals banks' appetite to allocate credit through the collateral channel. In addition, since the dataset includes both retail and commercial loans, the supply side of the housing market influences the housing prices and the residential real estate investment decisions in the short run.

This empirical evidence for the Turkish scenario provides support for the Taiwanese (Peng and Tsai, 2019), and the Polish (Cellmer, Bełej and Cichulska, 2019) experience since the real housing price index Toda-Yamamoto causes the level of unemployment and the absence of an adverse relationship. Surprisingly the results are similar for the cases of Germany, Italy, Netherlands, Sweden, Switzerland, and Spain (Irandoust, 2019). Contrary to the findings of this study, Jadevicius (2016) finds a correspondingly statistically significant effect of unemployment on the housing price index for the Lithuanian experience. The statistically significant positive coefficients point to increasing house prices, causing an increase in unemployment. Along with the decrease in construction activities during the winter, the decrease in the demand for temporary construction workers increases the unemployment rate, and housing prices rise in the metropolitan areas due to the short-term stalls in the housing supply. Similarly, there is a unidirectional causality running from real rents to the level of unemployment.

Instead, the government and the Central Bank of the Republic of Turkey (CBRT) may hike interest rates to halt the exuberances in housing prices. However, with the effect of two-digit inflation figures, nominal prices may remain steady or grow with a declining slope after mortgage rate hikes. In this circumstance, the government should anticipate a reduction in construction activities and an increase in unemployment figures.

The empirical evidence, exhibiting unidirectional causality from the price-to-income ratio to the real housing price index, supports the study of Zhang, Jia and Yang (2016) on the Chinese residential real estate market. However, the price-to-income ratio has no causal effect on rents and vice versa. The increase in the price-to-income ratio shows that housing prices increase above the income. Even though residential real estate market imperfections may lead to deviations in the price-to-income ratio, market corrections ultimately come into force, preserving the inclusive equilibrium point between the housing price and household income.

Rising income disparity has a more significant negative impact on housing affordability for lower-income households. The highest income groups' housing cost burden diminishes since the share of the 20% group with the highest equivalent household disposable income in total income was 46.3%, and the GINI coefficient was 0.395 in 2019 (Turkish Statistical Institute, 2020). In conclusion, Table 13 supports the premise that rising income inequality due to unequal income gains in wealthy households leads to increased housing prices, increasing the housing cost burden on lower-income households.

The empirical outcome supports and contradicts Rasekhi, Elmi and Shahrazi (2016), who find bidirectional causality between gold and the Iranian housing price index between 2002:M03 and 2015:M06. The results in Table 13 exhibit unidirectional causality from real gold prices to the real housing price index for the Turkish experience. However, real gold prices have no causal impact on real rents.

Increasing house prices trigger expectations of future price exuberances and generate prices departing from their fundamentals in the short term, thus, creating an environment to sell residential real estate with high-profit margins for the actors in the construction sector. Since the construction sector is the driving force of the economic growth in Turkey, this study expects causal linkages between house prices and growth rate. The outcome in Table 13 provides evidence of the expectations for the Turkish experience that the real housing price index Toda-Yamamoto causes the growth rate. Similarly, a unidirectional causality runs from real rents to the growth rate. The empirical evidence contradicts the studies of Nguyen and Wang (2010) and Jadevicius

(2016) for Taiwanese and Lithuanian real estate markets, which are unable to demonstrate linkages between growth rate and the housing price index.

The linkages between housing prices and rents are essential drivers for comprehending residential real estate markets. In particular, the form of housing prices signifying a function of demand and supply principles or the formation of a housing bubble indicates broader social policy problems reviving concerns on affordability, especially for the lower-income households. Contrary to the long-term cointegrating relationship among the abovementioned indicators for the residential Turkish real estate market, there is no short-term causality between the real housing price index, real rents, and price-to-rent ratio. The results support Cheung, Tsang and Mak (1995), Chen and Chiang (2021), and Mikhed and Zemcik (2009) for Hong Kong, Beijing, Shanghai, Shenzhen, and the US, respectively.

Table 13 exhibits the statistical insignificance of the causal relationships between the real housing price index and its predictors: the USDTRY foreign exchange rate and XMGYO index closing prices. Similarly, real gross minimum wage, the USDTRY foreign exchange rate, and XMGYO index closing prices have no causal influence on the real rent prices. Similarly, covering the period ranging from March 2010 to March 2020, Jawadi and Sellami (2021) cannot detect any causal relationship between the USDEUR exchange rate, stock markets, and housing prices for the US case. Lou (2017) presents contradicting evidence for the cases of Portugal, Italy, Greece, and Spain (PIGS), exhibiting a bidirectional relationship between real estate and stock returns in Italy, Greece, and Spain. However, the Portuguese real estate market offers unidirectional causality running from stock returns to real estate returns.

Table 13 illustrates the absence of causal relationships between the real housing price index and real gross minimum wage. Income is one of the fundamental core predictors of housing affordability both in the long and the short term. In addition, income, where the gross minimum wage is the proxy for income in this study, determines a household's ability to afford monthly mortgage installments. The empirical evidence in this dissertation promotes the study of Hort (1998), revealing that income does not influence housing prices for Swedish urban areas between 1967 and 1994. On the contrary, the findings of this study yielded different results than other studies. Oikarinen (2009), splitting the data into two forms, finds a bidirectional relationship between income and Helsinki housing prices between 1986:Q1 and 2006:Q2. A unidirectional causality runs from income to housing prices spanning from 1975:Q1 to 1985:Q4. Luo, Liu and Picken (2007) present that income Granger causes Australian house prices from 1989:M09 to 1996:M12.

The results in Table 13 exhibit bidirectional causality running from XMGYO index closing prices to the USDTRY foreign exchange rates. The Toda-Yamamoto causality test results cannot detect any causal relationship between real gold prices and the USDTRY foreign exchange rate. Similarly, there are no short-term linkages between real gold prices and XMGYO index closing prices. The results imply that these financial products are not complementary or suitable alternatives for real estate investing. This study provides conflicting results for Kirikkaleli, Athari and Ertugrul (2021), finding out that the foreign exchange rate, gold price, and stock market induce changes in XMGYO index closing prices.

### *6.4. Impulse Response Functions*

The impulse response functions (IRFs) are based on a moving average representation of the VAR model (Yuan et al., 2008). The IRFs assess the dynamic reactions of the dependent variable to a predictor across time. This dissertation employs generalized impulse response functions (IRFs) (Pesaran and Shin, 1998) to observe the effect of a one standard deviation shock to one variable on another one's current and future values over a 12-period horizon.

Figure 21, Figure 22, and Figure 23 exhibit the IRFs results for 12 periods with asymptotic standard errors. Since Vardar and Özgüler (2015) exhibit only the outcome for the dependent variable and its exogenous variables, this study with VAR composing of RHPI and its eleven regressors presents only the IRFs outcome among RHPI and its regressors for spare space. The following figures display the point estimates of the IRFs by straight blue lines. However, dotted yellow lines demonstrate a two standard deviation band around point estimates.

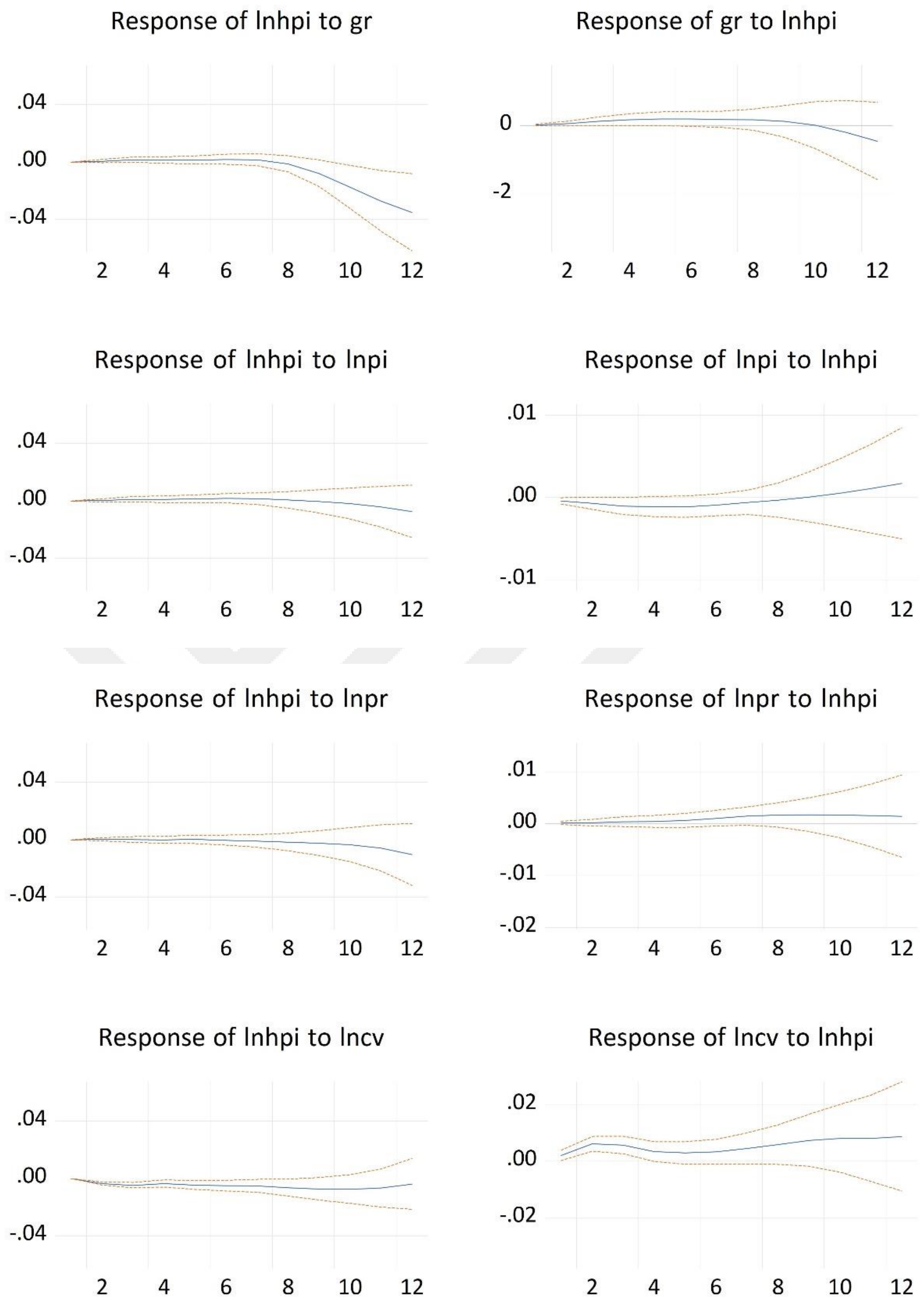



Figure 21. The Generalized Impulse Responses Between RHPI, Growth Rate, Price-to-Income, Price-to-Rent, and Credit Volume

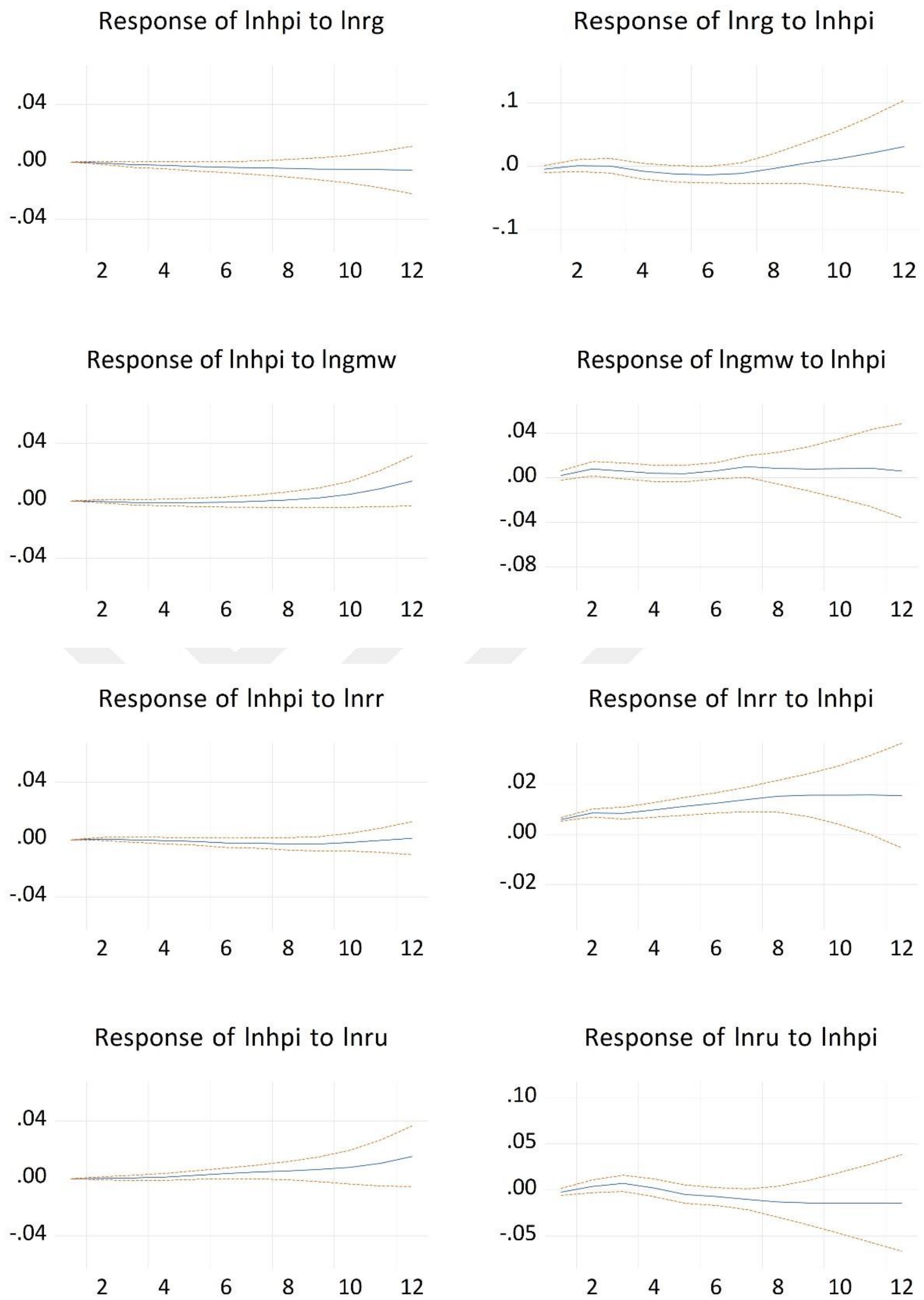



Figure 22. The Generalized Impulse Responses Between RHPI, Gold Prices, Gross Minimum Wage, RR, and USDTRY Foreign Exchange Rate

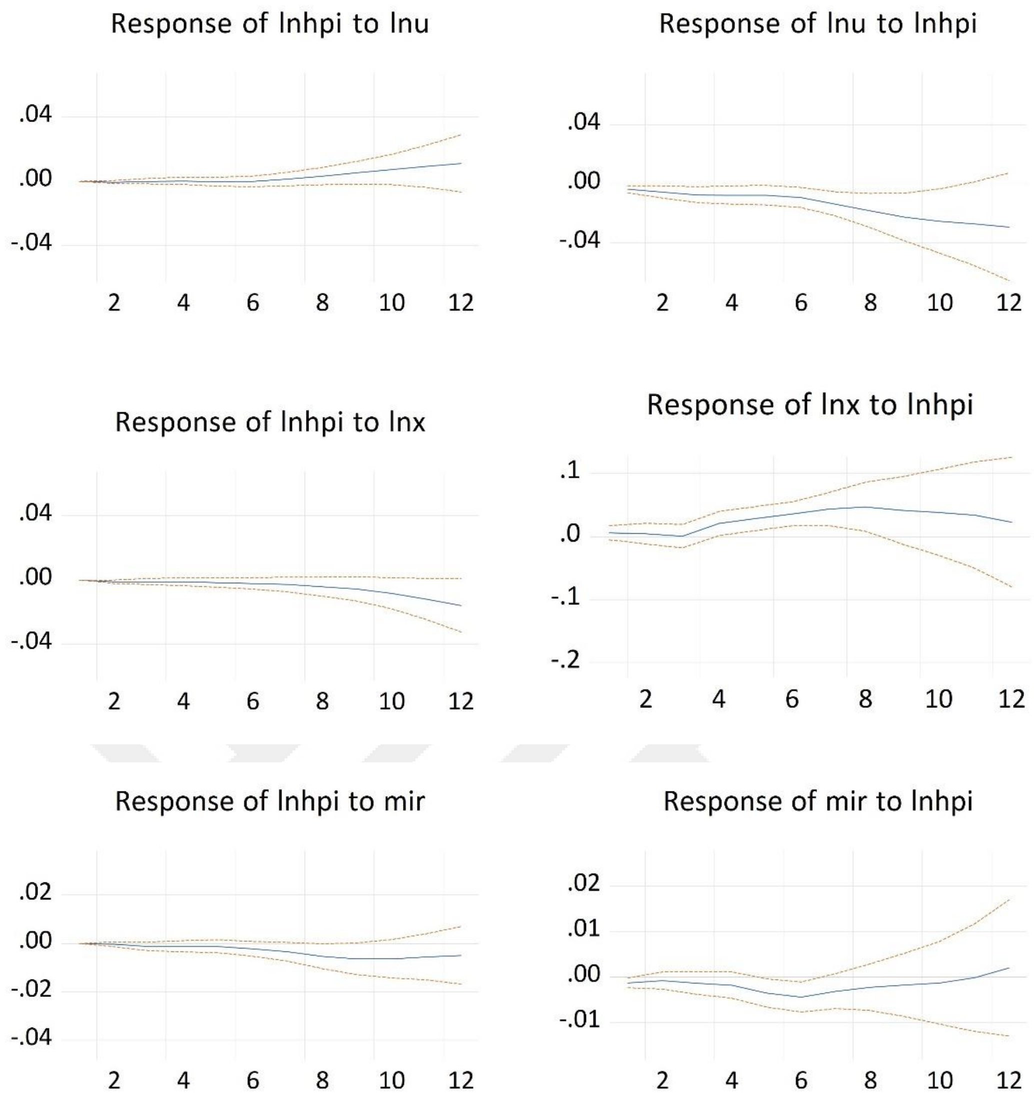



Figure 23. The Generalized Impulse Responses Between RHPI, Unemployment, XMGYO Index Closing Prices, and Mortgage Rates

Yuan et al. (2008) propose a rule of thumb for the significance of the reactions of the dependent variable to regressor shocks and vice versa on the condition that the bands cross point zero. Accordingly, Figure 21 exhibits that growth rate shock to the RHPI is significant and initially neutral and slowly decreases over the horizons. Concerning significant and positive credit volume responses to RHPI shocks and enervate quickly in four months. However, housing price exuberances trigger rises in credit volume after the sixth month of the shock. In addition, the rest of the IRFs in Figure 21 are insignificant.

Figure 22 demonstrates that the real gross minimum wage positively responds to a standard deviation shock in RHPI. However, the positive effects commence diminishing after the second month, while the rest of the IRFs in Figure 22 are insignificant.

Figure 23 indicates that the RHPI shock to unemployment is significant and negative and slowly decreases over the horizons, implying that the construction corporations prefer building new residences due to increasing prices resulting in decreases in the unemployment rate. In addition, the significant and negative response of mortgage rates to RHPI stops in the sixth month and starts to increase after the seventh month. Remarkably, the response of the mortgage rate becomes positive in the twelfth month. Considering significant and positive XMGYO Index closing prices' responses to RHPI shocks and enervate quickly in three months. However, housing price exuberances trigger rises in the closing prices of the XMGYO index stocks after the shock's third month, but the effects weaken through the twelve-month horizon. On the contrary, the rest of the IRFs in Figure 23 are insignificant.

# CHAPTER 7: CONCLUDING REMARKS

Price exuberances are causing an ongoing debate concerning bubble formations in the Turkish real estate market. There are limited studies on the Turkish experience; therefore, this dissertation surveys the housing price bubbles within the price convergence framework and aims to explain the housing price index and rent dynamics via the ARDL bounds test approach. In particular, to the best of the author's knowledge, no study focusing on the Turkish housing market attempts to disconfirm the existence of a bubble and measure the magnitude and timing of overvaluations through DCF estimates. In addition to all these aforementioned empirical approaches, this research investigates the short-term causality relationship of the RHPI and its predictors with the Toda-Yamamoto causality test.

From this outlook, this specific research aims to fill this gap in the relevant literature within the housing bubbles framework and has the potential to guide future studies in emerging markets. This study contributes to the existing literature in three main ways. First, this preliminary study examines bubble existence in the Turkish housing market through various approaches: ARDL cointegration, DCF, and GSADF. Second, this study is innovative in using two ARDL estimates for the Turkish RHPI and RRs as dependent variables. Finally, and perhaps most significantly, the research is novel in using one of the most extensive data sets to date in terms of multidimensionality and its period length among studies investigating Turkish housing dynamics with 11 different predictors through 2003:M01–2019:M12. However, this presented evidence requires careful assessment due to acknowledged limitations in the ARDL and DCF approaches. In addition, the REIDIN TR7 housing price index is limited to seven Turkish provinces, representing 42.37% of Turkey's population.

The dissertation provides four valuable insights into the Turkish housing market dynamics. First, the findings denote the positive role of rents and price-to-rent ratio and the adverse role of mortgage rates on housing price dynamics. More strikingly, the results suggest that rents have a more substantial impact than mortgage rates on house prices. This relatively low impact of mortgage rates on house prices and rents raises suspicions of asymmetric relationships. Second, ARDL cointegration evidence suggests that house prices and rents in Turkey have similar fundamentals. Third, the empirical results exhibiting the positive impact of real rents and the adverse effect of mortgage rates on house prices support the theory of investment value, which finds the fundamental value of a house by discounting future rent flows to the present with the mortgage rate. A final and perhaps the key finding in this study is that the ARDL and DCF estimates exhibit those fundamental prices exceed the observed housing prices in most of the 2003M01–2019M12 period, revealing that house purchase continues as an attractive long-term investment for the Turkish case, even at current market prices.

The relationship between housing and rental prices forms the fundamentals of the Turkish housing market since the empirical evidence rejects the null hypothesis of no cointegrating relationship. The presence of excessive increases in the price-to-rent ratio may indicate the formation of a bubble in housing prices, reviving affordability concerns, especially for lower-income households. The housing and rental price growth are cyclically the root cause of exuberances in each other.

The surveillance of bubble existence supports the ARDL cointegration evidence within the price convergence framework via DCF estimates and ARDL in-sample forecasts of house price fundamentals. The results indicate overvaluations of up to 7.97%, substantially below 20%, the threshold for bubbles determined in previous studies (see Section 4.3). These separations between actual and fundamental prices in the Turkish housing market are rare, small in magnitude, and temporal. The models adjust about 81.17% for the RHPI and 82.60% for RRs of any movements into disequilibrium within one period. In addition, the GSADF results reject the null hypothesis of no explosive behavior and reveal that explosive behaviors in real estate prices are compatible with implosions or decreases in fundamentals, including mortgage rates, rent prices, and price-to-rent ratio.

The Toda-Yamamoto causality results reject the null hypothesis of no causal relationship between RHPI, banking credit, and mortgage rates. The results confirm that banking credit and changes in mortgage rates trigger the housing demand. Seasonal construction halts, especially during winter, cause an increasing unemployment rate and housing prices. The government and the CBRT may increase interest rates to put an end to the exuberance in housing prices. On the other hand, nominal residential real estate prices may remain sticky due to two-digit inflation figures. Under the given scenario, the government should expect a decrease in building activity and a rise in unemployment rates. The Toda-Yamamoto outcome implies that even though inefficiencies in the residential real estate market cause variations in the price-to-income ratio, market corrections eventually take effect, sustaining the total equilibrium point between house prices and household income.

These results offer crucial implications for investors. The findings imply that a potential real estate buyer reaches a decision comparing the investment return of houses through price-to-rent ratio dynamics. Due to the high depreciation of the Turkish Lira, households prefer to keep their savings in TRY/FX or gold deposit accounts, and foreign exchange deposits have become an alternative investment tool in Turkey. In addition, foreign and institutional investors outnumber domestic investors in the stock exchange market. The findings imply that the financial instruments examined in this study with different return potentials are neither complementary nor competitive because the USDTRY exchange rate, gold prices, and XMGYO index closing prices have no or limited influence on RHPI. Accordingly, each investment instrument may have its own dynamics.

The lack of relationship between house prices and income revives affordability concerns for the lower-income groups. As the growth in housing prices exceeds income growth, a significant sector of the lower-income groups cannot afford to buy a new house and is thus excluded from benefitting from the current housing policies. The empirical evidence highlights the compulsory long-run housing policy objectives to advance housing affordability by considering price-to-income and gross minimum wage.

In order to address the issue of affordable housing by increasing the income and welfare level, the determination of requirements is necessary. An explicit map of the requirements should include the coordination of academic, institutional, financial, legal, economic, demographic, and social integration and cohesion between each other. In addition, this dissertation suggests that the government should ensure fair income distribution and increase the availability of affordable housing to lower-income groups by stabilizing house prices both in the short and long term. A more profound regulation and strict audit of the profits of construction companies and homeowners is necessary for house price stabilization.

In any case, the Turkish governments and CBRT may apply for Canadian and Italian housing policies, including:

- the transfer of ownership for a small fee in exchange for a promise of renovation in rural areas,
- extending the maturity period of mortgage loans to 30 years,
- rent-to-own agreements,
- providing incentives for first-time homeowners up to 10% of the purchase price.

However, extending the mortgage loan maturity is not enough to trigger an affordable credit policy due to high mortgage rates. Other possible measures involve supporting banks by terminating compulsory and special provision rates for mortgage loans and introducing tax exemptions on mortgage loan profits to reduce banks' cost of capital. These measures may also trigger lower mortgage rates.

Another approach to decrease housing prices for policymakers is to offer incentives to support block-based urban transformation projects instead of apartment renovation-based ones for supply generation. These include rent assistance for homeowners, social security premium and value-added tax (VAT) supports, and attractive loan offers for construction companies. These policies will make buying a first home more accessible, equitable, and affordable for lower-income groups.

Policies focusing on the construction sector's growth remain at a limited level for tenants. Turkish authorities may provide a variety of alternatives for low-income tenants, including the guarantee of finding a new house at the expiration date of the lease, a lifetime tenancy warranty, and an option to transfer the lease. Other measures to support affordable renting policy in the metropolitans are as follows: upper rent limits; monthly rent support exempt from income tax, which is set according to the households' income and the number of children; and the provision of state-owned residences for rent. Therefore, these incentives may reduce income disparity and promote an affordable rental policy in the Turkish real estate market.

Consequently, this dissertation provides a specific framework for future studies in emerging markets to test the bubble presence in the real estate market. Scholars may apply the price convergence framework in different emerging markets in a period affected by the end of the Federal Reserve and European Central Bank's monetary expansion and post-COVID-19 conditions. For the Turkish experience, the non-linear effects on housing prices may be the focus of future research on other macroeconomic variables. In addition to the benefits for scholars, identifying ways to measure the housing price affordability index may also be a valuable tool for investors, governments, and other housing-related organizations.

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# APPENDICES

## *Appendix A. Variable Definitions*

Table 14. Variable Definitions

| Variable | Source | Frequency | Explanation | Group |
|---|---|---|---|---|
| *lncpi* | TSI* | Monthly | Natural Logarithm of Consumer's Price Index | Economic |
| *lnrg* | FRED* | Quarterly** | Natural Logarithm of Real Gross Domestic Product | Economic |
| *gr* | TSI* | Quarterly** | GDP Growth Rate (%) | Economic |
| *lnipi* | CBRT EDDS Data Central* | Monthly | Natural Logarithm of Industrial Production Index | Economic |
| *lngmw* | Ministry of Labor and Social Security | Monthly | Natural Logarithm of Real Gross Minimum Monthly Wage | Economic |
| *lnhdtgdp* | BIS* | Quarterly** | Natural Logarithm of Household Debt to GDP | Economic |
| *lnu* | TSI* | Monthly | Natural Logarithm of Unemployment Rate | Economic |
| *cgr* | BRSA* | Quarterly** | Credit Growth Rate | Economic |
| *lncv* | BRSA* | Quarterly** | Natural Logarithm of Real Credit Volume | Economic |
| *lnyu* | TSI* | Quarterly** | Natural Logarithm of Unemployment Rate for Young Population | Economic |
| *lnbist100* | CBRT EVDS Data Central* | Monthly | Natural Logarithm of BIST100 Index Closing Prices | Financial |
| *lnrg* | CBRT EVDS Data Central* | Monthly | Natural Logarithm of Real Republican Gold Sale Price (TRY / Piece) | Financial |
| *lnru* | CBRT EVDS Data Central* | Monthly | Natural Logarithm of Real USDTRY Exchange Rate | Financial |
| *lnx* | Bloomberg | Monthly | Natural Logarithm of XMGYO Index Closing Prices | Financial |
| *lnbpkm2* | TSI* | Monthly | Natural Logarithm of Building Permits per $km^2$ | HSR* |
| *lnho* | EUROSTAT | Yearly** | Natural Logarithm of Home Ownership Rate (%) | HSR* |
| *lnpr* | REIDIN | Monthly | Natural Logarithm of Rate of Average Price to Rent per $m^2$ | HSR* |
| *lncc* | CBRT EVDS Data Central* | Monthly*** | Natural Logarithm of Real Construction Cost Index (2005=100) | HSR* |
| *lnhpi* | REIDIN | Monthly | Natural Logarithm of Real TR7 Housing Price Index | HSR* |
| *lnrr* | REIDIN | Monthly | Natural Logarithm of Average Real Rent per $m^2$ | HSR* |
| *lnpi* | REIDIN & TSI* | Monthly | Natural Logarithm of Median House Prices divided by Median Income | HSR* |
| *mir* | CBRT EVDS Data Central* | Monthly | Average Mortgage Rates | HSR* |

Notes to Table 14:

*TSI, FRED, CBRT, BIS, BRSA, and HSR connote Turkish Statistical Institute, Federal Reserve Economic Data, Central Bank of the Republic of Turkey, Bank of International Settlements and Banking Regulation and Supervision Agency, and Housing Sector Related, respectively.

**The quarterly and yearly series were transformed into monthly series by employing the cubic spline interpolation method.

***2003 and 2004 series of the *lnrealconstructioncosts* are calculated by taking the first difference of the Construction Cost Index (2003=100) series and transforming the differences backward from 2005-01 of the Turkish Statistical Institute's Construction Cost Index (2005=100) series up to 2003-01.

## *Appendix B. Unit Root Test Results*

Table 15. ADF Unit Root Test Results

| Variables | Model: Intercept | | | | Model: Trend & Intercept | | | |
|---|---|---|---|---|---|---|---|---|
| | Level | | First Difference | | Level | | First Difference | |
| | *ADF t-stats* | *Lag(s)* | *ADF t-stats* | *Lag(s)* | *ADF t-stats* | *Lag(s)* | *ADF t-stats* | *Lag(s)* |
| *lnbist100* | -2.34 | 0 | -14.97*** | 0 | -3.00 | 0 | -15.03*** | 0 |
| *lnbpkm2* | -3.32** | 2 | -15.31 | 1 | -2.94 | 2 | -15.44*** | 1 |
| *lncpi* | 1.68 | 1 | -10.67*** | 0 | -0.18 | 1 | -10.85*** | 0 |
| *lngdp* | -0.80 | 13 | -2.53 | 14 | -2.11 | 13 | -2.56 | 14 |
| *gr* | -3.67*** | 13 | -3.99 | 14 | -3.57** | 13 | -3.97 | 14 |
| *lnho* | -2.60 | 12 | -0.15 | 10 | -2.84 | 12 | 0.49 | 10 |
| *lnhdtgdp* | -3.45** | 12 | -2.10 | 11 | -4.03*** | 13 | -2.18 | 11 |
| *lnipi* | -1.00 | 2 | -17.15*** | 1 | -2.34 | 2 | -17.12*** | 1 |
| *lnpr* | -3.48*** | 1 | -4.01 | 0 | -4.44*** | 1 | -5.13 | 0 |
| *lncc* | -1.66 | 1 | -9.43*** | 0 | -1.67 | 1 | -9.44*** | 0 |
| *lnrg* | -0.47 | 2 | -10.45*** | 1 | -2.74 | 1 | -10.44*** | 1 |
| *lngmw* | -2.14 | 0 | -15.04*** | 0 | -3.23 | 0 | -15.05*** | 0 |
| *lnhpi* | -1.77 | 3 | -3.52*** | 2 | -1.78 | 3 | -3.51** | 2 |
| *lnrr* | -2.65 | 3 | -3.59*** | 2 | -2.53 | 3 | -3.84** | 2 |
| *lnru* | -2.43 | 2 | -10.69*** | 1 | -2.45 | 2 | -11.09*** | 1 |
| *lnu* | -2.36 | 4 | -4.91*** | 3 | -2.90 | 4 | -4.92*** | 3 |
| *cgr* | -11.25*** | 0 | -10.22 | 5 | -11.22*** | 0 | -10.21 | 5 |
| *lncv* | -0.70 | 3 | -5.71*** | 2 | -1.28 | 3 | -5.71*** | 2 |
| *lnpi* | -4.30*** | 3 | -7.14 | 6 | -5.88*** | 3 | -6.87 | 6 |
| *lnx* | -3.17** | 0 | -13.37 | 0 | -2.91 | 0 | -13.44*** | 0 |
| *lnyu* | -1.29 | 13 | -3.61*** | 14 | -1.22 | 13 | -3.60*** | 14 |
| *mir* | -5.31*** | 2 | -9.42 | 1 | -4.80*** | 2 | -9.74 | 1 |

Notes to Table 15: Table 14 describes the definitions of the variables. The null hypothesis is the existence of a unit root that concludes the series are random walk for the ADF test. In the tables, superscripts *** and ** denote the rejection of the null hypothesis at 1% and 5% significance levels, respectively. The term t-stats represents test statistics. ADF critical values are due to Mac Kinnon (1996). Three lag selection information criteria are performed in order to confirm the results in this study, namely Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), and Hannan-Quinn Information

Criterion (HQIC). Stationarity values of the variables were determined according to the 5% significance level. The critical values are -3.46, -2.88, and -2.57 at 1%, 5%, and 10%, respectively for the intercept model. The critical values for the trend and intercept model are -4.00, -3.43, and -3.14 at 1%, 5%, and 10%, respectively.

Table 16. Phillips-Perron Unit Root Test Results

| Variables | Model: Intercept | | | | Model: Trend & Intercept | | | |
|---|---|---|---|---|---|---|---|---|
| | Level | | First Difference | | Level | | First Difference | |
| | PP t-stats | Bandwidth | PP t-stats | Bandwidth | PP t-stats | Bandwidth | PP t-stats | Bandwidth |
| *lnbist100* | -2.36 | 1 | -14.95*** | 2 | -3.00 | 2 | -15.03*** | 1 |
| *lnbpkm2* | -4.13*** | 5 | -28.40 | 11 | -4.95*** | 6 | -32.26 | 14 |
| *lncpi* | 1.67 | 2 | -10.70*** | 1 | 0.18 | 2 | -10.72*** | 4 |
| *lngdp* | -1.44 | 3 | -3.61*** | 47 | -2.40 | 3 | -3.63** | 46 |
| *gr* | -3.04** | 21 | -3.68 | 57 | -3.01 | 21 | -3.64*** | 57 |
| *lnho* | -1.31 | 9 | -5.83*** | 7 | -2.43 | 9 | -5.69*** | 8 |
| *lnhdtgdp* | -7.44*** | 9 | -2.55 | 5 | -3.12 | 8 | -4.02*** | 5 |
| *lnipi* | -0.91 | 9 | -39.22*** | 5 | -8.98*** | 9 | -39.19 | 5 |
| *lnpr* | -2.82 | 10 | -4.01*** | 0 | -3.49** | 9 | -5.07 | 3 |
| *lncc* | -1.51 | 5 | -9.50*** | 5 | -1.50 | 4 | -9.51*** | 5 |
| *lnrg* | -0.34 | 2 | -11.47*** | 6 | -2.65 | 1 | -11.44*** | 6 |
| *lngmw* | -2.12 | 5 | -15.04*** | 5 | -3.27 | 6 | -15.06*** | 5 |
| *lnhpi* | -1.31 | 10 | -7.88*** | 8 | -1.33 | 10 | -7.87*** | 8 |
| *lnrr* | -1.96 | 10 | -7.56*** | 8 | -1.69 | 10 | -7.96*** | 8 |
| *lnru* | -2.45 | 0 | -9.67*** | 6 | -2.43 | 4 | -9.77*** | 8 |
| *lnu* | -2.05 | 8 | -9.75*** | 7 | -2.32 | 8 | -9.73*** | 7 |
| *cgr* | -11.82*** | 7 | -60.49 | 31 | -11.79*** | 7 | -63.48 | 32 |
| *lncv* | -0.35 | 8 | -11.53*** | 6 | -1.58 | 8 | -11.50*** | 6 |
| *lnpi* | -4.03*** | 8 | -4.95 | 19 | -4.98*** | 5 | -5.20 | 19 |
| *lnx* | -3.18** | 5 | -13.49 | 5 | -3.06 | 5 | -13.49*** | 4 |
| *lnyu* | -1.12 | 0 | -3.20** | 43 | -1.78 | 1 | -3.12 | 43 |
| *mir* | -3.76*** | 3 | -8.86 | 8 | -3.31 | 3 | -8.92*** | 10 |

Notes to Table 16: Table 14 describes the definitions of the variables. The null hypothesis is the existence of a unit root that concludes the series are stationary for the PP test. In the tables, superscripts *** and ** denote the rejection of the null hypothesis at 1% and 5% significance levels, respectively. The term t-stats represents test statistics. PP critical values are due to Phillips and Perron (1988). Three lag selection information criteria are performed in order to confirm the results in this study, namely Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), and Hannan-Quinn Information Criterion (HQIC). Stationarity values of the variables were determined according to the 5% significance level. The critical values are -3.46, -2.88, and -2.57 at 1%, 5%, and 10%, respectively for the intercept model. The critical values for the trend and intercept model are -4.00, -3.43, and -3.14 at 1%, 5%, and 10%, respectively.

Table 17. KPSS Unit Root Test Results

| Variables | Model: Intercept | | | | Model: Trend & Intercept | | | |
|---|---|---|---|---|---|---|---|---|
| | Level | | First Difference | | Level | | First Difference | |
| | LM t-stats | Bandwidth | LM t-stats | Bandwidth | LM t-stats | Bandwidth | LM t-stats | Bandwidth |
| *lnbist100* | 1.57 | 11 | 0.19*** | 1 | 0.22 | 10 | 0.05*** | 1 |
| *lnbpkm2* | 0.88 | 10 | 0.21*** | 23 | 0.23 | 10 | 0.06*** | 26 |
| *lncpi* | 1.79 | 11 | 0.40*** | 4 | 0.23 | 11 | 0.19 | 2 |
| *lngdp* | 1.76 | 11 | 0.14*** | 2 | 0.09*** | 11 | 0.07 | 3 |
| *gr* | 0.13*** | 6 | 0.06 | 28 | 0.07*** | 6 | 0.06 | 28 |
| *lnho* | 0.74 | 11 | 0.22*** | 9 | 0.22 | 11 | 0.16 | 9 |
| *lnhdtgdp* | 1.29 | 11 | 1.35 | 10 | 0.42 | 11 | 0.15 | 9 |
| *lnipi* | 1.74 | 11 | 0.04*** | 9 | 0.12*** | 10 | 0.04 | 9 |
| *lnpr* | 0.38*** | 11 | 1.03 | 10 | 0.38 | 11 | 0.30 | 10 |
| *lncc* | 0.23*** | 11 | 0.14 | 4 | 0.24 | 11 | 0.07*** | 4 |
| *lnrg* | 1.61 | 11 | 0.09*** | 2 | 0.20 | 11 | 0.08*** | 2 |
| *lngmw* | 1.51 | 11 | 0.10*** | 5 | 0.09*** | 10 | 0.06 | 5 |
| *lnhpi* | 0.32*** | 11 | 0.18 | 10 | 0.31 | 11 | 0.17 | 10 |
| *lnrr* | 0.14*** | 11 | 0.30 | 10 | 0.12*** | 11 | 0.14 | 10 |
| *lnru* | 0.43*** | 11 | 0.54 | 1 | 0.43 | 11 | 0.04*** | 5 |
| *lnu* | 0.48 | 11 | 0.07*** | 8 | 0.13*** | 11 | 0.06 | 8 |
| *cgr* | 0.28*** | 8 | 0.16 | 48 | 0.28 | 8 | 0.14*** | 49 |
| *lncv* | 1.77 | 11 | 0.28*** | 8 | 0.20 | 11 | 0.28 | 8 |
| *lnpi* | 0.30*** | 10 | 0.62 | 8 | 0.21*** | 10 | 0.07 | 8 |
| *lnx* | 0.84 | 11 | 0.19*** | 5 | 0.12*** | 11 | 0.07 | 5 |
| *lnyu* | 0.15*** | 11 | 0.11 | 1 | 0.15 | 11 | 0.05*** | 2 |
| *mir* | 0.89 | 10 | 0.35*** | 3 | 0.33 | 10 | 0.09*** | 1 |

Notes to Table 17: Table 14 describes the definitions of the variables. The null hypothesis is that the series has no unit root. The null hypothesis concludes that the series are non-stationary for the KPSS test. In the tables, superscripts *** and ** denote the rejection of the null hypothesis at 1% and 5% significance levels, respectively. The term t-stats represents test statistics. KPSS critical values from Kwiatkowski et. al (1992). Three lag selection information criteria are performed in order to confirm the results in this study, namely Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), and Hannan-Quinn Information Criterion (HQIC). Stationarity values of the variables were determined according to the 5% significance level. The critical values are 0.74, 0.44, and 0.35 at 1%, 5%, and 10%, respectively for the intercept model. The critical values are 0.22, 0.15, and 0.12 at 1%, 5%, and 10%, respectively for the trend and intercept model.

Table 18. DF-GLS Unit Root Test Results

| *Variables* | Model: Intercept | | | | Model: Trend & Intercept | | | |
|---|---|---|---|---|---|---|---|---|
| | Level | | First Difference | | Level | | First Difference | |
| | *DF-GLS t-stats* | *Lag(s)* | *DF-GLS t-stats* | *Lag(s)* | *DF-GLS t-stats* | *Lag(s)* | *DF-GLS t-stats* | *Lag(s)* |
| *lnbist100* | 0.81 | 0 | -8.01*** | 1 | -1.49 | 0 | -14.73*** | 0 |
| *lnbpkm2* | -1.00 | 2 | -0.17 | 9 | -1.88 | 2 | -1.86 | 9 |
| *lncpi* | 4.06*** | 3 | -2.63 | 2 | -0.84 | 1 | -4.04*** | 2 |
| *lngdp* | 2.10** | 13 | -2.18 | 14 | -1.60 | 13 | -2.43 | 14 |
| *gr* | -3.67*** | 13 | -3.64 | 14 | -3.69*** | 13 | -3.64 | 14 |
| *lnho* | -2.63*** | 11 | -0.97 | 10 | -3.17** | 11 | -0.48 | 10 |
| *lnhdtgdp* | -0.31 | 14 | -2.33*** | 11 | -1.78 | 14 | -2.39 | 11 |
| *lnipi* | 1.35 | 2 | -0.29 | 11 | -2.35 | 2 | -2.23 | 11 |
| *lnpr* | -0.40 | 1 | -2.09** | 1 | -0.79 | 1 | -2.53 | 1 |
| *lncc* | -1.69 | 1 | -9.21*** | 0 | -1.75 | 1 | -9.47*** | 0 |
| *lnrg* | 0.40 | 1 | -1.51 | 5 | -2.15 | 1 | -8.63*** | 0 |
| *lngmw* | 0.51 | 0 | -2.44** | 5 | -1.98 | 0 | -13.62*** | 0 |
| *lnhpi* | -1.46 | 3 | -2.91*** | 2 | -1.67 | 3 | -3.37** | 2 |
| *lnrr* | -1.25 | 3 | -2.15** | 2 | -1.65 | 3 | -2.78 | 2 |
| *lnru* | -0.55 | 2 | -4.44*** | 2 | -0.57 | 2 | -6.89*** | 2 |
| *lnu* | -1.15 | 4 | -3.89*** | 3 | -2.86 | 4 | -4.76*** | 3 |
| *cgr* | -2.60*** | 2 | -0.79 | 10 | -4.03*** | 2 | -15.64 | 1 |
| *lncv* | 1.43 | 3 | -3.28*** | 2 | -1.16 | 3 | -4.52*** | 2 |
| *lnpi* | -0.63 | 3 | -1.02 | 6 | -0.75 | 3 | -3.04** | 6 |
| *lnx* | 0.01 | 0 | -2.58*** | 4 | -1.23 | 0 | -12.22*** | 0 |
| *lnyu* | -1.36 | 13 | -2.51** | 14 | -1.41 | 13 | -2.98** | 14 |
| *mir* | -0.07 | 2 | -9.27*** | 1 | -1.19 | 2 | -9.39*** | 1 |

Notes to Table 18: Table 14 describes the definitions of the variables. The null hypothesis is the existence of a unit root that concludes the series are random walk for the DF-GLS test. In the tables, superscripts *** and ** denote the rejection of the null hypothesis at 1% and 5% significance levels, respectively. The term t-stats represents test statistics. The DFGLS for the drift term (μ) follows the critical values of Mac Kinnon (1996), while the asymptotic distributions for the drift and deterministic trend are obtained from Elliot et al. (1996, Table I, pp. 825). Three lag selection information criteria are performed in order to confirm the results in this study, namely Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), and Hannan-Quinn Information Criterion (HQIC). Stationarity values of the variables were determined according to the 5% significance level. The critical values are -3.46, -2.88, and -2.57 at 1%, 5%, and 10%, respectively for the intercept model. The critical values for the trend and intercept model are -4.00, -3.43, and -3.14 at 1%, 5%, and 10%, respectively.

Table 19. ERS Point Optimal Unit Root Test Results

| *Variables* | Model: Intercept | | | | Model: Trend & Intercept | | | |
|---|---|---|---|---|---|---|---|---|
| | Level | | First Difference | | Level | | First Difference | |
| | *ERS t-stat* | *k* | *ERS t-stat* | *k* | *ERS t-stat* | *k* | *ERS t-stat* | *k* |
| *lnbist100* | 111.47 | 0 | 0.29*** | 0 | 22.70 | 0 | 0.97*** | 0 |
| *lnbpkm2* | 14.78 | 2 | 0.85*** | 1 | 13.59 | 2 | 1.34*** | 1 |
| *lncpi* | 2879.65 | 1 | 0.94*** | 0 | 24.96 | 1 | 1.90*** | 0 |
| *lngdp* | 703.17 | 13 | 4.20 | 14 | 14.66 | 13 | 13.41 | 14 |
| *gr* | 0.26*** | 13 | 2.09 | 14 | 0.93*** | 13 | 7.31 | 14 |
| *lnho* | 0.06*** | 12 | 101.45 | 10 | 0.27*** | 12 | 139.10 | 10 |
| *lnhdtgdp* | 1955.30 | 12 | 14.63 | 11 | 3718.41 | 13 | 29.73 | 11 |
| *lnipi* | 133.38 | 2 | 2.05** | 1 | 12.26 | 2 | 2.55*** | 1 |
| *lnpr* | 96.36 | 1 | 2.56** | 0 | 355.58 | 1 | 6.46 | 0 |
| *lncc* | 4.07 | 1 | 0.30*** | 0 | 13.26 | 1 | 1.05*** | 0 |
| *lnrg* | 49.84 | 2 | 0.74*** | 1 | 10.54 | 1 | 1.13*** | 1 |
| *lngmw* | 62.35 | 0 | 0.35*** | 0 | 13.88 | 0 | 1.03*** | 0 |
| *lnhpi* | 5.20 | 3 | 1.69*** | 2 | 15.06 | 3 | 4.94** | 2 |
| *lnrr* | 9.13 | 3 | 3.01** | 2 | 19.24 | 3 | 6.70 | 2 |
| *lnru* | 41.75 | 2 | 0.29*** | 1 | 69.80 | 2 | 0.60*** | 1 |
| *lnu* | 7.28 | 4 | 1.00*** | 3 | 5.23** | 4 | 2.99 | 3 |
| *cgr* | 0.80*** | 0 | 8.73 | 5 | 1.37*** | 0 | 28.70 | 5 |
| *lncv* | 290.55 | 3 | 1.26*** | 2 | 29.79 | 3 | 2.75*** | 2 |
| *lnpi* | 43.07 | 3 | 12.02 | 6 | 122.13 | 3 | 9.92 | 6 |
| *lnx* | 56.30 | 0 | 0.42*** | 0 | 32.47 | 0 | 1.13*** | 0 |
| *lnyu* | 6.52 | 13 | 0.04*** | 14 | 24.32 | 13 | 0.01*** | 14 |
| *mir* | 80.69 | 2 | 0.22*** | 1 | 51.26 | 2 | 0.79*** | 1 |

Notes to Table 19: Table 14 describes the definitions of the variables. The null hypothesis is that the unit root exists against the (trend-) stationary alternative for the ERS point optimal test. In the tables, superscripts *** and ** denote the rejection of the null hypothesis at 1% and 5% significance levels, respectively. The term t-stats represents test statistics. *k* denotes the lag length for the HACC corrected long-run variance using OLS spectral autoregression. It is chosen using Schwarz's information criteria for each case (with a maximum of 14 lags). The ERS critical values from Elliott et al. (1996). Stationarity values of the variables were determined according to the 5% significance level. The critical values for the intercept model are 1.94, 3.17, and 4.33 at 1%, 5%, and 10%, respectively. The critical values for the trend and intercept model are 4.05, 5.64, and 6.87 at 1%, 5%, and 10%, respectively.

Table 20. Ng-Perron Modified Unit Root Test Results

| Variables | Model: Intercept | | | | | | | | | | Result |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Level | | | | | First Difference | | | | | |
| | *MZa* | *MZt* | *MSB* | *MPT* | *k* | *MZa* | *MZt* | *MSB* | *MPT* | *k* | |
| *lnbist100* | 0.74 | 0.86 | 1.16 | 87.24 | 0 | -64.88 | -5.69 | 0.09 | 0.38 | 1 | I (1)*** |
| *lnbpkm2* | -1.81 | -0.90 | 0.50 | 12.85 | 2 | -0.01 | -0.01 | 1.60 | 132.50 | 9 | I (2)*** |
| *lncpi* | 1.99 | 6.41 | 3.23 | 805.86 | 3 | -12.68 | -2.51 | 0.20 | 1.95 | 2 | I (1)** |
| *lngdp* | 1.28 | 2.58 | 2.01 | 277.69 | 13 | -3.35 | -1.29 | 0.38 | 7.31 | 14 | I (2)*** |
| *gr* | -94.16 | -6.86 | 0.07 | 0.26 | 13 | -273.30 | -11.70 | 0.00 | 0.00 | 14 | I (0)*** |
| *lnho* | -174.71 | -9.34 | 0.05 | 0.14 | 11 | -0.11 | -0.13 | 1.25 | 81.28 | 10 | I (0)*** |
| *lnhdtgdp* | 0.33 | 0.47 | 1.44 | 117.78 | 14 | -1.75 | -0.92 | 0.53 | 13.87 | 11 | I (2)*** |
| *lnipi* | 1.32 | 1.63 | 1.23 | 109.59 | 2 | 0.48 | 1.19 | 2.49 | 351.90 | 11 | I (2)*** |
| *lnpr* | -0.43 | -0.38 | 0.88 | 39.86 | 1 | -8.78 | -2.04 | 0.23 | 3.02 | 1 | I (1)** |
| *lncc* | -6.83 | -1.71 | 0.25 | 4.07 | 1 | -84.30 | -6.49 | 0.08 | 0.29 | 0 | I (1)*** |
| *lnrg* | 0.68 | 0.45 | 0.66 | 32.18 | 1 | -4.23 | -1.39 | 0.33 | 5.90 | 5 | I (2)*** |
| *lngmw* | 0.63 | 0.54 | 0.86 | 49.41 | 0 | -6.37 | -1.78 | 0.28 | 3.87 | 5 | I (2)*** |
| *lnhpi* | -5.26 | -1.58 | 0.30 | 4.78 | 3 | -14.47 | -2.69 | 0.19 | 1.70 | 2 | I (1)*** |
| *lnrr* | -3.25 | -1.27 | 0.39 | 7.53 | 3 | -8.49 | -2.04 | 0.24 | 2.97 | 2 | I (1)** |
| *lnru* | -0.66 | -0.54 | 0.82 | 34.07 | 2 | -31.69 | -3.97 | 0.13 | 0.82 | 2 | I (1)*** |
| *lnu* | -3.44 | -1.06 | 0.31 | 7.07 | 4 | -19.37 | -3.11 | 0.16 | 1.27 | 3 | I (1)*** |
| *cgr* | -11.89 | -2.38 | 0.20 | 2.28 | 2 | -0.22 | -0.32 | 1.45 | 103.90 | 10 | I (0)** |
| *lncv* | 1.03 | 1.57 | 1.52 | 153.62 | 3 | -17.33 | -2.91 | 0.17 | 1.54 | 2 | I (1)*** |
| *lnpi* | -0.88 | -0.63 | 0.72 | 25.83 | 3 | -0.65 | -0.38 | 0.59 | 20.91 | 6 | I (2)*** |
| *lnx* | 0.04 | 0.04 | 0.85 | 42.99 | 0 | -9.14 | -2.13 | 0.23 | 2.69 | 4 | I (1)** |
| *lnyu* | -3.79 | -1.22 | 0.32 | 6.57 | 13 | -5.55 | -1.52 | 0.27 | 4.83 | 14 | I (2)*** |
| *mir* | 0.07 | 0.06 | 0.92 | 49.28 | 2 | -112.4 | -7.50 | 0.07 | 0.22 | 1 | I (1)*** |

| *Model* | Intercept | | | |
|---|---|---|---|---|
| *Level of Significance* | *MZa* | *MZt* | *MSB* | *MPT* |
| *1%* | -13.80 | *-2.58* | 0.17 | 1.78 |
| *5%* | -8.10 | *-1.98* | 0.23 | 3.17 |
| 10% | -5.70 | *-1.62* | 0.28 | 4.45 |

Notes to Table 20: Table 14 describes the definitions of the variables. The null hypothesis is the existence of a unit root for the NG-Perron modified unit root test. In the tables, superscripts *** and ** denote the rejection of the null hypothesis at 1% and 5% significance levels, respectively. k denotes the lag length using the GLS-detrended spectral autoregression. It is chosen using Schwarz's information criteria for each case (with a maximum of 14 lags). The critical values are from Ng and Perron (2001). Stationarity values of the variables were determined according to the 5% significance level.

Table 21. Ng-Perron Modified Unit Root Test Results (continued)

| *Variables* | Model: Trend & Intercept | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Level | | | | | First Difference | | | | | Result |
| | *MZa* | *MZt* | *MSB* | *MPT* | *k* | *MZa* | *MZt* | *MSB* | *MPT* | *k* | |
| *lnbist100* | -4.59 | -1.45 | 0.32 | 19.41 | 0 | -100.84 | -7.09 | 0.07 | 0.95 | 0 | I (1)** |
| *lnbpkm2* | -7.25 | -1.77 | 0.24 | 12.82 | 2 | -0.17 | -0.17 | 1.03 | 203.08 | 9 | I (2)** |
| *lncpi* | -2.90 | -0.87 | 0.30 | 23.32 | 1 | -26.47 | -3.61 | 0.14 | 3.60 | 2 | I (1)** |
| *lngdp* | -5.42 | -1.57 | 0.29 | 16.58 | 13 | -4.79 | -1.55 | 0.32 | 19.02 | 14 | I (2)** |
| *gr* | -103.37 | -7.19 | 0.07 | 0.89 | 13 | -470.86 | -153.44 | 0.00 | 0.00 | 14 | I (0)** |
| *lnho* | -52.96 | -5.14 | 0.10 | 1.77 | 11 | -0.70 | -0.39 | 0.56 | 65.05 | 10 | I (0)** |
| *lnhdtgdp* | -5.35 | -1.49 | 0.28 | 16.59 | 14 | -2.05 | -0.98 | 0.48 | 42.28 | 11 | I (2)** |
| *lnipi* | -7.55 | -1.94 | 0.26 | 12.06 | 2 | -0.20 | -0.27 | 1.35 | 334.30 | 11 | I (2)** |
| *lnpr* | -1.09 | -0.63 | 0.57 | 64.21 | 1 | -12.28 | -2.47 | 0.20 | 7.44 | 1 | I (2)** |
| *lncc* | -6.99 | -1.77 | 0.25 | 13.18 | 1 | -86.21 | -6.56 | 0.08 | 1.06 | 0 | I (1)** |
| *lnrg* | -9.36 | -2.15 | 0.23 | 9.80 | 1 | -79.70 | -6.31 | 0.08 | 1.16 | 0 | I (1)** |
| *lngmw* | -7.54 | -1.93 | 0.26 | 12.12 | 0 | -100.82 | -7.10 | 0.07 | 0.91 | 0 | I (1)** |
| *lnhpi* | -6.17 | -1.75 | 0.28 | 14.77 | 3 | -18.50 | -3.03 | 0.16 | 4.99 | 2 | I (1)* |
| *lnrr* | -7.23 | -1.80 | 0.25 | 12.79 | 3 | -13.35 | -2.58 | 0.19 | 6.86 | 2 | I (2)** |
| *lnru* | -1.12 | -0.57 | 0.51 | 53.35 | 2 | -75.50 | -6.14 | 0.08 | 1.22 | 2 | I (1)** |
| *lnu* | -16.83 | -2.89 | 0.17 | 5.48 | 4 | -29.34 | -3.81 | 0.13 | 3.23 | 3 | I (1)** |
| *cgr* | -24.31 | -3.49 | 0.14 | 3.75 | 2 | -156.80 | -8.85 | 0.06 | 0.59 | 1 | I (0)** |
| *lncv* | -3.03 | -1.16 | 0.38 | 28.40 | 3 | -28.81 | -3.79 | 0.13 | 3.16 | 2 | I (1)** |
| *lnpi* | -2.05 | -0.85 | 0.41 | 35.51 | 3 | -5.12 | -1.59 | 0.31 | 17.75 | 6 | I (2)** |
| *lnx* | -3.16 | -1.20 | 0.38 | 27.51 | 0 | -98.88 | -7.01 | 0.07 | 1.01 | 0 | I (1)** |
| *lnyu* | -3.90 | -1.28 | 0.33 | 21.93 | 13 | -13.33 | -2.55 | 0.19 | 7.03 | 14 | I (2)** |
| *mir* | -2.35 | -1.01 | 0.43 | 35.67 | 2 | -114.08 | -7.55 | 0.07 | 0.80 | 1 | I (1)** |

| *Model* | Trend & Intercept | | | |
|---|---|---|---|---|
| *Level of Significance* | *MZa* | *MZt* | *MSB* | *MPT* |
| *1%* | -23.80 | *-3.42* | 0.14 | 4.03 |
| *5%* | -17.30 | *-2.91* | 0.17 | 5.48 |
| 10% | -14.20 | *-2.62* | 0.19 | 6.67 |

Notes to Table 21: Table 14 describes the definitions of the variables. The null hypothesis is the existence of a unit root for the NG-Perron modified unit root test. In the tables, superscripts *** and ** denote the rejection of the null hypothesis at 1% and 5% significance levels, respectively. k denotes the lag length using the GLS-detrended spectral autoregression. It is chosen using Schwarz's information criteria for each case (with a maximum of 14 lags). The critical values are from Ng and Perron (2001). Stationarity values of the variables were determined according to the 5% significance level.

## *Appendix C. Autoregressive distributed lag (ARDL) Diagnostic Tests*

Table 22. ARDL Long-Run Form Cointegration Diagnostic Tests

| Test | F Statistic for lnhpi | p-value | F Statistic for lnrr | p-value |
|---|---|---|---|---|
| Breusch-Godfrey Serial Correlation Test | 1.71 | 0.19 | 2.13 | 0.12 |
| Breusch-Pagan-Godfrey Heteroskedasticity Test | 0.66 | 0.94 | 0.79 | 0.81 |
| Jarque-Bera Normality Test | 4.34 | 0.11 | 3.78 | 0.14 |
| Ramsey RESET Test | 0.07 | 0.79 | 0.45 | 0.50 |

Notes to Table 22: lnhpi and lnrr denote the natural logarithm of the real housing price index and real rent series, respectively. The diagnostic tests indicate no serial autocorrelation or model misspecification problems. The residuals are homoscedastic and normally distributed.

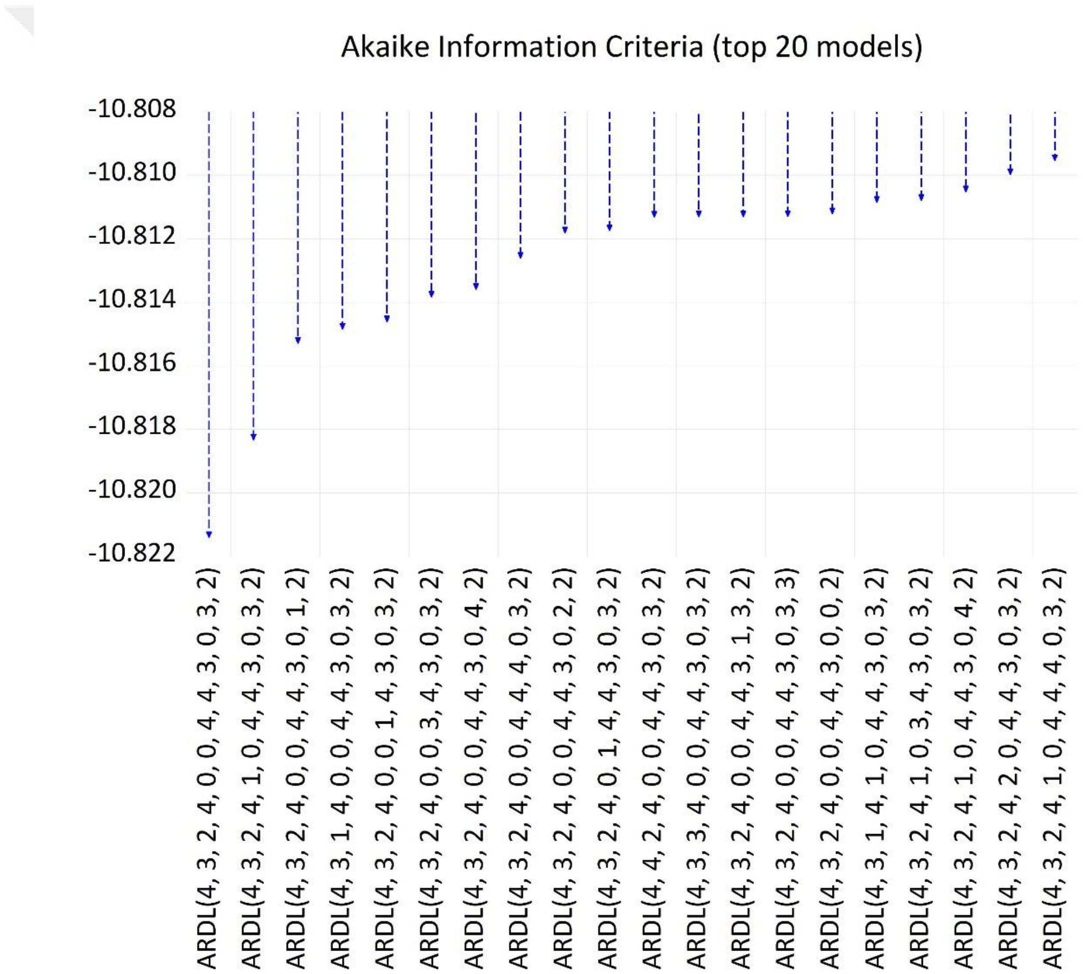


Figure 24. Optimal Lag Selection via Akaike Information Criteria for The Natural Logarithm of Real Housing Price Index

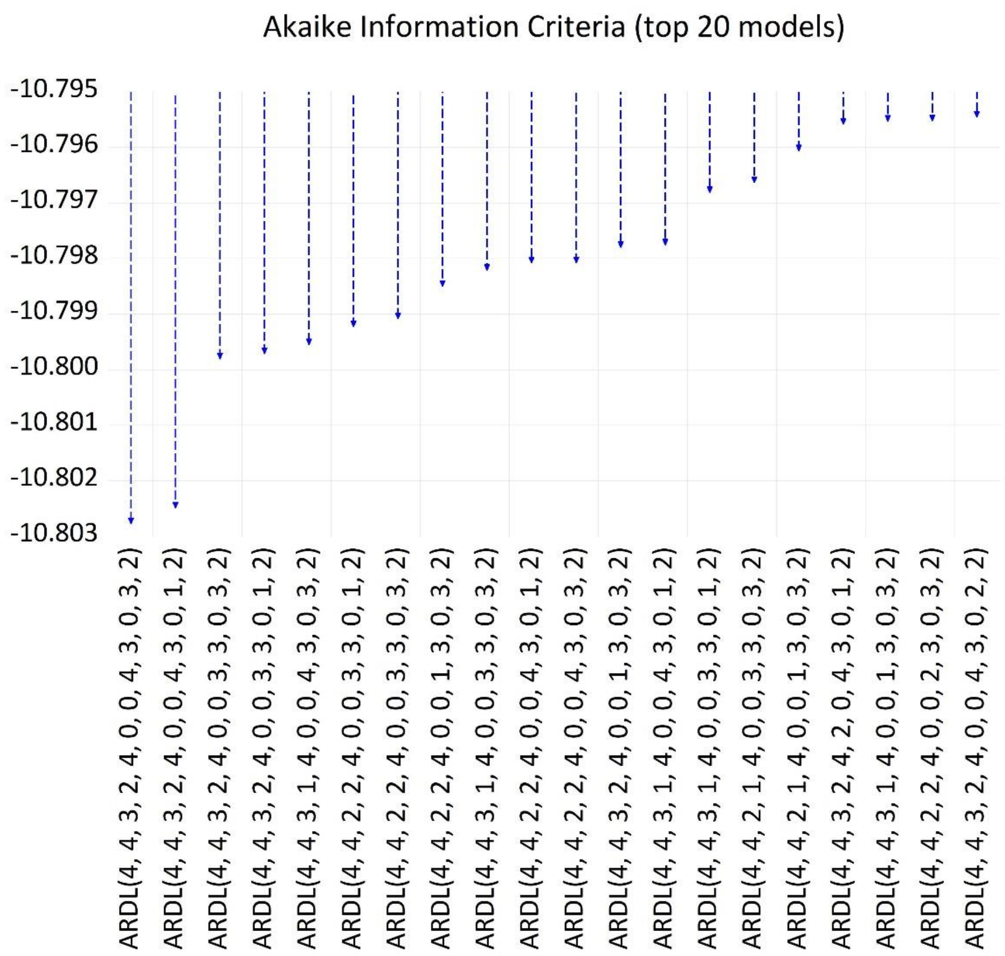


Figure 25. Optimal Lag Selection via Akaike Information Criteria for The Natural Logarithm of Real Rent

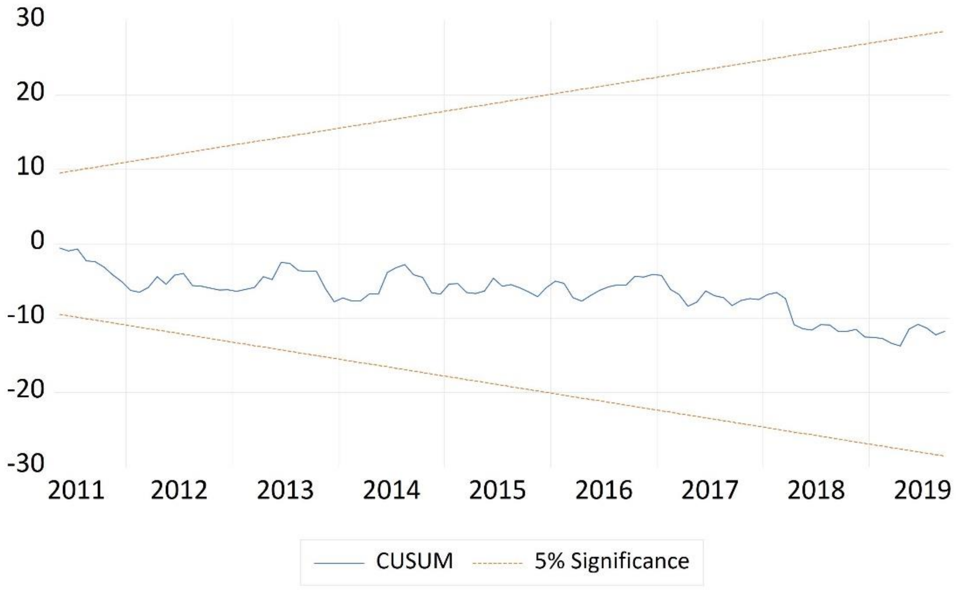


Figure 26. CUSUM Control Chart of The Estimated Long-run ARDL Model for The Natural Logarithm of Real Housing Price Index

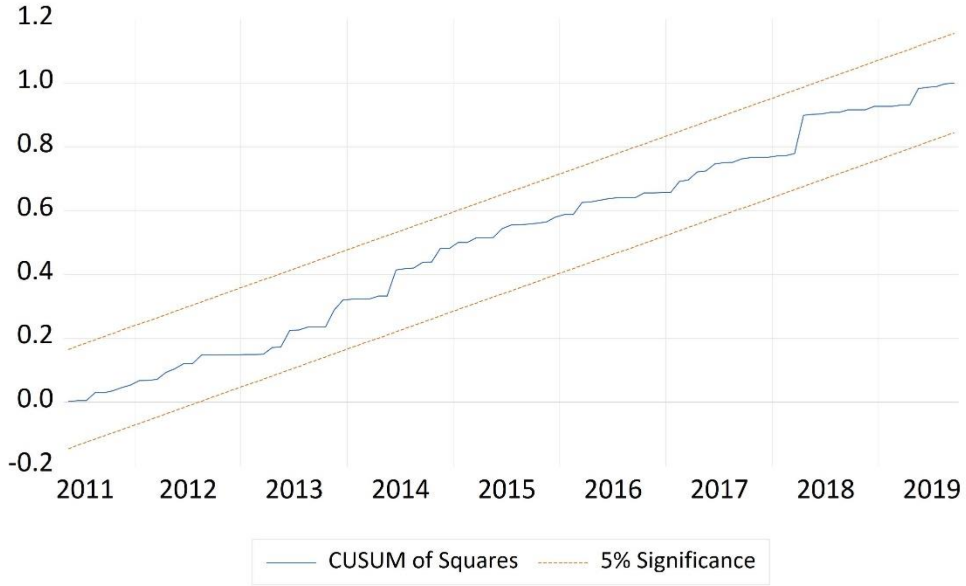


Figure 27. CUSUM of Squares Control Chart of The Estimated Long-run ARDL Model for The Natural Logarithm of Real Housing Price Index

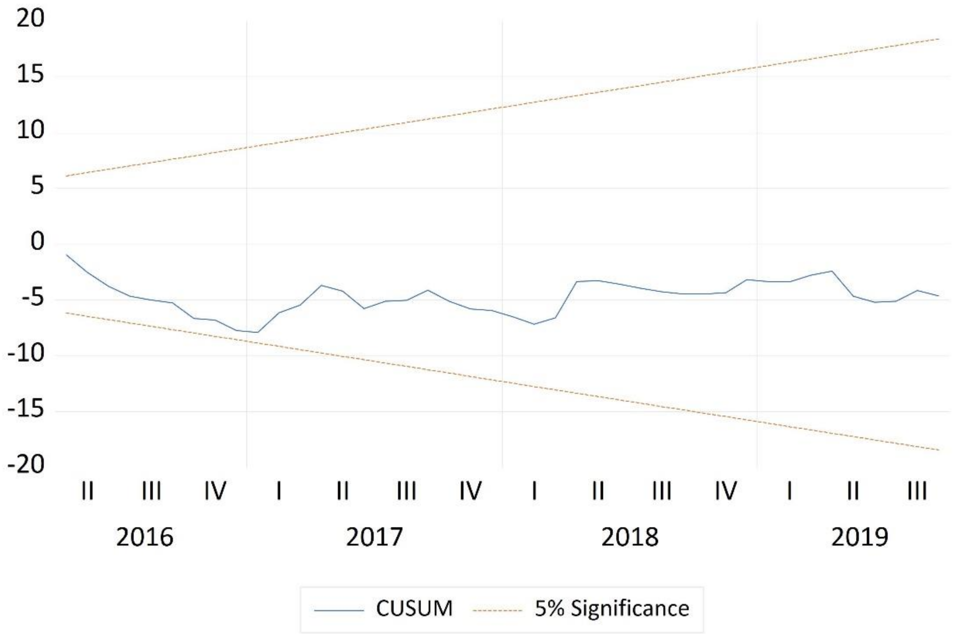


Figure 28. CUSUM Control Chart of The Estimated Long-run ARDL Model for The Natural Logarithm of Real Rent

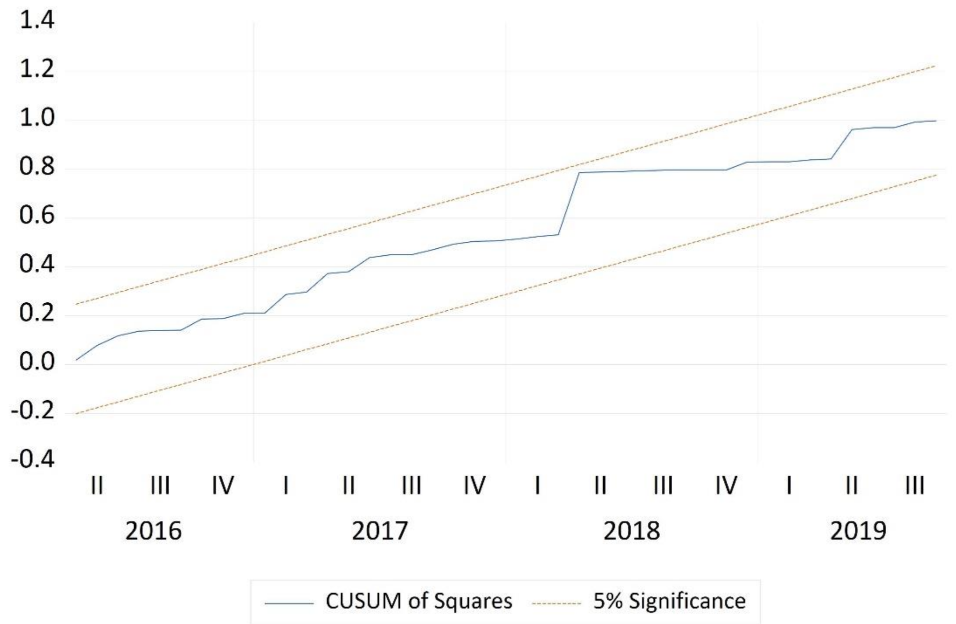


Figure 29. CUSUM of Squares Control Chart of The Estimated Long-run ARDL Model for The Natural Logarithm of Real Rent

## *Appendix D. The Toda-Yamamoto (TY) Causality Test Lag-Length Selection Criteria and Diagnostics*

Table 23. VAR Lag Order Selection Criteria

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 2475.46 | NA | 4.85E-25 | -24.77 | -24.59 | -24.69 |
| 1 | 5828.16 | 6301.06 | 3.81E-39 | -57.257 | -55.06 | -56.36 |
| 2 | 6303.38 | 840.59 | 1.09E-40 | -60.81 | -56.62* | -59.11* |
| 3 | 6472.14 | 279.86 | 6.95E-41 | -61.29 | -55.10 | -58.78 |
| 4 | 6676.21 | 315.83 | 3.17e-41* | -62.12 | -53.93 | -58.81 |
| 5 | 6800.67 | 178.88* | 3.33E-41 | -62.16* | -51.96 | -58.03 |

Notes to Table 23: superscript * indicates lag order selected by the criterion. LR, FPE, AIC, SC, and HQ denote sequentially modified LR test statistic, final prediction error, Akaike information criterion, Schwarz information criterion, and Hannan-Quinn information criterion, respectively.

Table 24. Lagrange Multiplier Autocorrelation Test

| Lag | LRE* statistic | df | p-value | Test statistic | Degrees of freedom | p-value |
|---|---|---|---|---|---|---|
| 1 | 93.29 | 121 | 0.43 | 0.89 | (121, 887.5) | 0.43 |
| 2 | 133.98 | 121 | 0.22 | 1.17 | (121, 887.5) | 0.22 |
| 3 | 151.15 | 121 | 0.16 | 1.23 | (121, 887.5) | 0.16 |
| 4 | 139.04 | 121 | 0.13 | 1.16 | (121, 887.5) | 0.13 |
| 5 | 114.89 | 121 | 0.64 | 0.95 | (121, 887.5) | 0.64 |
| 6 | 122.60 | 121 | 0.44 | 1.01 | (121, 887.5) | 0.45 |

Notes to Table 24: LRE* represents Edgeworth expansion corrected likelihood ratio statistic. The diagnostic tests indicate no serial autocorrelation problems.

Table 25. White's Residual Heteroskedasticity Test

| Test | Test Statistic | p-value |
|---|---|---|
| White's Residual Heteroskedasticity Test $\chi 2$ | 11366.18 | 0.19 |

Notes to Table 25: The diagnostic tests indicate that the residuals are homoscedastic at 1% significance level.

Table 26. Jarque-Bera Normality Test

| Component | Jarque-Bera test statistics | degrees of freedom | p-value |
|---|---|---|---|
| 1 | 0.77 | 2 | 0.68 |
| 2 | 0.04 | 2 | 0.98 |
| 3 | 0.22 | 2 | 0.89 |
| 4 | 7.86 | 2 | 0.02 |
| 5 | 5.23 | 2 | 0.04 |
| 6 | 3.63 | 2 | 0.16 |
| 7 | 3.47 | 2 | 0.14 |
| 8 | 1.57 | 2 | 0.46 |
| 9 | 1.30 | 2 | 0.12 |
| 10 | 22.08* | 2 | 0.00 |
| 11 | 58.99* | 2 | 0.00 |
| Joint | 198.21** | 1287 | 0.04 |

Notes to Table 26: Superscript * and ** indicate normally distributed residuals at 1% and 5%, respectively.

Table 27. Roots of Characteristic Polynomial

| Root | Modulus |
|---|---|
| 0.992985 | 0.992985 |
| 0.965477 - 0.105052i | 0.971175 |
| 0.965477 + 0.105052i | 0.971175 |
| 0.963922 - 0.019007i | 0.96411 |
| 0.963922 + 0.019007i | 0.96411 |
| 0.775226 + 0.507141i | 0.926373 |
| 0.775226 - 0.507141i | 0.926373 |
| 0.475118 + 0.790290i | 0.922115 |
| 0.475118 - 0.790290i | 0.922115 |
| 0.918917 | 0.918917 |
| 0.881263 + 0.229217i | 0.910585 |
| 0.881263 - 0.229217i | 0.910585 |
| 0.895635 - 0.144449i | 0.907208 |
| 0.895635 + 0.144449i | 0.907208 |
| 0.715284 - 0.543142i | 0.898128 |
| 0.715284 + 0.543142i | 0.898128 |
| 0.805418 - 0.375783i | 0.888769 |
| 0.805418 + 0.375783i | 0.888769 |
| 0.541740 + 0.700782i | 0.885764 |
| 0.541740 - 0.700782i | 0.885764 |
| 0.237969 - 0.807740i | 0.842065 |
| 0.237969 + 0.807740i | 0.842065 |
| -0.467153 + 0.693528i | 0.83619 |
| -0.467153 - 0.693528i | 0.83619 |
| 0.821239 | 0.821239 |
| 0.033657 + 0.813386i | 0.814082 |
| 0.033657 - 0.813386i | 0.814082 |
| -0.689876 - 0.420351i | 0.807852 |
| -0.689876 + 0.420351i | 0.807852 |
| -0.231191 + 0.771361i | 0.805262 |
| -0.231191 - 0.771361i | 0.805262 |
| 0.628374 + 0.502175i | 0.804385 |
| 0.628374 - 0.502175i | 0.804385 |
| -0.610694 - 0.511124i | 0.796363 |
| -0.610694 + 0.511124i | 0.796363 |
| -0.469720 + 0.620517i | 0.778253 |
| -0.469720 - 0.620517i | 0.778253 |
| -0.738371 - 0.226394i | 0.772299 |
| -0.738371 + 0.226394i | 0.772299 |
| 0.313242 + 0.684863i | 0.753099 |
| 0.313242 - 0.684863i | 0.753099 |
| 0.722105 - 0.194175i | 0.747756 |
| 0.722105 + 0.194175i | 0.747756 |
| -0.641789 - 0.355169i | 0.733511 |
| -0.641789 + 0.355169i | 0.733511 |
| -0.726330 - 0.040641i | 0.727466 |
| -0.726330 + 0.040641i | 0.727466 |
| 0.170090 - 0.692977i | 0.713546 |
| 0.170090 + 0.692977i | 0.713546 |
| -0.271396 + 0.654016i | 0.708091 |
| -0.271396 - 0.654016i | 0.708091 |
| -0.072359 + 0.691887i | 0.69566 |
| -0.072359 - 0.691887i | 0.69566 |

Notes to Table 27: VAR (1,5) satisfies the stability condition since no root lies outside the unit circle.

Table 28. Roots of Characteristic Polynomial (*continued*)

| Root | Modulus |
|---|---|
| -0.674635 | 0.674635 |
| 0.586654 - 0.285366i | 0.652377 |
| 0.586654 + 0.285366i | 0.652377 |
| 0.631895 | 0.631895 |
| 0.197608 - 0.582467i | 0.615075 |
| 0.197608 + 0.582467i | 0.615075 |
| 0.289356 + 0.448392i | 0.53365 |
| 0.289356 - 0.448392i | 0.53365 |
| -0.271425 + 0.219740i | 0.349224 |
| -0.271425 - 0.219740i | 0.349224 |
| 0.066867 - 0.291256i | 0.298833 |
| 0.066867 + 0.291256i | 0.298833 |
| 0.009227 | 0.009227 |

Notes to Table 28: VAR (1,5) satisfies the stability condition since no root lies outside the unit circle.

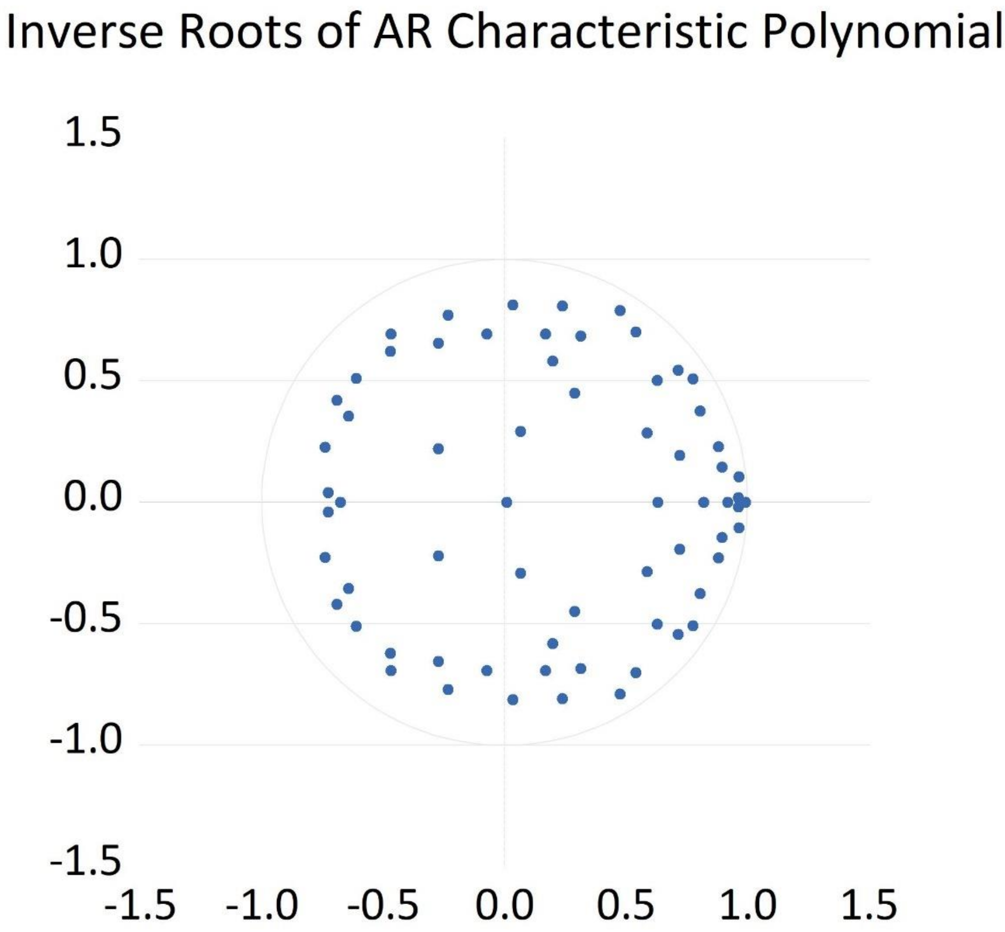


Figure 30. Inverse Roots of Characteristic Polynomial

## CURRICULUM VITAE

Ismail Cem Özgüler completed his high school education with a high honor degree in Izmir Bornova Anatolian High School (BAL) in 2004. Mr. Özgüler attended the Izmir University of Economics, where he received a B.A. Degree in Business Administration from Faculty of Economics and Administrative Sciences in 2008 as a high honor student. Mr. Özgüler received his MSc in Financial Economics degree in 2012 as a high honor student. In 2013, he started his Ph.D. degree at Izmir University of Economics. Mr. Özgüler received scholarships from the Izmir University of Economics to cover his tuition fees during his academic journey. From 2010 to 2012, he received a domestic Master's Degree Scholarship (BIDEB2210) from TUBITAK and a scholarship for success from AKDENET. He is currently Assistant Manager at the Isbank Headquarters, offering expertise in the non-performing loan (NPL) portfolio, operations, and projects management with experience of over 12 years. He is responsible for data analytics and reporting, auditing law firms, digital transformation, and artificial intelligence (AI) projects. His research focuses on NPLs, AI, and real estate markets. His academic papers have been published in indexed international journals, i.e., "Short term and long term linkages among nonperforming loans, macroeconomic and bank-specific factors: An empirical analysis for Turkey" and "Discovering the fundamentals of the Turkish housing market: a price convergence framework."