Real Estate Prices and Stock Market Returns in Germany: Analysis Based on Hedonic Price Index

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ABSTRACT

Real estate and stocks are the main assets in an investor's portfolio. It is essential to investigate the long-run relationship between the real estate and the stock market regarding risk diversification in a portfolio. This thesis examines the long-run relationship between residential real estate prices and stock market returns for the case of Germany for the period of 2005-2017 by applying econometrics techniques for time series. To this aim, the thesis uses Hedonic Price Index as a proxy for real estate prices and DAX30 as a proxy for stock market returns. Moreover, three additional variables, namely consumer confidence, credit availability and supply of mortgage loans are incorporated as control variables to assess the robustness of the results. Obtained empirical results indicate a long-run relationship between stock market returns and real estate prices which suggests that in long-run there is no diversification benefit from allocating stock and real estate assets in a portfolio.

Keywords: Real estate market, Stock market, Hedonic Price Index, Cointegration, Portfolio management.

ÖZ

Gayrimenkul ve hisse senedi bir yatırımcının portföyünde yer alan temel varlıklardandır. Portföy çeşitlendirmesi aşamasında bu varlıklar arasındaki ilişkiyi araştırmak büyük önem arz etmektedir. Bu tez zaman serisi teknikleri kullanarak, 2005–2017 yılları aralığında Alman gayrimenkul ve hisse senedi piyasası getirileri arasındaki uzun dönemli ilişkiyi incelemektedir. Hedonic Fiyat Endeksi gayrimenkul piyasası fiyat göstergesi, DAX30 Endeksi ise hisse senedi piyasa getiri göstergesi olarak kullanılmıştır. Ayrıca, sonuçların güvenilirliğini test etmek amacıyla oluşturulan ekonometrik modele üç farklı kontrol değişkeni; tüketici güveni, kredi erişilebilirliği ve ipotek kredileri; eklenmiştir. Elde edilen sonuçlar gayrimenkul fiyatları ile hisse senedi getirileri arasında uzun dönemli bir ilişki olduğunu göstermektedir. Bu bulguya göre uzun dönemli portföy çeşitlendirmesinde hisse senedi ve gayrimenkulü kullanmak yeterince etkili olmayacaktır.

Anahtar Kelimeler: Gayrimenkul piyasası; Hisse senedi piyasası; Hedonic Fiyat Endeksi; Eş bütünleşme; Portföy yönetimi.

Dedicated to my beloved little angel,

JUANNA

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Chapter 1

INTRODUCTION

Financial markets play an essential role in the economy primarily as an intermediary to allocate the excess capitals of households to investors with funding needs. This intermediary role of financial markets helps enterprises to get access to credit and minimize business risk. As it is argued by Levine (1997) funds can be transferred to investors more efficiently by financial markets and consequently, the investment process becomes more profitable and less risky. In this process, the role of financial markets is crucial as they allocate resources to the productive investors. In other words, financial market efficiently channels the capital to investments. Other fundamental functions of financial markets are the rise in savings and accumulation of wealth, monitoring and exercising corporate governance, hedging and diversifying risk, reduction of cost of transactions and information, and facilitating the exchange of goods and services (Levine, 2005).

Although all segments of the financial market are essential factors to the economy, the stock market has a critical role in the firm development and economic growth indeed. Stock markets stimulate the economy by activating and increasing the savings, easing capital mobilization and risk reduction. Developed stock markets improve the allocation of capital and therefore increase productivity by offering longer-term investments (Levine, 2002). Stock markets can finance investments which are either long-term or excessively risky for banks and other financial intermediaries. Flourishing equity markets help the movement of savings directly via

stocks into the economic cycle and decreases the role of banks and other intermediaries. Expansion of the stock markets benefits the economy by amending the prices of corporate debt and easing the capital allocation process. Such a price modification stimulates capital inflows through stocks and helps the businesses and consequently the economy to grow. Developments in stock markets lead to economic growth in different respects, such as growth in output, increase in real income, lower unemployment rates, more economic stability and higher rates of homeownership (Dudley & Hubbard, 2004). The speedy growth in the number of stock markets from 50 in 1975 to 160 in 2015 indicates its crucial role in the economy. Recent data shows that in 2016, the number of listed companies in stock markets all around the world was 50,000 and their market capitalization was almost $70,000 billion (WFE, 2016).

Like any other developed economy, the stock market has a profound role in Germany. As the biggest European economy, Germany's stock market is a remarkable target for international investors by holding 40 out of 500 major publicly-traded firms in the world. According to Bundesbank (2014), in 2012 around 11,000 firms were trading at the major German stock markets. The market capitalization of these companies was almost €1,200 billion which makes the German stock market the seventh largest worldwide (Bundesbank, 2014). Since the end of 2010, the German stock market is rising more than all other major European markets by the help of strong GDP growth and European Central Bank's interest rate reductions (Deutsche BundesBank, 2016). The stock market index is reached record high in 2017 (Schildbach, Schneider, & AG, 2017). This rise in the market index along with market capitalization growth and the quantity of listed firms may be representing the shift in the German economy from a bank-oriented system towards a market-oriented

system. Recent development in German stock market helps economic growth by providing capital resources, financial information, liquidity and various ways of financing (Rousseau & Wachtel, 1998; Beck & Levine 2004; Masoud, 2013; Jedidia, Boujelbène & Helali, 2014).

Real estate can be defined as all lands and buildings, used by government, firms, and individuals (DiPasquale & Wheaton, 1996). This broad definition reveals that real estate is accountable for a significant segment of the economy and has strong connections with other economic sections. The real estate market makes a chief contribution to the economic growth due to its relationship to multiple sectors and industries. Building any property includes different activities such as management, financing, construction, and marketing. All these events make real estate a substantial source of economic growth and employment. The quality of real estate beside other infrastructures like, ways, schools and hospitals, affect the standards of living in a country. Real estate market can change the government's capacity to afford safe, suitable, and reasonably priced housing for its people. In the times of economic growth with increasing demand over time for real estate, there would be the opportunity of "land finance" for the government. This means reducing the financial deficits by selling the public real estate and collecting property taxes. Real estate is an essential tool for monetary policy with a substantial relationship to consumption and employment (Borio & McGuire, 2004; Davis & Palumbo, 2001). Regarding the financial institutions real estate is an attractive asset that maximizes the investment opportunities. Any change in the price of real estate also affects the value of firms and their growth opportunities. Real estate represents the central section of wealth for a household. Therefore, deviations in the price of real estate and stocks explain most of the changes in the net wealth of a household. Moreover, real

estate can influence the wealth of families by affecting their basic needs like financing children's education, healthcare, and insurance. This crucial role of real estate implies that any change in its market also is essential.

The economic crises of 2008 busted the attention to impacts of changes in real estate prices. At the household level, real estate price changes lead to changes in wealth and consequently improves the household spending behaviour as a substantial force in the economic recession (Case, Quigley & Shiller, 2013). From the financial sector's point of view, falling real estate prices have a damaging effect on the safety of the financial system. This impact includes the financial condition of households, credit ratings, collateral evaluation, and the debt to equity ratio. In addition, fluctuations in real estate prices influence mortgage and commercial bank balance sheets and their interactions to economic and financial stability (Scatigna, Szemere, & Tsataronis, 2014). Studies on the relationship between changes in real estate prices and economy indicate a strong correlation between the two variables (Goodhart & Hofmann, 2008). Considering the fact that since 1970 significant crises in the banking sector are related to falling in real estate prices after a bubble in the market (Reinhart & Rogoff, 2009), policymakers must take into account the fluctuations in real estate prices very carefully.

Comparing to other classes of assets, real estate market demonstrates unique characteristics. Because of heterogeneity and immovability, the real estate is an illiquid asset with high transaction costs. Heterogeneity implies that apiece property has unique features, for example, age, plan, and geographic location. In addition, real estate markets are localized and highly segmented because of the heterogeneity of properties. According to the localized characteristics of real estate markets, they are

highly segmented which indicates the variation in the prices for similar properties. Participation in the real estate market with characteristics as mentioned above is possible both directly and indirectly. Direct investment accrues if the property is bought to obtain profits either form rent or change in the value over time. Indirect investment is possible by contributing to an investment fund or gaining stocks in the property firms. One of the current indirect investments in real estate markets is by purchasing a share of a Real Estate Investment Trust (REIT) which is handling portfolios of real estate properties.

Germany has the second largest real estate market among the Euro area countries after France (Wijburg & Aalbers, 2017). After the dramatic failure of financial markets due to the global financial crises of 2008, financial institutions tend to invest more in the real estate market of Germany (Scharmanski, 2012). According to the real estate market research by Deutsche BundesBank (2016), the German real estate market is growing in correspondence with the safe economic environment, the healthy employment market, growing population (especially increasing the number of migrants) and low-interest rates.

In the German real estate market, the value of properties represents the largest class of assets similar to most other countries. Looking at Germany from an economic point of view, residential and commercial real estate represents 84% of overall gross assets which means 20% of the German gross value added (Sollner, 2014). As an industry, out of 10 billion euro of total assets, 55% is assigned to real estates and this makes the real estate the biggest industry in Germany (Oertel, 2015).

The relationship between the real estate market and stock market attracted the attention of investors for several reasons. First, their relationship has important implications for the process of portfolio optimization and financial security selection. Also, fluctuations in one market transfer the capital into or out of that market (Okunev & Wilson, 1997). In other words, when a market is growing and making higher returns, investors transfer their money from other markets to invest more in that growing market. There are different expectations about the long-run relationship between these two markets. On the one hand, both stock and real estate prices are subject to changes by the common economic forces (for instance: unemployment rate, economic development, inflation and interest rates, financial crunches) which make us expect a strong long-run relationship among them which will have some important practical consequences. A relationship between real estate and stock market suggests that they can be interchangeably selected by portfolio managers. Also, any possible relationship between these two assets enables investors to forecast one market by perceiving the other market's function. On the other hand, some market situations or government interference, (for example changes in supply or demand, tax, price making or transaction costs) may cause the stock market and real estate market behaves independently from each other. In the case of no significant relationship between the two markets, one can conclude that they are segmented and diversification is possible by keeping both assets in one portfolio.

The relationship between stock market and real estate market has been discussed in the literature in the field (Kapopoulos & Siokis 2005; Piazzesi, Schneider, & Tuzel. 2007; Lin, & Lin, 2011) and outline three main theoretical explanations to interpret this relationship. One way of interaction between stock markets and real estate is described by wealth effect theory which indicates that individuals with unexpected

gains from stock markets tend to invest more in real estate. Real estate is assumed to be a dual functional good simultaneously; it is a good for consumption and at the same time a good to invest in. Consequently, wealth effect works through two channels. The first mechanism suggests that by increasing in wealth due to unanticipated gains, one will increase the aggregate consumption. In the second mechanism, by increasing in stock prices, one will adjust the increased share in stock portfolio by selling stocks and purchasing real estate (Markowitz, 1952). Another possible way of interaction between the two markets is called credit-price effect. The focus of this theory is that real estate for firms and legal entities is acting as collateral for credits. Growing real estate prices allows firms to borrow more and consequently upsurge their investments. In this way, the real estate market leads the stock market. The third theory about the stocks and real estate interaction is substitution effect (Piazzesi, Schneider & Tuzel, 2007). According to this theory, any change in the price of a stock or real estate shifts their weight in the portfolio and affects the expected return and risk. To keep the weights as constant, the investor must increase the amount of real estate and decrease the amount of stock. As a result, the demand for real estate increases and the price will increase too. To figure out which theoretical explanation has more explanatory power to a specific market necessitated the implementation of empirical studies.

The purpose of this thesis is to examine the long-run relationship between the German stock and real estate markets. In this regard, we employed the Johansen cointegration test (Johansen, 1988; Johansen & Juselius, 1990) to check the possibility of a long-run relationship between the stock market and real estate market in Germany during 2005 to 2017. Afterward, Vector Error Correction Models (VECM) conducted to estimate the short-run and long-run coefficients and to

calculate the speed of adjustment through equilibrium. To test the robustness of our model VECM was repeated by adding consumer confidence, credit growth and mortgage growth as control variables one after another.

This thesis employs data for Germany for some reasons. First, because of the financial crisis of 2008, the stock market in Germany collapsed but the housing market stayed almost untouched. Such a crisis makes it appealing to inspect the connection between the two markets in the case of Germany. Second, the Hedonic Price Index has not been used in the similar studies in the case of Germany. Finally, the German economy is among the leading economies in the world and the biggest in Europe and has an impact on the global economy. The outcomes of this thesis may thus be valid in other economies with similar markets to Germany.

This thesis contributes to the literature by using Hedonic real estate price index as the proxy for German real estate market and examines its long-run relationship with the stock market returns for the first time. Previous studies on the relationship between stock markets and real estate market have been applied to other markets, but it has not been performed on the German market. Employing hedonic index for the real estate market returns can be helpful to study the pure price changes in the market which consider the quality adjustments. This study can also be beneficial for specialists to better understand the movements of stocks in regard to movements in real estate market.

This study can be beneficial for portfolio managers and investors by offering empirical evidence of integration or segmentation between stocks and real estate markets. Since integration between two markets indicates that similar economic

forces can drive them, the results of this thesis may help investors in both markets to predict the performance of one market from the other's counterpart. Moreover, integration shows the substitutability between two asset classes because fluctuation in either market is likely to impact the other while in the case of segmentation between the two markets, both stocks and real estate can be held in a portfolio for diversification purpose. Both individual and institutional investors with different risk aversions and different time horizons will be able to realize the competitive advantages and potential gains of putting stocks and real estate in one portfolio by considering the relationship between these two markets.

The remainder of the thesis is ordered as follows; chapter 2 offers a review of the related literature. Moreover, central theoretical relationships between two markets are discussed. The methodological framework is presented in chapter 3. Chapter 4 is titled the empirical results and discusses the results of statistical tests. Chapter 5 which is dedicated to the conclusion is the last part of this thesis.

Chapter 2

LITERATURE REVIEW

Before 1980, the macroeconomic literature almost neglects the real estate market and its relationship with other macroeconomic variables (Leung, 2004). Dimand (2002) in his book, Origins of Macroeconomics, mentions just a single article associated with the real estate market and it is a study by Fisher (1933). Furthermore, Klein (2001) in his collection of landmark macroeconomic papers references only one article by Kahn (1931) which is directly related to the real estate market. Other resources similar to Klein (2001) don't include any research directly on the relationship between real estate and macroeconomic variables. These examples identify the earlier gap in the studies on real estate and its relationship to macroeconomic variables. However, lately, there is an increasing interest in this field of study and helps to fulfil this gap in the literature.

Form 1980s onwards, the study of relationships between stock market returns and real estate prices have been established and focused on the integration and correlation between the two markets in the short-run (for example: Jorion & Schwartz, 1986; Gyourko & Keim, 1992; Wilson, Okunev, & Ta, 1996; Okunev & Wilson, 1997; Ling & Naranjo, 1999; Liow, 2006) to cointegration studies which consider the long-run dynamics assessment (among others: Fraser, Leishman, & Tarbert, 2002; Lin & Lin, 2011). In addition to tests of cointegration between the stock market and the real estate market, some researchers apply the causality tests to

clarify that real estate and stocks causally related (Okunev, Wilson, & Zurbruegg, 2000; Fraser, Leishman, & Tarbert, 2002; Lin & Lin, 2011). Regarding the sample of study, most of the studies on the relationship between the two markets are conducted considering only the U.S. market. Outcomes vary despite investigating the same market because of different techniques, sampling, time horizon or economic situations (Liu, Hartzell, Greig, & Grissom, 1990; Liow & Yang, 2005; Chan, Treepongkaruna, Brooks & Gray, 2011; Tsai, Lee & Chiang, 2012; Hui & Chan, 2014; Li, Chang, Miller, Balcilar & Gupta, 2015). A summary of the related literature is presented in Table 1.

Table 1: Summary of Related Literature

Author	Methodology	Time Span	Country under Study	Summary of Results
Liu, Hartzell, Greig & Grissom (1990)	Regression	1978-1986	USA	Evidence of segmentation of real estate from stock market
Gyourko & Keim (1992)	Regression	1978-1990	USA	Integration between the two markets
Liu & Mei (1992)	Multifactor Latent Variable Model	1971-1989	USA	Co-movement between the two markets
Myer & Web (1993)	VAR	1978-1990	USA	No correlation
Wilson, Okunev, & Ta (1996)	Cointegration	1972-1993	Australia	Integration between the two markets
Okunev & Wilson (1997)	Cointegration	1979-1993	USA	Segmentation between the two markets
Ling & Naranjo (1999)	Multifactor Asset Pricing Model	1978-1994	USA	Integration between the two markets

Table 1 Continued

Quan & Titman (1999)	Regression	1984-1996	17 countries	In the U.S. there was no relationship, while in the U.K., Japan, and some other smaller countries there was a strong positive relationship between the two markets
Wilson & Okunev (1999)	Fractional Cointegration	1971-1993	USA, UK, and Australia	No cointegration in the US and the UK, but some evidence of cointegration in Australia
Glascock, Lu, & So (2000)	Cointegration and VAR	1972-1996	USA	Cointegration between stocks and REITs
Okunev, Wilson, & Zurbruegg (2000)	Linear and Nonlinear Causality	1972-1998	USA	Unidirectional causal relationship from the stock market to the commercial real estate market
Chen (2001)	Granger Causality	1973-1992	Taiwan	Equity prices are found to Granger-cause real estate prices.
Fraser, Leishman, & Tarbert (2002)	Cointegration	1967-1999	UK	Conflicting evidence of cointegration. The stock returns lead the commercial real estate returns
Okunev, Wilson, & Zurbruegg (2002)	Linear and Nonlinear Granger Causality	1980-1999	Australia	Bi-directional Granger causality between stock market and real estate returns
Clayton & MacKinnon (2003)	Regression	1978-1998	USA	REITs have direct relationship with real estate returns

Table 1 Continued

Kapopoulos & Siokis (2005)	Granger Causality	1993-2003	Greece	Stock market Granger causes the real estate market
Liow &Yang (2005)	VECM	1986-2002	Japan, Hong Kong, Singapore and Malaysia	Fractional cointegration in some economies
Liow (2006)	ARDL Cointegration	1985-2002	Singapour	Cointegration between stock market and real estate market
Sim & Chang (2006)	VAR	1986-2005	Korea	Real estate prices Granger cause stock prices
Zhang & Fung (2006)	Multivariate Regression Granger Causality	1997-2005	China	Two markets are systematically negatively related
Georgia, Grissom & Ziobrowski (2007)	Mean and Standard Deviation Analysis	1998-2005	11 Asia-Pacific countries	Two markets are highly correlated
Ibrahim (2010)	VAR	1995-2006	Thailand	Unidirectional causality that runs from stock prices to house prices
Apergis & Lambrinidis (2011)	Cointegration, VECM	1985-2006	UK and USA	Two markets are considered highly integrated

Table 1 Continued

Chang, Chen & Leung (2011)	Serial Correlation LM Test	1975-2008	USA	No role for the stock return on the real estate
Lin & Lin (2011)	Johansen Cointegration, Granger Causality	1995-2010	Japan, China, Hong Kong, Taiwan, South Korea and Singapore	Integrated into Japan, fractional integration in China, Hong Kong, and Taiwan. Segmentation existed in South Korea and Singapore. The causality test showed that the real estate Granger causes the stock market in Taiwan and Singapore.
McMillan (2011)	Linear and non-linear Cointegration	1974-2009	USA and UK	Cointegration between stock prices and house prices
Ni & Liu (2011)	VECM	1998-2010	China, Hong Kong, and the USA	Positive cointegration
Su (2011)	TECM	2000-2008	Western European countries	Evidence of wealth effect and credit-price effect in both markets
Su, Chang, & Zhu (2011)	TECM	2000-2007	European countries	Evidence of long-term relationship under a specific threshold value
Anderson & Beracha (2012)	Regression	1989-2004	USA	Real estate prices conditionally affect stock prices
Heaney & Srianantha kumar (2012)	DCC	1986-2009	Australia	Time-varying correlation between the two markets

Table 1 Continued

Hiang (2012)	GARCH	1995-2009	Australia, Japan, Hong Kong, Singapore, China, Malaysia, Taiwan and the Philippines	Positive and significant co-movement between the two markets
Lean & Smyth (2014)	Cointegration, Granger Causality	2006-2009	Malaysia	Granger causality runs from house prices to stock prices
Tsai, Lee & Chiang (2012)	Threshold Cointegration	1970-2009	USA	Cointegration among the two markets
Aye, Balcilar & Gupta (2013)	Linear and Nonparametric Cointegration Granger Causality	1966-2011	South Africa	A long-run relationship between the two markets. The nonparametric Granger causality test showing a bi-directional causality
Burdekin & Tao (2014)	VAR	1999-2011	China	Codetermination of stock prices and housing prices
Chan & Chang (2014)	GMM	2003-2011	China	Price transmission from the stock market to the real estate market
Ding, Chong & Park (2014)	Granger Causality	1998-2011	China	Significant causal relationship between the two markets

Table 1 Continued

Hui & Chan (2014)	Forbes–Rigobon, Coskewness, and Cokurtosis Tests	2004-2012	Hong Kong, USA, and UK	Significant evidence of contagion between the equity and real estate markets
Lin & Fuerst (2014)	Linear and Nonlinear Cointegration	1980-2012	Nine Asian Countries	Linear cointegration between the two markets in Taiwan, fractional cointegration in Singapore and Hong Kong and no cointegration in China, Japan, Thailand, Malaysia, Indonesia and South Korea.
Liow & Schindler (2014)	DCC	1990-2011	USA, France, Germany, Netherlands, UK, Australia, Japan, Hong Kong and Singapore	The two markets are integrated
Li, Chang, Miller, Balcilar & Gupta (2015)	Wavelet Analysis	1890-2012	USA	Correlation between the two markets mainly in long-term
Yuksel (2016)	Threshold Cointegration Johansen Cointegration Granger Causality	2005-2009	Turkey	Both Wealth and Credit-price effects during the pre-crisis period but in the period of crisis just Credit-price effect is observed
Kiohos, Babalos & Koulakiotis (2017)	ARFIMA	1990-2014	Germany and the UK	Results provide support to the wealth effect
Li, Fan, Su & Lobonț (2017)	Bootstrap Granger Causality	2000-2015	China	The two markets have both positive and negative impacts on each other in several sub-periods

Table 1 Continued

Lou (2017)	Quantile Causality	1990-2014	Portugal, Italy, Greece, and Spain	Significant causal relationship between these two markets
Wang, Huang, Nieh, Ou & Chi (2017)	Linear Cointegration Time-Varying VECM	2006-2015	Taiwan	Non-existence of cointegration

* ARFIMA stands for Autoregressive Fractionally Integrated Moving Average; DCC stands for Dynamic Conditional Correlation; GARCH stands for Generalized Autoregressive Conditional Heteroscedasticity; GMM stands for Generalized Method of Moments; TECM stands for Threshold Error Correction Model; VAR stands for Vector Autoregression.

The relationship between stock and real estate markets are quite crucial for portfolio management purposes. Integration between stocks and real estate markets reduces diversification benefits for a portfolio. There are different levels of integration between the two markets which can be categorized as no integration (markets segmentation); fractional integration and full integration between two markets (Wilson, Okunev & Ta, 1996). Many studies provide evidence for the long-run relationship between these two markets. Tse (2001) reports a cointegration between the Hong Kong real estate and stock returns. Apergis and Lambrinidis (2011) investigated the US and the UK markets between 1985 and 2006 and conclude that if one put real estate and stock in a portfolio, there was no gain in this period because of the integration between the two assets. Burdekin and Tao (2014) investigated the linkages between lending, real estate prices, stock prices, and inflation by employing causality testing and VAR estimation during 1999 to 2011 in China. Their empirical results confirm the co-movement between the stock and real estate markets. They conclude that changing government policies was namely a common factor which caused the fluctuations in China's stock and real estate markets.

Some studies provide evidence for segmented stock and real estate markets (for example Liu et al., 1990; Ling & Naranjo, 1999; Quan & Titman, 1999; Lin & Lin, 2011). Lizieri and Satchell (1997) on the UK market indicate a negative relationship between the real estate and stock market. Lu, Chang, and Wei (2007) suggest that real estate and stock markets are not cointegrated. Therefore, investors and portfolio managers can allocate both assets in one portfolio. Lean and Smyth (2014) apply cointegration and Granger causality tests to inspect the dynamic relationships between real estate price, interest rates and stock prices in the case of Malaysia. For

the country as a whole they find no cointegration among the variables but by applying the tests to sub-regions they conclude that stock prices lead the real estate prices. Chan and Chang (2014) conducted a comprehensive study in China on the equity, bond, and property markets from February 2003 to June 2011, to examine the efficiency of the interest rate as a tool to diminish the real estate industry by employing GMM statistical method. Based on the findings, the two markets show similar movements neither in volatility patterns nor returns as asset classes. Wang, Huang, Nieh, Ou, and Chi (2017) apply linear and non-linear cointegration models to examine the Taiwan markets and conclude that real estate markets are segmented from stock markets. The evidence of segmentation between stock market and real estate market suggests that investors can diversify the risk by allocating both assets in one portfolio.

Some of the studies on the stock market and real estate association show mixed results which can be explained due to different countries in the sample, different time periods or different statistical techniques. For example, Lin and Fuerst (2014) studied the relationship between equity and real estate market in nine East Asian states by using linear and nonlinear cointegration methods during 1980 to 2012. They employed the quarterly transaction-based property price index which is consistent across countries under study. This index is a non-controversial transaction-based property index and helps to accurately determine the association between stock and direct real estate among multiple markets. The empirical results are different for these countries. For instance, there is a linear cointegration in Taiwan, but the cointegration is fractional in the case of Singapore and Hong Kong. The authors report no significant cointegration of stock and real estate markets for China, Japan, Thailand, Malaysia, Indonesia and South Korea. Li, Chang, Miller, Balcilar, and

Gupta (2015) employ Wavelet analysis to study the link between real estate and stock markets in the U.S. between 1890 and 2012. Their results suggest that the interaction between two markets changes over time. Yuksel (2016) investigates any change in the relationship between housing prices and stock prices after the financial crisis of 2008 in Turkey. Based on threshold cointegration test, both wealth and credit-price effects exist before the financial crises of 2008. However, during the crises, no wealth effect is observed. Li, Fan, Su, and Lobonţ (2017) show that in different time periods real estate and stock prices have positive and negative impacts on each other in China. The positive effect indicates that stock market has a wealth effect on real estate, and real estate has a credit-price effect on the stock market.

Alongside the investigations of a cointegration relationship, many studies investigate the causal relationship between stock and real estate markets and its direction. Okunev, Wilson, and Zurbruegg (2002) show a significant unidirectional causality relationship from the stocks to the property market in the case of Australia. Hui and Chan (2014) for the first time use the co-kurtosis test to inspect the relationship between stock markets and real estate in the case of Hong Kong, the US, and the UK. The empirical results indicate a significant evidence of a unidirectional causality relationship between the stocks and real estate, particularly in the case of the US. Ding, Chong, and Park (2014) examine the non-linear causal relationship between stock market and real estate market and claim a significant association between these two markets in China. Lou, (2017) for the first time applies quantile causality to test the relationship between real estate and the stock market in Portugal, Italy, Greece, and Spain. The outcomes show a non-linear causality relationship between the two markets. Lee, Lee, Lee and Liao (2017) study the relationships between the real estate prices and stock prices by applying the Toda and Yamamoto causality tests

and conclude that in the case of Australian market, a causality relationship was running from real estate to stock market before the financial crises of 2008, but after 2008, stock market leads the real estate market in Australia.

Although, the second most efficient stock market after Spain in the Euro area (Borges, 2010) and fast-growing market for real estate makes Germany an excellent case to study, the empirical studies on the possible relationships between German real estate and stock markets are scarce. Among a few studies on German stock market and real estate, Maurer, Reiner, and Rogalla (2004) investigate the risk and return of German securitized real estate market and match it with major asset classes such as stocks and bonds, and identify the appropriate role of each asset in a portfolio. By applying correlation tests, they conclude that real estate market and the stock markets have no correlation but there is a positive correlation between the bond market and the real estate market. In another study on Germany, Kiohos, Babalos, and Koulakiotis (2017) use ECM-ARFIMA methodology to examine the relationships between stock and securitized real estate market. Their sample covers the period 1990-2014 and the empirical results support the wealth-effect theory.

One of the major difficulties researchers face in the investigation real estate market is to obtain the real estate prices. On the one hand, the measurement methods of real estate prices vary from country to country and make it difficult for inter-country comparisons. On the other hand, designing an accurate index is challenging when the central importance goes to how quality adjustments can be taken into account and how to obtain the pure price changes. In this regard, Hedonic approaches are getting a growing role in calculating value trends and price movements in recent years. The first use of Hedonic index goes back to Waugh (1928) who appraised a land using

this technique. After the seminal work by Griliches (1961, 1971) and Rosen (1974) which made the hedonic pricing model more popular, extensive studies have applied hedonic pricing models to real estate markets. Goodman (1978) employed the hedonic model for property pricing in a metropolitan zone and concludes that hedonic model can be used to deal with the problem of neglected quality characteristics of real estate. Harrison and Rubinfeld (1978) applied the hedonic method to explain the demand for clean air in metropolitan areas. Hayes and Taylor (1996) used the hedonic model to determine the impact of school accessibility on the property prices. McMillen (2004) studied the effects of development in the airports on the real estate price.

Recent literature has also given an increasing attention to hedonic prices and many studies employ this variable to investigate real estate market. Ottensmann, Payton, and Man (2008) used hedonic pricing model to determine the importance of location characteristics of a property, for example, the distance from the business centres. More recently, Chow (2011) applied hedonic index model for the commercial real estate market in Hong Kong and found significant positive relationships between the price and features like location and school availability. Ye (2015) employed the hedonic pricing method to the Hong Kong real estate market and state that this method has considerable advantages over an average-price index which suffer from significant reliability problems, for example, quality biases. As he concludes, hedonic models are able to control these biases. Deng, Girardin, and Joyeux (2016) construct daily hedonic prices and explain the volatility in the real estate market, as well as transaction volumes in major Chinese cities, such as Beijing and Shanghai. Although the hedonic real estate price is available for Germany and studies concluded that this method is a favorable alternative to conventional methods

(Deschermeier, Voigtländer & Seipelt, 2014), this thesis is the first study on the relationship between stock market and real estate which employs the hedonic real estate price index for the case of Germany.

Chapter 3

DATA, MODEL, AND METHODOLOGY

3.1 Data

This thesis employs Hedonic Real Estate Price Index with monthly data for Germany from August 2005 to August 2017, comprising 145 observations. The time span is selected based on the availability of hedonic index data for Germany. For stock prices, we obtained monthly data for DAX30 that is calculated by Deutsche Börse and consists of the stock price of the 30 largest German public limited companies which are traded on the Frankfurt Stock Exchange. In July 2014, the firms included in the DAX30 index accounted for 64% of the stock capital of Germany with a market capitalization of €776 billion (Bundesbank, 2014). Mortgage growth (MRG) and Credit supply growth (CREDIT) are employed as control variables in the model to represent the changes in credit availability by the banks. Moreover, Consumer Confidence (CONF) is used as another control variable to observe the consumer sentiment in the future financial income. All variables are converted to natural log form excluding CONF which cannot be converted due to negative numbers. The data for variables in this study are collected from DataStream.

3.1.1 Hedonic Real Estate Price Index

The main function of a price index is to track the fluctuations in the value of a bundle of goods at different times. A price index for real estate does exactly the same role. However, generating a price index for this market has difficulties due to distinctive characteristics of real estate market. As properties are different concerning scope,

geographical location, and other features, their price does not change at the similar rate. The uniqueness of each property, regarding its location, scope, possession, and facilities, makes it problematic to characterize a typical one for generating a price index. These alterations suggest that averaging all prices in a market without monitoring for house heterogeneity is not reasonable (Jiang, Phillips, & Yu, 2014). Furthermore, real estate transactions are not happening every day and sales data are unbalanced because most properties are single sale houses and the ones that have been traded more than once shape a small part of the entire market. Moreover, properties traded in a period may be relatively different from period to period. These issues disturb the assessing data and result in econometric problems of heterogeneous and missing data.

There are several indices for real estate that are commonly used each of which has its limitations. The simplest index is the Average Price Index which is the mean of prices of a bundle of properties in each time period. The only required data for this method is the price of transacted properties in a period. This method does not control for any features of a property other than its price and extensively exaggerating the rise in price for a property with constant quality (Case & Wachter, 2005). Another real estate price index is Representative Property Index. For this index, a data collector records the price and a limited number of characteristics for each property. However, these characteristics may not be comparable with other markets due to differences in data collectors and unmeasured quality changes. Repeat Sale Method is the following index used which tracks the change in the price of a property in two periods and takes the average of prices to signify the general change in the market price. According to the repeated sale approach, if the features of a real estate are fixed between two transactions, then any change in price is a genuine change in the

real estate market. This technique produces an easy way to compute a quality-adjusted index. However, a property at two different points in time does not necessarily keep the same fixed features. The heterogeneity in real estate market pushed the methods toward adjusting the quality in the final price calculation.

To overcome the problem of ignored quality features, a Hedonic Pricing Index was first introduced in the 1980s in the United States. Since then, it has been used for different products, such as housing, clothing and digital products (Moulton, 2001). The hedonic index assumes that price of a property is a function of physical characteristics, location and time. This method establishes a precise quality adjustment technique considering how quality variations can be taken into account for defining the final price of a property. Hedonic pricing method uses regression analysis to assess the effect of product's characteristics on the final price. Therefore, changes in price because of qualitative changes can be identified mathematically. In order to control for heterogeneity, Hedonic price Index assumes that the price of a house is the function of multiple physical characteristics. Econometric techniques can be used to estimate the values associated with each character to come up with an appropriate index (Jiang, Phillips, & Yu, 2014). In other words, a property is broken down into different quality characteristics and afterwards, the impact of each quality characteristic on the end price is calculated using regression analysis. A standard model of the hedonic method is:

$$H = Z\beta + D\gamma + \epsilon \qquad (3.1)$$

where H is an $N \times 1$ vector, Z represents a $N \times P$ matrix of physical features, β is a $C \times 1$ matrix of features' prices, D is a $N \times T - 1$ vector of dummy variables for time period, γ is a $T - 1 \times 1$ matrix of prices for each time period, and ϵ denotes a $N \times 1$

matrix of errors. Lastly, *N*, *P*, and *T* represent the number of properties, physical features, and time periods respectively.

As a result, the fluctuations in the price from qualitative changes in a property are mathematically separated from net price changes. The fundamental aim of hedonic pricing model is to generate a precise analytical model. Hedonic techniques are valuable tools for real estate researchers, developers, and real estate firms in defining the relationship between property features and the final price, as well as to forecast future prices Considering the advantages of hedonic index in measuring quality features of real estate price changes and to achieve more reliable results, this thesis is employed the hedonic real estate price index to represent the real estate prices in Germany.

3.2 Methodology

Investigating the variables' order of integration is the first step before doing any empirical analysis. Since a variable with unit root does not have a finite variance the characteristics of non-stationary time series vary in time (Harris & Sollis, 2003). As a result, using a non-stationary variable to do a regression analysis will result in spurious regression (Deng, 2013). Afterward the Johansen test of cointegration is conducted to examine the long-run relationship between stock market and real estate market and finally, this thesis continues with vector error correction model (VECM).

3.2.1 Unit Root Tests

Among the unit root tests to find the order of integration Dickey-Fuller (1981) and Phillips and Perron (1998) tests are commonly used. Two types of the Dickey-Fuller test are available which are the simple and the Augmented Dickey-Fuller (ADF) test. In order to eliminate the autocorrelation problem, the augmented form of the Dickey-

Fuller unit root test contains lagged terms of the dependent variable (Asteriou & Hall, 2015). ADF test involves the assessment of one of the following equations:

$$\Delta X_t = \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \quad (3.2)$$

$$\Delta X_t = \alpha_0 + \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \quad (3.3)$$

$$\Delta X_t = \alpha_0 + \alpha_1 t + \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \quad (3.4)$$

where j is the number of lags and the coefficient of interest is β for all three equations.

A model with no intercept and no trend in the equation (3.3) is used and under the H_0 and it is a pure random walk model. But, this model is not preferable as it is unlikely to happen in practice (Asteriou & Hall, 2015). The second equation (3.4) is conducted to a model with an intercept but no trend and under the null hypothesis it is a random walk with drift. Equation (3.5) is for a model with an intercept and linear trend and the power of the model depends on its deterministic coefficients (Campbell & Perron, 1991). The distinctive characteristic among the three regressions is the deterministic factors α_0 and $\alpha_1 t$, where α_0 is a drift term and $\alpha_1 t$ is a linear time trend. To decide on which equation to use is determined by the properties of the variable. To guarantee that the error terms are not correlated, lagged terms are involved in the equation.

The null hypothesis is that X_t has a unit root (H_0: $\beta = 0$) and it is possible to reject it when β is significantly negative ($\beta < 0$). When the ADF statistic is bigger than critical values suggested by the null hypothesis (H_0) is failed to reject and as a result the X_t has a unit root and integrated of order one I(1). In an opposite scenario,

rejecting the H_0 indicates that the series are stationarity. In the case of failing to reject the H_0, the test is conducted on the difference of the series (X_{t-1}) , and differencing is continued up to the rejection of null hypothesis (Dickey & Fuller, 1979).

Phillips-Perron (PP) test accounts for the independent and identical distribution of error terms. In the case of weak autocorrelation and heteroskedastic regression residuals, PP test is more robust than the ADF. Unlike the ADF test, PP test does not use lagged differenced terms to control for autocorrelation. The model for PP test is :

$$\Delta y_t = \alpha_0 + \gamma X_{t-1} + \varepsilon_i \quad (3.5)$$

where γ is corrected t-statistic of coefficient β in the ADF model. The null hypothesis is $H_0: \gamma = 0$ against the alternative of $H_0: \gamma < 0$. When test statistic is more than the critical value, the null hypothesis is failed to reject and as a result the series has a unit root.

3.2.2 Johansen Cointegration Test

When the variables are defined to be integrated of the same order, $I(d)$, the next step is to perform the cointegration test.Test for cointegration can be considered as a primary test to refrain from spurious results (Granger, 1986) and it helps to identify the common trend of the time series variables (Engle & Yoo, 1987). If two nonstationary series are integrated of the same order, linear combination of them may show stationarity and is known as cointegration. Cointegration test examines any long-run equilibrium relationship among the variables. In the case of no cointegration, variable have no long-run equilibrium relationship (Dickey, Jansen, & Thornton, 1994).

Cointegration tests in this study are conducted using the method developed by Johansen and Juselious (Johansen, 1988; Johansen & Juselius, 1990). This method suggests two test statistics for identifying the number of cointegrating vectors. Specifically, these tests are the trace ($\lambda trace$) and the maximum eigenvalue (λmax) statistics. The likelihood ratio statistic for the trace test ($\lambda trace$) is:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i) \quad (3.6)$$

where $\hat{\lambda}_i$ is the eigenvalue (biggest estimated value of characteristic root), r = 0, 1, 2,…….$p - 1$, and T represents the number of observations. The H_0 for the $\lambda trace$ statistic states that the number of characteristic roots is less than or equal to r (where $r = 0, 1, or\ 2$) and the H_1 is that there are more than r cointegrating vectors.

The second test statistics is the maximum Eigenvalue (λmax) statistic by Johansen:

$$\lambda_{max}(r, r+1) = -T\ \ln(1 - \hat{\lambda}_{r+1}) \quad (3.7)$$

where T is the number of usable observations and λ is the estimated eigenvalues. The null hypothesis for the λmax test is that the number of cointegrating vectors is r against the alternative of $r + 1$.

When two tests for cointegration rank show different results, the trace test is more reliable because it is more powerful than maximum eigenvalues tests (Lüutkepohl, Saikkonen & Trenkler, 2001).

3.2.3 Vector Error Correction Model

After confirming the existence of cointegration, we can move to VECM which can capture both the short-run dynamic and the long-run equilibrium relationship between variables. If Z_t and X_t are founded to be $I(d)$, consider their cointegrating equation to be

$$Z_t = \beta X_t + e_t \quad (3.8)$$

If any change in Z_t rest on the deviations from this equilibrium in the former period $(t-1)$, then the VECM will be

$$\Delta X_t = \alpha_2(Z_{t-1} - \beta X_{t-1}) + e_t \quad (3.9)$$

$$\Delta Z_t = \alpha_1(Z_{t-1} - \beta X_{t-1}) + e_t \quad (3.10)$$

The β is the cointegrating coefficient for the long-run. α represents adjustment parameters that identify the deviation from equilibrium in past period which is corrected for existing period. The right side of both equations is the same error correction term, or it can be considered as the same cointegrating relationship. A multivariate model covers the deviation in one variable by other variables; therefore the model converges to long-run equilibrium.

$$X_t = \sum_{i=1}^{k} \Gamma_i X_{t-i} + \Pi X_{t-k} + CZ_t + \varepsilon_t \quad (3.11)$$

where X_t is the vector of dependent variables and Z_t represent the vector of independent variable; Γ_i symbolizes the coefficient matrix of dependent variable and C is the coefficient matrix of independent variables. The short-run adjustments are captured by Γ_i matrices, and the long-run cointegration is measured by the matrix Π. Finally, ε_t represents the white noise, which is serially and mutually independent.

According to Johansen (1995), this model depends on examining the rank $r \leqslant 5$ of matrix Π. When $r = 0$, there is no cointegration. But if $r \neq 0$, there is the possibility of r linear combinations.

Chapter 4

EMPIRICAL RESULTS

The empirical analysis in this research begins by examining the descriptive statistics and after that, the unit root tests are presented in order to assess the stationarity of the data. Subsequently, the method of Johansen cointegration is performed to test the long-run relationships and the Vector Error Correction Model (VECM) is employed to evaluate the long-run and short-run properties of the cointegrated series. The variables involved in the study are stock market index (DAX30), house price index (H), consumer confidence (CONF), the supply of mortgage loans (MRG) and credit availability (CREDIT). The descriptive statistics in Table 2 are intended for the full sample of August 2005 to August 2017.

Table 2: Descriptive Statistics

	Mean	Median	Max	Min	SD	Skewness	Kurtosis	J-B
DAX30	8.91	8.88	9.44	8.25	0.27	0.08	2.11	4.88***
H	4.68	4.62	4.94	4.55	0.11	0.85	2.50	19.14*
CONF	-3.44	-1.80	11.60	-34.70	9.62	-1.19	4.68	51.64*
MRG	11.93	11.98	12.38	11.42	0.27	-0.21	1.92	8.03**
CREDIT	14.76	14.77	14.84	14.69	0.03	-0.17	2.58	1.75

*, ** and *** imply a rejection of the null hypothesis at 1%, 5% and 10% level accordingly.

The mean of the H shows that an average monthly change in real estate market is 4.6%, whereas the stock market is providing a monthly average of 8.9% during the sample period. The average of consumer confidence to the future financial situation is negative which implies that investors are less confident about future financial conditions. The standard deviations for the series are high especially in the case of

CONF. Compared to other variables, real estate (H) market and credit availability have a lower standard deviation. The Jarque-Bera statistics is conducted to test the normality of the data series. In all series, except for the CREDIT, the null hypothesis of a normal distribution is rejected. According to Gujarati and Porter (2009) in regard to large samples, the assumption of normality has less importance. In this study, each variable includes 145 observations; as a result, any possible abnormality must not affect the validity of the outcomes.

4.1 Unit Root Tests Results

Results of the ADF (Dickey & Fuller, 1981) and PP (Phillips & Perron, 1988) unit root tests are presented in Table 3. For ADF test the maximum lag length is considered to be 13 based on Schwartz Information Criterion. For PP test, Bartlett Kernel technique for spectral assessment and Newey-West automatic bandwidth selection (Newey & West, 1987 and 1994) is selected by default settings of Eviews. After examining with the trend and with trend and intercept, the tests failed to reject the null hypothesis of a unit root for all variables and indicate that series are non-stationary. In the case of non-stationarity in levels, we have to take the first difference of the series and apply the unit root test to differenced data. A further ADF and PP tests on the first differences show that all variables are stationary with 1% significance level and we can conclude that all variables are integrated of order one or I(1). As stated by Engel and Granger (1987) a linear combination of series with an order of integration of one may be stationary (Engle & Granger, 1987) and in this case, we can apply the cointegration test to the variables for investigating any possible long-run equilibrium relationships.

Table 3: Results of Unit Root Tests

Level		ADF	PP
Intercept	*DAX30*	-1.04	-1.18
	H	2.83	3.21
	CONF	-2.24	-2.45
	MRG	0.73	1.45
	CREDIT	-0.98	-0.91
Trend & Intercept	*DAX30*	-1.97	-2.25
	H	-0.97	-1.00
	CONF	-2.33	-2.57
	MRG	-2.60	-2.50
	CREDIT	-1.91	-1.72
1st Difference			
Intercept	*DAX30*	-10.33*	-10.29*
	H	-4.69*	-7.28*
	CONF	-9.32*	-9.61*
	MRG	-13.41*	-14.96*
	CREDIT	-13.24*	-13.24*
Trend & Intercept	*DAX30*	-10.29*	-10.25*
	H	-6.36*	-7.67*
	CONF	-9.29*	-9.58*
	MRG	-13.38*	-15.21*
	CREDIT	-13.20*	-13.20*

* and ** imply a rejection of the null hypothesis of a unit root at 1% and 5% level accordingly.

4.2 Cointegration Test Results

To test the cointegration between DAX30 and H, Johansen and Juselius (1990) and Johansen (1991) method is implemented and the results are presented in Table 4. The test includes an intercept and linear trend in the terms but no exogenous variables. As it is presented in table 5, the optimum lag length is determined based on LR, FPE, AIC and HQ criteria.

Table 4: Lag Order Selection Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	179.16	NA	0	-2.66	-2.62	-2.64
1	699.11	1016.45	1.02E-07	-10.42	-10.29	-10.36
2	711.9	24.6	8.94E-08	-10.55	-10.33*	-10.46
3	713.75	3.5	9.23E-08	-10.52	-10.21	-10.39
4	721.8	15.02	8.69E-08	-10.58	-10.19	-10.42
5	733.31	21.1	7.76E-08	-10.69	-10.21	-10.5
6	734.94	2.94	8.05E-08	-10.66	-10.09	-10.43
7	746.57	1.51*	7.53E-08*	-10.72*	-9.98	-10.42*
9	748.4	1.64	7.89E-08	-10.68	-9.85	-10.34
10	749.8	2.34	8.22E-08	-10.64	-9.73	-10.27
11	753.29	5.77	8.30E-08	-10.63	-9.63	-10.22
12	754.7	2.28	8.64E-08	-10.59	-9.51	-10.15

To test the cointegration, this study employs trace statistics. The test results reject the null hypothesis of no cointegration (i.e., r = 0) and the null hypothesis of at least one (i.e., r = 1) cointegrating relationship between real estate and the stock market. As shown in Table 4, trace test indicates cointegrating equations at the 0.05 level which shows the presence of cointegration between the two variables. Based on results of cointegration test, the stock market and real estate are integrated and there is no segmentation between two markets. This finding has important implication for portfolio management. Because of integration between the two markets, they will show similar characteristics in the long-run implying that there is no risk reduction benefit in holding both stocks and real estate in the same portfolio.

The results are consistent with the study of Oikarinen (2010), Lin and Lin (2011), McMillan (2011) and Tsai, Lee, and Chiang (2012) which suggests the existence of a cointegrating relationship between stock market and real estate market. Specifically, in the case of Germany, our findings are in line with the study by Su (2011) and

Kiohos, Babalos and Koulakiotis (2017) who claim the existence of cointegrating relationships between the two markets. These findings are in contrast to the study by Wilson, Okunev and Ta (1996), Lean and Smyth (2014) and Wang *et al*. (2017) who claim that the two markets are segmented and there is no long-run relationship between them.

Table 5: Results of Johansen Test of Cointegration

Testing Hypothesis	Eigenvalue	Trace Statistic	5% Critical Value	Prob.
H_0: $r = 0$ and r=1 (None)	0.06	17.72	15.49	0.02**
H_0: $r \leq 1$and r=2 (At most 1)	0.05	8.02	3.84	0.00*

* and ** denotes rejection of the hypothesis at the 0.01 and 0.05 level accordingly

4.3 Vector Error Correction Model

Following the finding of long-run relationships, we conduct the VECM to capture the short and long-run dynamic adjustments concerning the stock market and real estate of Germany. First VECM was developed with no control variable. Afterward CONF, MRG, and CREDIT added to the model one by one as control variables to assess the robustness of the findings.

Results of lag order selection are presented in Table 5. Seven lags are selected by the Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC) and Hannan-Quinn (HQ) methods. Although the number of lags is illustrated by Schwarz information criterion (SC) to be two, based on the majority of tests we continue the VECM by using seven lags.

In the first step, when no control variable is used, as it is presented in Table 6, VECM indicates a long-run relationship between the stock market and real estate

market. The speed of adjustment is statistically significant at 1% level (t-statistics = -2.85) and shows a negative sign (-0.09). This indicates that short-run values of stock market returns converge to its long-run equilibrium level by 9% speed of adjustment by the contribution of real estate market.

Table 6: Results of VECM (with no control variable)

Error Correction CointEq1 (speed of adjustment)	-0.09 (0.03) [-2.85]
H(-1)	-2.17 (0.42) [-5.11]

*The numbers in the parenthesis are SE and numbers in the brackets are t-statistics

Employing control variable in a model aids robustness testing and is likely to decrease bias results (Young & Holsteen, 2017). In this regard, we add control variables to the model. In the next model, as table 7 presents, adding CONF as the control variable confirms the results of the first model. The long-run coefficient again is negative and statistically significant (t-statistics = -10.29). In this model coefficient for H is equal to -2.45 which shows a minor change from the first model (-2.17) and the coefficient for CONF (0.02) is positive and significant. Our results regarding with confidence variable are in line with Lee, Jiang and Indro (2002) who examined the relationship between consumer confidence and the stock market by using data of the Dow Jones Industrial Average, S&P 500, and NASDAQ. They stated that stock market returns are positively correlated with changes in consumer confidence. Also, results are in line with the study by Finter, Niessen-Ruenzi, and Ruenzi (2012) and Hengelbrock, Theissen and Westheide (2013) who find a significant positive relationship between the consumer confidence and stock market in the case of Germany.

Consistent with the results of Baker and Wurgler (2006) and Finter, Niessen-Ruenzi and Ruenzi, (2012) our results establish a positive but weak predictive power of consumer confidence in the case of Germany. According to Finter, Niessen-Ruenzi, and Ruenzi, (2012), low impact of consumer confidence on the stock market, comparing to markets of the US and the UK, can be explained by some characteristics of the German market. The main character is the share of retail investors (5.2% of the population) which is much lower comparing to the U.S. (25.4%) or the U.K. (23.0%) (Deutsches Aktieninstitut, 2011). So consumer confidence plays a positive but minor role in the German stock market.

Table 7: Results of VECM with CONF

Error Correction CointEq1 (speed of adjustment)	-0.30 (0.07) [-4.24]
H (-1)	-2.45 (0.23) [-10.29]
CONF	0.002 (0.00) [2.40]

*The numbers in the parenthesis are SE and numbers in the brackets are t-statistics

By adding the next control variable (CREDIT) to the model the coefficient of real estate prices (H) is still significant and have expected sign (Table 8). Moreover, applying for the CREDIT as a control variable has a minor effect on the coefficient of real estate (H) changing it from -2.45 to -2.51. The results show that the coefficient for consumer confidence is again 0.002 and statistically significant. Credit expansion by banks can lead to signs of augmented risk in financial markets because of relaxed VaR (Value at Risk) constraints by financial intermediaries (Adrian, Moench & Shin, 2013). In this regard, negative relationship between credit

expansion and the stock market in our results are in line with Gandhi (2011) and Baron and Xiong (2017) who conclude that bank credit expansion leads to lower stock market returns. The results are in contrast to the study by Helbling and Terrones (2003), Lim *et al*., (2011), Yu (2010) who state that credit growth helps both stock market and housing price rise.

Table 8: Results of VECM with CONF and CREDIT

Error Correction CointEq1 (speed of adjustment)	-0.35 (0.07) [-4.76]
H (-1)	-2.51 (0.20) [-12.51]
CREDIT	-0.56 (0.26) [-2.10]
CONF	0.002 (0.00) [2.32]

*The numbers in the parenthesis are SE and numbers in the brackets are t-statistics

By adding the last control variable (MRG) to the model the coefficient of real estate (H) becomes -1.46. H still have the expected sign (-) and is significant as it is presented in Table 9. The coefficient for credit has increased to -0.91 and is significant. Also, the coefficient of confidence is again 0.002 and significant.

According to our results, growth in mortgage supply affects the stock market returns negatively, specified by the significance of its coefficient which is -0.19. More supply of mortgages can increase the demand for real estate and put a pressure on the prices. These results indicate that higher mortgage supply leads to lower stock

market returns. It is consistent with the expectation that by more supply of mortgages the investment in stock market shifts to real estate market.

Table 9: Results of VECM with CONF, CREDIT and MRG

Error Correction CointEq1 (speed of adjustment)	-0.35 (0.07) [-4.88]
H (-1)	-1.46 (0.34) [-4.20]
MRG	-0.19 (0.04) [-3.95]
CREDIT	-0.91 (0.30) [-2.96]
CONF	0.002 (0.00) [3.21]

*The numbers in the parenthesis are SE and numbers in the brackets are t-statistics

Control variables are involved in the tests to check whether the relationship of stocks returns and real estate prices persists with and without them. For all models, error correction term has expected sign, is between 0 and -1 and highly significant. After including control variables, ECT becomes higher which shows the contribution of the control variables. For each of the models with control variables ECT is around -0.3 which shows that the German stock market is expected to converge to its long-run equilibrium at a high rate of adjustment. For the coefficient of real estate (H), employing control variables confirm almost the same result which indicates the slight influence of control variables and the robustness of the results. In addition, the sign and the statistical significance of the control variables do not change for different models.

The benefits of a portfolio diversification rest on the cointegration relationship between the markets, especially in long-run. Diversification benefits disappear in the case of positive cointegration between the two markets and become important in negative cointegrations. Stocks offer the most suitable investment opportunity with minor transaction costs and high liquidity while real estate is an asset with opposite characteristics. That is why investors are interested in both assets to diversify the portfolios (Lin & Fuerst, 2014). However, our results indicate that the diversification opportunities diminish in the long-run by allocating both real estate and stocks in one portfolio. A long-term relationship between two assets makes portfolio diversification unviable. The diminishing advantage of risk diversification in a portfolio with real estate and stock in it is discussed by literature and is confirmed as a result of integration between the two markets. Consistent with our general results, Li *et al.*, (2015) indicate that there are fewer diversification benefits from combining stocks and real estate assets in a single portfolio. Our results are also in line with Ullah and Zhou (2003) who state that stocks and real estate have the tendency to move together in long-run.

In this regard, these findings are especially important for investors and portfolio managers who consider a long-time investment strategy. Furthermore, a long-run relationship helps to identify movement patterns of the stocks and real estate and makes it possible to predict the performance of one asset by tracking the other.

Chapter 5

CONCLUSION

Empirical studies suggest that the return distributions of real estate are entirely different from stocks (Benjamin, Sirmans & Zietz, 2001). Stocks are comparatively ideal assets to invest in because of high liquidity and low transaction costs, while a real estate has much higher transaction costs and is considered to be less liquid (Lin & Lin, 2011). At the same time, real estate is a worthy asset to invest in since it usually has minor price fluctuations compared to the stock market (Fraser, Leishman, & Tarbert, 2002). That is why investors are interested in both assets to diversify the portfolios (Lin & Fuerst, 2014). In this regard, investigating long-run relationship between the stock market and the real estate market is vital to both institutional and individual investors. Understanding the relationship between real estate and stock markets helps investors in portfolio optimization. This topic has become more important especially after the global crises in 2008 because investors have become more worried that the fluctuations in stock market transfer risk to the real estate market or the other way around.

This thesis makes use of the monthly data over 2005-2017 to examine the long-run relationship between the stock market and real estate market in Germany. The existence or absence of any relationship between two markets can either be used to forecast the markets or to diversify a portfolio accordingly. The existence of this linkage helps us to explain any possible integration between two markets and

suggests that portfolio managers can be interchangeably selected them. If stock markets and real estate markets are integrated, we can conclude that the two assets are good substitutes in portfolio construction. Besides, it is essential for an economy to have integration and segmentation among its markets because fluctuations in one market can stimulate other relevant markets. The German case is interesting since its real estate market was among the markets which did not fall during the global financial crisis of 2008. After an extended steady period, the German real estate market is in a growing stage because of growth in demand. The increasing demand for real estate seems to continue due to high economic growth, overflow of refugees in recent years and low-interest rates.

One of the distinctive features of this research is to employ the hedonic real estate price index. Due to assessing problems, using an appraisal-based index is not appropriate for cointegration tests between stocks and real estate. Hedonic methods establish a precise quality adjustment technique in which principal importance is devoted to how quality variations can be taken into account. Moreover, DAX30 is employed as a representation of stock market returns and three other variables; index of consumer confidence, changes in credit availability and change in the supply of mortgage loans; are incorporated as control variables.

The long-run relationship between the stock market and real estate is examined by applying Johansen Cointegration test and VECM. Data is collected from Thomson Reuters Data Stream and estimation and statistical tests are done with EViews. The results of Johansen Cointegration test suggest that in long-run the stock market and the real estate markets are cointegrated in Germany. This result indicates that the two markets will reach equilibrium in the long-run; hence they can be included in a

portfolio alternatively. Results of cointegration tests are consistent with the study of Oikarinen (2010), Lin and Lin (2011), McMillan (2011), Su (2011), Tsai, Lee and Chiang (2012), and Kiohos, Babalos and Koulakiotis (2017). The VECM without any control variables or even when applying the control variables both confirmed the long-run adjustment of the stock market toward its equilibrium employing real estate market. Additionally, the VECM indicated no short-run relationship between the stock market and the real estate market.

From an investor's viewpoint existence of cointegration suggests that in long-run there is no diversification advantage from allocating stock and real estate assets together in one single portfolio. In other words, real estate and stocks will yield similar return and risk characteristics in the long-run. However, investors should be aware that in the short-run the returns on stocks and real estate might vary a lot because of the possibility of different trends. Due to no significant short-run relationship, stocks and real estate can show diversification benefits in shorter time horizons. No short-term relationship between two markets can be explained by considering the comparison of stocks to the real estate since it is less liquid and its response to shocks are different. Because of higher liquidity, more participants and less transaction cost the stock market is expected to be more informationally efficient than the real estate market. Thus, the price of stocks is assumed to respond quicker to shocks than the price of real estate. Due to illiquidity, the integration from real estate market to stock market is not possible in short-run. However, in long periods it is likely for investors to rebalance the share of real estate in the portfolio and additionally the market can return to its long-run equilibrium (Yuan, Hamori & Chen, 2014).

Our findings indicate that facing common economic factors, both real estate and stock markets show similar behaviour in the long-run which implies the predictability of the real estate and the stocks market in Germany. As a result, stability in one of these markets appears to be crucial for the stability in the other market for Germany. From the government's perspective, the real estate market has important impacts on the macro-economy through wealth effects (Aron, Duca, Muellbauer, Murata, & Murphy, 2012; Jansen, 2013) and fluctuations in real estate prices may expose risk to the economy and financial system (Goodhart & Hofmann, 2007). By understanding the consequences of changes in either real estate or the stock market, policymakers can improve their policies. Moreover, the results are essential for banks and other financial institutes holding real estate as an asset or collateral. A fall in the stock markets also reduces real estate prices and declines the creditworthiness and wealth of a household. Finally, our findings are valuable for households which plan to buy or sell a real estate in the future.

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